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Assessing the Labour, Financial and Demographic Risks to Retirement Income from Defined-Contribution Pensions

by

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This article examines the impact of labour, financial and demographic risks on retirement income from DC pension plans, with a special emphasis on labour-market risk. It uses a stochastic model that incorporates uncertainty about returns on investment, inflation, discount rates, life expectancy, employment prospects and real wages. The analysis herein highlights that labour-market risk, as well as uncertainty about returns on investment and inflation, have the largest impact on retirement income. The results suggest that default life-cycle investment strategies that reduce exposure to risky assets in the last decade before retirement are quite helpful in reducing the risk of sharp reductions in retirement income, in particular when a negative shock to equity markets occurs in the years before retiring. However, life-cycle strategies fail to address issues of retirement income adequacy or smooth out the volatility in retirement income from DC pension plans.

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EXECUTIVE SUMMARY

This article examines the impact of labour market, financial market and demographic risks on retirement income derived from defined contribution (DC) pension plans. The amount of retirement income that people investing in DC plans will get after retirement depends on several parameters that are not known with certainty. Indeed, labour market outcomes, such as employment prospects and real wage career paths, are uncertain. Moreover, future realisations of returns on different asset classes, portfolio returns, interest rates and inflation are also uncertain, as well as future life expectancy. These labour, financial and demographic risks make the amount of retirement income that is derived from DC plans inherently uncertain.

This article relies on a stochastic model that takes into account the uncertainty inherent in returns on investment, inflation, discount rates, life expectancy, employment prospects and real wages, coupled with their correlations, in order to examine the extent of uncertainty of retirement income from DC plans. The main conclusions drawn from examining these risks when assessing retirement income can be summarised as follows:

- The impact on retirement income of varying employment and real-wage career paths, as well as uncertainty about investment returns, inflation, discount rates, and life expectancy is far from negligible. The risk of a shortfall in retirement income is well above 50%, with replacement rates quite dispersed based on any target or median replacement rate considered. Moreover, replacement rates can be quite low when considering worst-case scenarios.

- Labour-market risk, as well as uncertainty about returns on investment and inflation, have the largest impact on retirement income from DC pension plans.

- When assessing the impact of labour-market risk, there is a need to use an absolute standard for the amount of retirement income workers are entitled to receive, in addition to the replacement rate. The replacement rate may be misleading, since individuals who suffer spells of unemployment may have higher replacement rates than those with uninterrupted careers, even though the absolute pension benefits of the former may be lower. The same may happen when there is a shift to different real-wage career paths.

- Regulators and policy makers should seriously consider implementing life-cycle strategies, at least as defaults. Life-cycle investment strategies that reduce exposure to risky assets in the decade before retirement are quite helpful in reducing the risk of sharp reductions in retirement income, in particular when a negative shock to equity markets occurs in the years just prior to retirement.

- The length of the contribution period also matters. The shorter the contribution period, the stronger is the positive effect of life-cycle strategies on retirement income in the event of negative shocks.

- Employment policies may need to focus on younger workers, as workers who suffer spells of unemployment early in their careers will have lower pension benefits than those who suffer otherwise similar bouts of unemployment late in their careers.

- If stagflation or deflation were to occur, policies may also need to focus on older workers as either scenario will have a bigger impact on people reaching retirement age within the next decade than on people who are just beginning their careers. Both scenarios are characterised by lower growth, which leads to higher unemployment and lower returns on equities, but the portfolio-size effect dominates.

Based on the analysis, the main recommendation for regulators and policy makers is:

- First establish a target replacement rate for DC pension plans taking into account the overall structure of the pension system;
- Then, set contributions and the length of the contribution period accordingly, keeping in mind that to achieve adequate retirement income people need to "contribute and contribute for long periods", and that it is preferable to increase contribution periods by postponing retirement;
- And, afterwards, focus on asset-allocation strategies, and establish default life-cycle investment strategies that reduce exposure to equities in the last decade before retirement. This is particularly important if contribution periods are short or intermittent, or when a main policy issue is how to address sharply lower replacement rates for those near retirement due to a negative shock to equity markets.

I. Introduction

Retirement income derived from DC pension plans is uncertain

The amount of retirement income to be derived from defined contribution (DC) pension plans is uncertain. Indeed, in addition to the risk posed by life expectancy (how long one can expect to live after retiring), the current economic and financial crisis has highlighted two additional risk factors: (1) financial market conditions and their impact on the savings accumulated in DC pension plans; and (2) labour market conditions, in particular employment prospects. All of these risks have shaken public confidence in DC pension plans, making it necessary to examine the factors that contribute to the lack of certainty regarding retirement income. The ultimate goal of this examination is to foster polices that reassure people about saving for retirement through DC pension plans.

It depends on several factors whose future outcomes are unknown

Retirement income derived from DC pension plans depends on several factors, some of which are uncertain. The factors affecting retirement income include: the amount saved during the time worked; the length of the contribution period; the pension investment policy; the returns on different assets classes, inflation, wages; periods of employment; and life expectancy. Individuals, regulators and policy makers have some control over certain factors, such as the amount saved periodically during the working life (*i.e.*, the contribution rate) or the length of time people will save for retirement.[1] However, other factors are inherently beyond policy makers' control, such as: the returns on different asset classes; returns and yields on government bonds; and the rate of inflation. Similarly, career wage-growth paths vary for individual workers, as well as whether they will suffer unemployment spells during their careers. Additionally, how long people may expect to live is also undetermined. As a result of these labour, financial, and demographic risks, saving for retirement entails a variety of risks. One of the main implications of such risks is that pension benefits derived from DC pension plans are uncertain and can be highly volatile.

This article assesses the impact of labour, financial and demographic risks on retirement income of DC plans

The purpose of this article is to assess the impact of labour, financial and demographic risk to retirement income derived from DC plans. Specifically, the three major risk factors are: (1) the time employed and real wages (*labour-market risk*); (2) uncertainty about returns on investment, inflation and interest rates (*financial-market risk*); and (3) life expectancy (*demographic risk*). The article comprises four sections.

It uses a stochastic model of the determination of retirement income

Section II presents a stochastic model for introducing uncertainty into the determination of retirement income from DC plans. This model incorporates financial market and demographic risk, as well as labour-market risk, including periods of unemployment and the possibility of having different real-wage career paths. The main outcome of this model is probability distributions for assets accumulated, wages and retirement income. Consideration of these probability distributions permits the authors to assess the level of resulting uncertainty.

That incorporates these risks

Section III assesses the impact of uncertainty on retirement income from DC pension plans. Firstly, it assesses the impact of full uncertainty, *i.e.* uncertainty about returns on investment, inflation, discount rates, life expectancy, employment and real-wage career paths. The analysis concludes that, as a result of all this uncertainty, both the risk of a shortfall in retirement income and the volatility of retirement income from DC plans are quite high.

It focuses on the role of labour market risk on retirement income

Secondly, section III examines the role of labour-market risk on retirement income. To disentangle the impact of unemployment and real wages on retirement income requires using other indicators, in addition to the replacement rate. The replacement rate is the standard measure used by regulators and policy makers to assess retirement income, expressed as the ratio of retirement income to final wages. Unfortunately, in certain cases, the replacement rate may be misleading. For example, individuals who suffer spells of unemployment may actually have higher measured replacement rates than those without spells of unemployment, despite having lower absolute pension benefits. Spells of unemployment reduce the amount of assets accumulated and thus retirement income, but they may also reduce final wages. Depending on the magnitude of these effects, the replacement rate could be higher than for an otherwise comparable individual without periods of unemployment. The same effect may occur when comparing individuals with different real-wage career paths. As a consequence of these effects, to assess the impact on retirement income of uncertainty about employment and wages, there is a need to use a standard measure for the total amount of retirement income one is entitled to receive.

But it also assesses these risks combined, and separately

Section III also examines the relative importance of each risk, and whether it matters when during one's career episodes of unemployment occur. Labour market risk, uncertainty about returns on investment, and uncertainty about inflation have the largest impact on the adequacy of retirement income. Moreover, workers who suffer spells of unemployment early in their careers will have lower income at retirement than those who suffer comparable spells of unemployment late in their careers, other things being equal. That is because contributions during the early stages benefit from the compound-interest effect. Consequently, if the goal of policy is to ensure adequate income at retirement, it might be more effective to focus employment policies on younger workers.

It also examines the effect of using default life-cycle investment strategies

Sections IV and V look at the interaction between labour, financial and longevity risks, and life-cycle investment strategies, and at the impact of alternative economic scenarios, namely deflation and stagflation. The main finding is that life-cycle investment strategies may attenuate the drop in retirement income that would result from a negative shock to equity markets just before retirement (as compared to fixed portfolios with the same average exposure to equities). Introducing labour-market risk adds an interesting degree of detail to the importance of default life-cycle strategies. The positive effect of life-cycle strategies is even more important in the case of workers who have relatively flat real-wage growth paths and suffer spells of unemployment during their careers. Finally, the report assesses the impact on retirement income of alternative economic scenarios, such as high inflation and low growth (*stagflation*), and low inflation and low growth (*deflation*), in a world of uncertainty in which people may experience unemployment and different real-wage career paths. The impact on retirement income of both scenarios is worse for people in the final stages of their careers than for people just beginning their careers. Finally, section VI concludes.

II. Measuring Retirement Income in a World of Uncertainty

This section discusses how the model presented incorporates uncertainty

This section presents a model for incorporating the uncertainty prevalent in several pension parameters that affect retirement income from DC pension plans. This article relies on a stochastic model for the determination of retirement income in DC plans, where future realisations of several pension parameters are unknown or uncertain. This section first discusses financial-market risk (uncertainty about future investment returns, inflation and interest, or discount, rates), as well as demographic risk (the uncertainty surrounding mortality and life expectancy). Secondly, it focuses on the importance of considering labour-market risk (the uncertainty surrounding employment and wage prospects. After explaining why labour-market risk must be taken into account during the accumulation phase of DC pension plans, the section ends by presenting an approach for introducing labour-market risk (and its correlation with other risks) into the stochastic model for determining retirement income from a DC plan.

Introducing financial market and demographic risk

The crisis has highlighted the uncertainty of market conditions and their impact on retirement income

The recent financial and economic crisis has highlighted the effect of market conditions on retirement savings accumulated through DC pension plans, and the uncertainty as to whether those retirement savings will prove adequate to finance retirement – particularly for those close to retirement. Antolin (2010), using a deterministic approach, highlighted the sensitivity of retirement income to investment returns, inflation, interest rates and life expectancy.[1] That analysis did not, however, take into account that the future outcomes of these pension variables are highly uncertain, which makes retirement income from DC pension plans also highly uncertain.

The analysis herein assesses this uncertainty with the help of a stochastic model

Consequently, the analysis in this article assesses this uncertainty with the help of stochastic modelling. In this stochastic model, uncertainty about returns on investment, discount rates, inflation and life expectancy was derived by assuming random-generating processes for each of the variables (or risks) in question.[2] The model produced 10 000 simulations for savings accumulated at retirement based on stochastic simulations of investment returns in equities and bonds, and of inflation. The value of the assets accumulated at retirement are the result of workers contributing 5% of wages to their DC plan during each year they are employed, starting from age 25 until retirement at age 65. Contributions to DC plans are invested in a portfolio that is 60% equities and 40% government bonds.[3] At retirement, people would have accumulated a certain amount of assets to finance retirement. Assets accumulated are transformed into a pension stream based on the assumption that the individual buys a life annuity priced using the annuity-premium formula (using stochastic life expectancy and discount rates). The main outcome is a probability distribution of assets accumulated at retirement, final salary and pension benefits.[4]

The stochastic model includes labour- market risk

The model needs to consider also the uncertainty surrounding labour-market outcomes. Labour market outcomes, in particular employment and wages, determine the amount of contributions, and thus of assets accumulated and retirement income. In fact, contributions to DC plans depend on individuals being employed, as well as on their wage-growth career paths.

Why is there a need to introduce labour-market risk?

This risk originates from the possibility of suffering unemployment or inactivity during people's careers …

Labour-market risk originates from the possibility of spells of unemployment or inactivity during people's careers. During such episodes of unemployment or inactivity, contributions set aside to finance retirement may be discontinued. Consequently, the amount of assets accumulated to finance retirement at the end of one's career would tend to be lower than in the absence of such episodes. Additionally, spells of unemployment or inactivity may also affect wages. People that suffer spells of unemployment may re-enter the labour market at lower wages than they enjoyed at their previous job.[5] This would tend, other things being equal, to reduce their total amount of contributions and the amount of assets accumulated relative to an uninterrupted career path (without spells of unemployment).

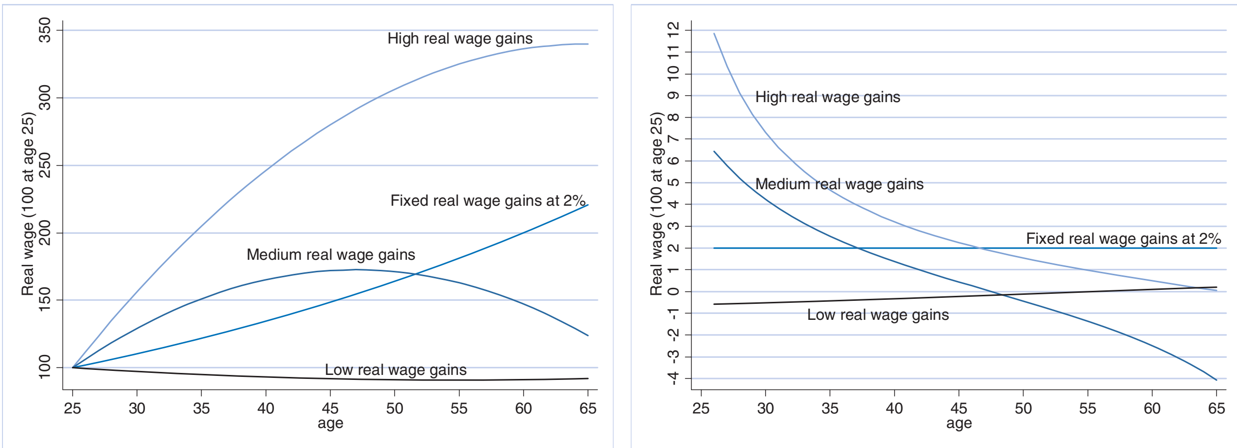
… and from the uncertainty surrounding the trajectory of real wages during one's career.

Additionally, labour-market risk may also originate from the uncertainty surrounding the trajectory of real wages during one's career. Real-wage gains during a career vary across individuals, according to their socio-economic situation (*e.g.* occupation, educational level and income).[6] Labour market studies document that there are three main career paths for real wages.[7] In general, real wages experience the largest gains during the early part of a person's career, with lower gains, even negative gains, in the latter part. This pattern results in real-wage paths that for some people reach a plateau at the end of their careers (high real-wage gains), while for others, real wages plateau earlier, around ages 45 to 55 (medium real-wage gains) and fall thereafter. A minority experience flat real wages throughout their working lives. Figure 1 shows the three types of career real-wage paths used in the model for assessing the impact of labour-market risk on retirement income from DC pension plans.

Assessments of the adequacy of retirement income are incomplete if labour market risk is not taken into account

Assessments of the adequacy of retirement income are incomplete if the likelihood of unemployment, or the existence of different real-wage paths, are not taken into account. Labour-market data show that with unemployment rates at around 10%, segments of the working age population are without a job at any given point in time. In addition, OECD data indicate that different people experience different real-wage patterns during their working lives (OECD, 1998).[6] In particular, high-income people or people with high levels of education (university or higher), which may represent around 42% of the population aged 30 to 40, seem to experience real-wage paths that keep rising during their entire career. However, mid-income people and those with medium educational levels, which may represent around 55% of the population, experience real wages that fall in the final years before retirement. More importantly, low-income people or people with low levels of education, around 3% of the population, seem to experience flat real wages during their career.

Figure 1. Different real-wage levels and real-wage gains during individual careers



Source: OECD Secretariat calculations.

Which could lead to overstatements regarding the savings accumulated for retirement

Failing to take these results into account and assuming instead the same real-wage career path for all individuals, as well as uninterrupted employment, may lead to overstatements regarding the savings accumulated for retirement, as well as the adequacy of retirement income for important sub-groups of the population. This in turn could undermine confidence in DC pensions, as people reaching retirement realise that their retirement income is lower than expected.

How is labour market risk modelled?

Labour market data can be used to provide estimates of unemployment and different real-wage paths

Labour-market data can be used to provide estimates of unemployment and whether individuals experience different real-wage career paths. The chances of having different real-wage paths is based on the average probability across OECD countries of having high, medium and low income. It is also determined by the average probability across OECD countries of attaining high, medium or low educational levels.[8] Individuals tend to have one type of real-wage path for their entire career. In this context, the model assumes away volatility on inter-annual real wages around the career path.[9] Real-wage career paths also depend on whether people experience unemployment. The model assumes, for simplicity, that people who re-enter the labour market do so at the same wage level as in their previous employment.[10]

The unemployment rate is best proxy of the probability of suffering unemployment

Regarding unemployment, the unemployment rate is the best proxy of the probability of suffering unemployment. Although economy-wide unemployment provides a proxy for the chances of suffering unemployment, the model also takes into account the fact that, on average, only around 40% of individuals in any given cohort suffer spells of unemployment.[11] Therefore, the chances of suffering spells of unemployment are modelled taking into account both the cohort's probability of suffering spells of unemployment and the economy-wide unemployment rate. The economy-wide unemployment rate, according to labour market studies, shows a large degree of persistence, especially in Europe.[12] Moreover, unemployment is highly dependent on age, with young people experiencing higher rates of unemployment than other age groups. Finally, the unemployment rate is affected by shocks to the economy, so that unemployment increases when the economy underperforms.[13] Table 1 shows the percentage of individuals in our sample who do not suffer any unemployment (61%) and those who suffer spells of unemployment (39%), categorised by the number of years unemployed .[14]

Table 1. Percentage of the population experiencing spells of unemployment during their career

Full career (no unemployment)	Number of years in unemployment							
	1 or 2	3 or 4	5 or 6	7 or 8	9 or 10	11 to 15	16 to 20	21 or more
61.4	3.6	5.7	6.8	6.5	5.3	8.1	2.1	0.5

Source: OECD Secretariat calculations

Our stochastic model of uncertainty also assumes correlations between the various risk variables

The model also assumes that labour-market risk is correlated with the performance of equity markets. The chances of suffering unemployment or inactivity tend to be lower when the economy is booming, and they tend to increase when the economy slows down or enters into recession, generally with a lag. Real wages may also be positively correlated with a lag in economic growth. Moreover, improvements in the economy or higher economic growth may push up returns on investment. In this context, when the economy is doing well, returns on investments rise, the chances of suffering spells of unemployment fall, and real wages may go up, always with a lag, each reinforcing the positive feedback cycle regarding the accumulation of income for retirement. However, the opposite occurs when the economy tanks. When economic growth turns negative, investment returns fall, spells of unemployment increase and real wages suffer, compounding the negative cycle or impact on the accumulation of retirement income. To take these patterns into account, the model links unemployment rates to the performance of equity markets, with a lag.[15] The main link is through the state of the economy, in particular GDP growth. In addition, the model also assumes that there is a positive correlation between yields on long-term government bonds and inflation.

The resulting uncertainty can be assessed by looking into the probability distribution of retirement income outcomes

The uncertainty resulting from labour, financial and demographic risks can be assessed by looking into the probability distribution of retirement income outcomes. The main outcome of the stochastic modelling exercise that incorporates labour, financial and demographic risk as described above is this: a probability distribution of retirement income, and the replacement rate an individual could expect to achieve at retirement, if contributing to a DC pension plan for the years employed. The results assume random wage-growth paths and rely on stochastic simulations to derive returns on equities and bonds, inflation, interest rates (*i.e.* the discount rate or time preference), and the expected life span after retirement (*i.e.* life expectancy).

III. The Impact of Uncertainty on Retirement Income

This section assesses the impact on retirement income of labour-market, financial-market, and demographic risks

This section assesses the impact on retirement income of labour market, financial market and demographic risks. It first assesses the risk of a shortfall in retirement income resulting from spells of unemployment and different real-wage career paths, given uncertainty about investment returns, interest rates and inflation, and life expectancy. Secondly, this section proposes the use of complementary measures of retirement income when assessing labour-market risk. Thirdly, it assesses the relative importance of each of the risks. This section concludes by examining whether the timing of unemployment is significant; that is, does it matter when in their careers people suffer spells of unemployment?

Measuring the risk of a shortfall in retirement income

The risk of a shortfall in retirement income can be quite large,

The likelihood of a shortfall in retirement income can be quite large given all the risk factors involved (labour-market risk, financial-market risk and demographic risk). The analysis herein uses three measures to assess the impact of uncertainty on retirement income. The first measure, the *benefit-shortfall risk*, is based on the likelihood that the level of retirement income will fall short of the target replacement rate, which is set to equal the replacement rate that would prevail in a world without uncertainty.[16] The second measure provides the shortfall in replacement rates given worst-case scenarios, those that occur only 1% or 5% of the time.[17] The resulting level of retirement income or replacement rates are both so low (*i.e.* in the *1st and 5th percentiles)* such that 95% to 99% of all other replacement rates will be higher. These two measures are complemented by a third, which shows the degree of concentration of replacement rates. This concentration can be measured in two ways: (1) the difference between the replacement rates at the 3rd and 1st quartiles, *i.e.* the inter-quartile range; and (2) by the probability that replacement rates are no more than 5 percentage points below the replacement rate that would prevail in a world without uncertainty. Taken together, these measures help us to arrive at some important conclusions.

… as much as 58%

First, the shortfall risk could be as much as 58%. Due to uncertainty about investment returns, inflation, interest rates (the discount rate), life expectancy and labour market, the probability that the replacement rate will fall below a target replacement rate is around 58% (Table 2). This target replacement rate is the replacement rate – 41.3% – that would be achieved in a situation of certainty as regards the rate of return on investment, inflation, discount rates, life expectancy and labour market risk.[18] Table 2 shows the percentile distribution of replacement rates resulting from 10 000 Monte Carlo simulations in a world of uncertainty coupled with labour market risk. The target replacement rate falls above the median replacement rate. Figure 2 shows the probability histogram of replacement rates for those same 10,000 simulations of replacement rates.[19] Looking at Figure 1 and Table 1, the probability that replacement rates will fall below 41.3% is around 58%.

Figure 2. Histogram of retirement income relative to final salary[1]

Note: Based on 10 000 Monte Carlo simulations for the rate of return on investment, inflation, discount rate, life expectancy at 65, the probability of suffering spells of unemployment, and of having one of the three career wage-growth paths.

Source: OECD Secretariat calculations.

Estimated replacement rates are far from concentrated

Second, estimated replacement rates are far from highly concentrated. Focusing on replacement rates below the replacement rate that would prevail in a situation of certainty (*i.e.* a situation without risks), their concentration is 14.1% (see Table 2 below). That is, only 14.1% of the replacement rates below 41.3% are within 5 percentage points; the rest are below 36.3%. Additionally, the inter-quartile range shows that the variability of replacement rates around the median can be as much 31 percentage points between the 25th and the 75th percentile.

Replacement rates in worst-case scenarios are quite low

Third, replacement rates can be quite low in worst-case situations. For example, replacement rates can be lower than 12.8% in 5% of the cases, or lower than 8.8% in 1% of the cases. An example of a plausible worst-case situation could be an individual experiencing six years of unemployment or inactivity between ages 25 and 30, a flat real-wage career path, average returns on investment of only 2% and inflation of 5%. Risk-averse individuals and pension regulators may find these rates, and their related probabilities, quite worrisome.

Table 2. Distribution of retirement income relative to final wages

	Percentile of distribution (%)									Benefit shortfall risk (%)[1]	Concen-tration[2]	IQR[3]
	1	5	10	25	50	75	90	95	99			
Replacement rate	8.8	12.8	16.0	23.5	36.3	54.5	77.5	95.6	143.9	58.1	14.1	31.0

Notes: These calculations result from assuming uncertain investment returns, inflation, discount rates, life expectancy and labour market conditions. People contributes 5% over a 40-year period, and assets are invested in a portfolio comprised of 60% equities, 40% government bonds.

(1) The benefits-shortfall risk is the percentage of replacement rates that are below the replacement rate prevalent in a world of certainty (41.3%). (2) Concentration is the probability that the replacement rates are within 5 percentage points below the replacement rate prevalent in a world of certainty. (3) IQR the inter-quartile range: the difference between the replacement rate at the 75th and the 25th percentiles.

Source: OECD Secretariat calculations.

The impact of full uncertainty on retirement income is the result of labour-market risk combined with uncertainty regarding investment returns, inflation, discount rates and life expectancy. What follows is an assessment of the relative impact of labour-market risk, based on distinctions regarding the different real-wage paths, the likelihood of suffering spells of unemployment, as well as the timing of that unemployment. This analysis also provides an estimate for the relative impact of the other risks (financial and demographic).

The need for additional measures of retirement income when assessing labour-market risk

The analysis of the impact of different real-wage paths and the possibility of unemployment requires the use of absolute measures of retirement income

In order to assess the impact of different real-wage paths, and the possibility of suffering unemployment, the use of absolute measures of retirement income is required. The standard measure used to assess the adequacy of retirement income is the ratio of retirement income-to-final salary, known as the replacement rate. This measure is the one that has been used so far. However, when considering the possibility of different real-wage career paths and spells of unemployment and/or inactivity, the replacement rate may be misleading in the absence of total or absolute pension benefits relative to a common benchmark. For example, individuals who suffer spells of unemployment may have higher replacement rates than those with uninterrupted careers, despite the fact that their absolute retirement income may be lower. The same can happen when considering individuals with different real-wage career paths (see Box 1). Therefore, this analysis uses a measure that accounts for the amount of retirement income received relative to a benchmark final salary. This benchmark final salary is the median salary for the economy.[20] The resulting relative measure allows one to compare and determine the likely shortfall in retirement income of a person having higher spells of unemployment or a worse real-wage career path (see table in Box 1). In the following section, we use this measure to assess the impact on retirement income of labour-market risk, as well as financial and demographic risk (that is, uncertain investment returns, inflation, discount rates and life expectancy).

Box 1. The replacement rate fails to provide a full picture of the impact of labour-market risk

The replacement rate fails to provide a full picture of the impact of different real-wage career paths on retirement income. The possibility of having different real-wage career paths means that real-wage growth over time will differ across individuals. This will result in some individuals having higher final wages than others. For example, the table below shows that an individual with low annual average real-wage growth, such as 0%, will have a final wage that may be only 27% of that of an individual with a high annual average real-wage growth (of 3%).[21] Not surprisingly, the total amount of each of these two individual's contributions will be different, resulting in different quantities of assets accumulated at retirement. For example, an individual with low real-wage growth during his/her career may accumulate less than half, 42%, of the total accumulated by an individual with high real-wage growth. As a result of these two factors, the replacement rate (the ratio of retirement income to final wage) can be higher for an individual with a low real-wage growth than for an individual with a high real-wage growth: 42% as compared to 27%, in the Table below. The fact that low real-wage growth over a career may lead to higher replacement rates illustrates the importance of taking into account the level of retirement income. For example, retirement income resulting from low real-wage growth may be only 11.5% (fourth row, right column) of the final salary of an individual, as opposed to 27% (second row, right column) for someone with high real wage-growth.[22]

Additionally, the replacement rate does not accurately reflect the impact of unemployment. Due to unemployment, people lose wages and stop contributing to their pension plans. Consequently, their final salary and the amount of assets accumulated at retirement will be lower than for those with an uninterrupted earnings path. Yet, the replacement rate may remain unchanged, even though retirement income will be lower. The table below shows that for an individual with high real-wage growth during his/her career (row 2), the replacement rates are the same in case of a full career, and in case of a partial career with spells of unemployment (bottom row). However, the amount of retirement income is much lower, dropping from 27% to 19% of the final salary, relative to a person with a full career (bottom row, right column).[23] Therefore, use of the replacement rate to assess the impact of spells of unemployment is in need of additional measures that incorporate the absolute amount of retirement income received.

Finally, one would have thought that calculating retirement income relative to average wage (throughout the career) would address the problem presented by standard replacement rates. Column 2 in the table below provides these calculations. Note that the retirement income-to-average wage ratio can also be misleading. For example, an individual with low real-wage growth during his/her career seems to have higher retirement income relative to his/her average wage than someone with high or medium real-wage growth. Obviously, moving from high to low real-wage growth entails a fall in absolute retirement income, from 27% to 11.5% (rows 2 and 4, right column) relative to the final salary of an individual with high real-wage growth.

Retirement income outcomes given different wage profiles and spells of unemployment

	Replacement rate	Retirement income over average wage[1]	Total accumulated Assets[2]	Final salary[2]	Relative retirement income[3]
	no unemployment spells				
Fixed real wage growth[4]	25.8	57.9	60.8	63.7	16.4
High real wage growth[4]	27.0	55.2	100.0	100.0	27.0
Medium real wage growth[4]	46.6	65.9	65.4	38.0	17.7
Low real wage growth[4]	42.4	70.7	42.3	27.0	11.5
	unemployment spells				
High real wage growth[4]	27.0	52.0	74.9	70.1	18.9

Notes: Calculations assuming a contribution rate of 5% over a 40-year period. Assets are invested in a portfolio comprised of 60% equities, 40% government bonds. (1) Retirement income relative to the career average wage. (2) Total assets accumulated, and the final salary of an individual with high real-wage growth over his/her career is taken as a reference and set to 100. (3) Consequently, relative retirement income measures retirement income of the other cases relative to the final salary of an individual with high real-wage growth during his/her career. (4) Average annual growth of 2%, 3%, 1% and 0%, respectively.

Source: OECD Secretariat calculations.

Comparing the impact on retirement income of labour-market risk as well as other risks

Incorporating different real-wage career paths and the possibility of unemployment increases the uncertainty in retirement income

The uncertainty in retirement income from DC pension plans increases when we incorporate different real-wage career paths, and the possibility of spells of unemployment. Table 3 provides retirement income relative to the benchmark final salary, defined as the median final salary for the economy. For example, the median retirement income that an individual with high real-wage growth would receive is 56.3% of the median final wage for the economy. Similarly, the median retirement income of an individual with low real-wage growth is only 23.9% (Table 3). Comparing rows 1 and 3 in Table 3, one can see that relative retirement income falls when moving from individuals with high real-wage growth to individuals with low real-wage growth, in all percentiles. Row 4 provides relative retirement income for the weighted average, real-wage growth of the economy,[24] whose results fall somewhere in between. Row 5 ("All risks") provides retirement income based on weighted average real-wage growth, including average spells of unemployment for the economy, relative to the median final wage. Comparing row 5 with row 4 indicates the end-result of including spells of unemployment: a drop in relative retirement income.

Table 3. Distribution of retirement income given different wage profiles and spells of unemployment relative the final wages of a "representative" individual in a world of uncertainty

	Percentile of distribution (%)									Benefit shortfall risk (%)[1]	IQR
	1	5	10	25	50	75	90	95	99		
	Impact of different wage profiles (full career)										
High real wage growth	8.3	11.4	14.3	22.8	56.3	122.7	186.7	237.9	360.8	47.2	99.8
Medium real wage growth	5.2	7.3	9.3	15.3	36.8	79.2	121.8	157.1	245.7	58.2	64.0
Low real wage growth	3.4	4.8	6.1	10.1	23.9	50.2	78.0	101.0	161.6	74.1	40.1
Weighted average real wage growth	5.6	8.4	10.9	17.9	42.7	94.1	152.2	196.2	317.8	53.9	76.2
	Spells of unemployment										
All risks	4.0	6.4	8.6	15.0	33.0	77.3	133.0	176.2	294.7	61.3	62.3

Notes: The table shows retirement income for different wage profiles and spells of unemployment as a percentage of the final wage of a "representative" individual. The representative, or "average" individual is one with weighted average real wage growth and average spells of unemployment. Calculations assume a contribution rate of 5% over a 40-year period, assets are invested in a portfolio comprised of 60% equities and 40% government bonds, and there is uncertainty as to rates of return on investment, inflation, discount rates, life expectancy and labour market conditions.

Source: OECD Secretariat calculations.

Switching to different real wage career paths have also a strong impact on retirement income

Moreover, switches to different real-wage career paths also have a strong impact on retirement income. Such switches can occur, for example, when an individual with a high real-wage career path suffers unemployment for a period long enough that his/her skills become partially obsolete and may therefore need to re-enter the labour market in a lower real-wage career path. Alternatively, an individual with a low real-wage career path could upgrade his/her skills to switch to a higher real-wage career path. Table 4 shows that retirement income relative to final salary for the representative individual modelled in this report could fall by more than 10 percentage points when he/she switches to a low real-wage career path (from a high real-wage career path) in the middle of his/her career. On the other hand, when that individual upgrades skills and switches to a high real-wage career (from a low real-wage career path), his/her retirement income could increase by more than 10 percentage points. Consequently, it does pay to upgrade one's skills.

Table 4. Retirement income as % of final salary for a representative individual switching to various new real-wage career paths

	Retirement income
High real wage growth career path	41.5
From high to low real wage growth career path	30.6
From low to high real wage growth career path	30.5
Low real wage growth career path	19.8

Note: Calculations assume a contribution rate of 5% over a 40-year period. Assets are invested in a portfolio comprised of 60% equities, 40% government bonds. The representative individual is the one with the weighted average in real wage growth and average spells of unemployment. The switch to a new real-wage career path occurs in the middle of the career, at age 45.

Source: OECD Secretariat calculations.

Table 5. Distribution of retirement income relative to the final wages of a representative individual given various types of risks

	Percentile of distribution (%)									Benefit shortfall risk (%)[1]	IQR[3]
	1	5	10	25	50	75	90	95	99		
	Weighted average real wage growth										
Investment risk	13.1	18.3	21.6	28.5	38.9	52.8	70.1	83.6	114.8	68.6	24.3
Discount rate risk	27.8	33.3	36.5	42.4	49.4	57.0	64.0	68.5	77.1	49.5	14.6
Inflation risk	14.6	19.0	22.4	31.1	49.1	83.7	150.4	218.0	429.6	50.2	52.7
Longevity risk	37.7	40.1	41.6	44.7	49.2	55.6	64.2	71.6	94.6	50.1	10.9
Unemployment risk	25.4	28.5	33.0	40.8	42.3	63.5	63.5	63.5	63.5	58.2	22.7
Wage profile risk	27.8	28.9	30.1	33.6	39.5	45.8	51.9	55.3	60.1	81.5	12.2
All human capital risks	24.7	27.2	28.4	31.3	36.6	43.4	49.9	53.6	59.0	88.1	12.1
All risks	4.0	6.4	8.6	15.0	33.0	77.3	133.0	176.2	294.7	59.2	62.3

Notes: Calculations assume a contribution rate of 5% over a 40-year period. Assets are invested in a portfolio comprised of 60% equities and 40% government bonds. The representative individual's real-wage growth career path equals the weighted average. and he/she has average spells of unemployment.

Source: OECD Secretariat calculations.

Labour market conditions, inflation, and investment returns are the factors that have the biggest impact on retirement income

Labour market conditions, inflation, and investment returns are the factors that have the biggest impact on retirement income. Following up on the argument in the previous section that replacement rates by themselves can provide a misleading picture, Table 5 provides retirement income relative to the median final wage of the economy. Focusing on the shortfall-risk measure, the difference in real-wage career paths (either by itself or when combined with spells of unemployment) provides the highest shortfall in retirement income relative to a situation with no uncertainty. In terms of relative impact, labour risk is followed by investment risk and unemployment risk. Focusing on worst-case scenarios, such as those in the 1st and 5th percentiles, the risk of very low retirement income indicates that investment risk, followed by inflation and unemployment, are the main causes for concern. Finally, looking at the volatility around the median, *i.e.* the inter-quartile range, inflation shows the higher volatility.

The importance of the timing of unemployment

Workers who suffer spells of unemployment earlier rather than later in their careers will experience worse retirement income outcomes

Workers who suffer spells of unemployment earlier in their careers will experience worse retirement-income outcomes. Retirement income outcomes are very sensitive to the timing of unemployment spells. The impact is different depending on whether unemployment spells occur at the beginning, the middle or the end of one's career. Interest-rate compounding means that spells of unemployment at the beginning of a career lead to lower accumulation of assets to finance retirement, than when unemployment occurs at the end of one's career, other things being equal. Yet, final wages are instead relatively less-affected when unemployment spells occur early in one's career versus later in the career. Table 6 provides retirement income relative to the median final wage of the economy, assuming that spells of unemployment occur at different periods in a person's career.[25] Relative retirement income is lower for individuals who suffer spells of unemployment early in their career (at ages 28 and 29) than for individuals who suffer the same amount of unemployment, but later in their career (at ages 59 and 60). The median relative retirement income of an individual who suffers unemployment early in his/her career is just below 33%, as opposed to 40% for an otherwise comparable individual suffering who is unemployed late in his/her career. Contributions made early during the career benefit from longer investment periods plus the positive effect of compound interest. Also, when unemployed early in his/her career, the individual fails to contribute, thus lowering the amount of assets accumulated for retirement.

Table 6. Distribution of retirement income relative to final wages of a representative individual, given periods of unemployment at different times in one's career

	Percentile of distribution (%)									
	1	5	10	25	50	75	90	95	99	IQR
No spells of unemployment	5.5	8.2	10.6	18.0	42.5	93.6	154.1	197.3	317.1	75.60
Spells of unemployment[1]										
Early in their career	4.5	6.9	8.8	14.3	32.6	70.6	114.4	143.8	225.7	56.29
In the middle of their career	5.0	7.6	9.8	16.5	38.2	83.6	136.8	176.7	287.9	67.14
At the end of their career	5.2	7.8	10.1	17.2	39.9	89.6	145.6	186.7	301.3	72.42

Notes: Calculations assume a contribution rate of 5% over a 40-year period. Assets are invested in a portfolio comprised of 60% equities and 40% government bonds. The representative individual has weighted average real-wage growth and average spells of unemployment.

1. Spells of unemployment occur for two consecutive years at the beginning of a worker's career (ages 28 and 29), in the middle (ages 45 and 46) and close to the end (ages 59 and 60).

Source: OECD Secretariat calculations.

Such periods of unemployment leads to a loss of relative retirement income

Periods of unemployment lead to a loss of relative retirement income. Table 6, by comparing row 1 with rows 2 to 4, shows that spells of unemployment lead to a loss of relative retirement income. This loss is higher the earlier in the career that the unemployment occurs. For example, the relative loss of retirement income could be as much as 10 percentage points when comparing a person with an uninterrupted career to one suffering two consecutive spells of unemployment at ages 28 and 29.

There remain other important questions to be addressed

There remain some important questions to be addressed. The analysis so far has examined the impact on retirement income of labour-market risk given uncertain rates of return on investment, discount rates, inflation and life expectancy, and where savings for retirement are invested in a portfolio with a fixed asset allocation during the accumulation period. However, there is a rich literature on asset allocation and pensions (*e.g.*, Hinz *et al*, 2010; Maurer *et al.*, 2009; Viceira, 2008). The literature suggests that life-cycle investment strategies in which the allocation to risky assets depends on the age of the individual may provide welfare gains over fixed-portfolio strategies. This seems to be more the case when labour-market risk is part of the picture.

IV. Retirement Income and Life-Cycle Strategies in a World of Uncertainty[26]

The impact of labour market, financial market and demographic risk when using life-cycle investment strategies

This section assesses the impact of labour market, financial market and demographic risk when using life-cycle investment strategies. The analysis so far has looked at the impact of labour market, financial market and demographic risk assuming that assets are allocated 60% to equities and 40% to bonds (in fixed proportion) throughout the accumulation period. This section relaxes this assumption and introduces life-cycle strategies whereby the proportion of assets invested in risky assets (*e.g.*, equities) declines as the individual ages.

The analysis considers two types of life-cycle investment strategies. In the first one, the allocation to equities falls linearly with age, from an initially high allocation. The second life-cycle strategy assumes that the allocation to equities remains constant during the first three decades of the accumulation period but falls sharply during the last decade before retirement. The analysis compares the impact of labour-market, financial-market and demographic risk for investment strategies that have the same age-weighted average exposure to equities (Box 2).

Life-cycle investment strategies can have a positive impact on retirement income in a world of uncertainty

Life-cycle investment strategies can have a positive impact on retirement income in a world of uncertainty. Table 7 shows the percentage of cases in which retirement income is higher when using life-cycle strategies compared to relying on fixed-portfolio strategies, given the same age-weighted average equity exposure and assuming a negative shock to equity markets during three different periods just before retirement. Specifically, the table compares two life-cycle investment strategies with fixed-portfolios that have the same exposure to equities when the shock to equity markets occurs (respectively, in the final year before retirement, two years before retirement, and within five years of retirement). The first life-cycle strategy calls for equity exposure to decline linearly with age (linear decrease). The second life-cycle strategy assumes constant equity exposure during the first three decades of the accumulation period, but calls for equity exposure to fall sharply in the last decade before retirement (sharp decrease). Table 7 also presents two different age-weighted average-equity exposures, 44% and 60%.[27]

Box 2. Investment strategies with the same average exposure to risky assets

To assess the impact of a change in investment strategies on retirement income, it is necessary to compare strategies that have the same average exposure to risky assets over the accumulation period. There are alternative approaches to assess whether different investment strategies have the same average exposure to risky assets (or equities) over the accumulation period. One straightforward approach is to calculate the simple average of the percentage of equities in the portfolio over the accumulation period -- the *time-weighted average*. However, as this measure gives the same weight for each year during the accumulation period, it fails to take into account the impact of portfolio size. As the size of the portfolio increases over the accumulation period, later years should be given a higher weight than earlier years, as the amount of assets at risk is rising. Obviously, one way of accounting for this portfolio-size effect is to take the amount of assets accumulated in each period and weight the equity exposure by the amount of assets accumulated (portfolio-weighted average). Unfortunately, this amount is random, and thus is only known *a posteriori*. However, in order to assess the likely impact of different investment strategies on retirement income risks, the investment strategies compared need to be selected in advance, *a priori*.

The analysis herein considers investment strategies with the same age-weighted exposure to equities. One approach, which takes into account the portfolio-size effect but does not require advance knowledge of the actual amount of assets accumulated in each period, is to weight the exposure to equities in each year by the age of the individual. In this way, equity exposures at later ages get a higher weight, replicating the effect of higher assets accumulated as individuals near retirement. The table below compares the different approaches discussed so far in order to calculate the average equity exposure for alternative investment strategies.[28] When using the time-weighted approach, the table below shows that a linear-decrease, life-cycle strategy starting with 100% invested in equities seems to have a higher average equity exposure than a fixed-portfolio strategy with 44% invested in equities; however, these two strategies have equal average-equity exposures when using the age-weighted approach. When considering the portfolio-weighted approach,[29] it appears that the linear-decrease strategy has a lower average-equity exposure than the fixed portfolio with 44% invested in equities; this result underscores the importance of the portfolio-size effect.[30] The remainder of this section focuses on the age-weighted approach.

Comparison of averaging methods used to calculate equity exposure

	Fixed portfolio	Linear decrease	Steep decrease	Fixed portfolio	Steep decrease
Initial equity exposure	44	100	52	60	71
Average equity exposure					
Time-weighted	44	51	46	60	63
Age-weighted	44	44	44	60	60
Portfolio-weighted[1]	44	30	39	60	53

Notes:

1. The portfolio-weighted average has been calculated by assuming 2% productivity, 2% inflation, 5% contribution rate, and 6% return.

Source: OECD Secretariat calculations.

Life-cycle investment strategies provide higher replacement rates than fixed portfolios

Finally, Table 7 presents estimates for the probability that life-cycle strategies provide higher retirement income than fixed portfolios (given the same age-weighted equity exposure) for different real-wage growth career paths and for people with uninterrupted working lives, as compared to people who suffer spells of unemployment. Looking at each row in Table 7 separately, it is clear that:

(1) Life-cycle strategies may provide higher replacement rates than fixed portfolios with the same age-weighted equity exposure; and

(2) Among the life-cycle strategies, the one with a sharp decrease in equities in the last decade just before retirement performs best, at least when the shock occurs within one or two years before retirement.

Negative shocks to equity markets in the last year or two before retirement are frequent enough that people could experience them with a 15% or 26% likelihood, respectively.[31] In addition, comparing the results across rows in the table, one can examine the impact of labour market risk in more detail.

This positive impact is enhanced in the case of individuals who suffer unemployment and have flat real-wage growth career paths

The positive impact of life-cycle strategies is enhanced in the case of individuals who suffer spells of unemployment and who also have flat real-wage growth career paths. Comparing rows 2 to 4 (in Table 7) indicates that: independent of the period in which the shock to equities occurs and independent of the average age-weighted equity exposure, the probability that life-cycle strategies provide higher retirement income than fixed portfolios is greater for individuals who have a flat real-wage growth career path. Moreover, comparing rows 2 and 5, one sees that this estimated probability is also higher for people who suffer spells of unemployment.

The positive impact of life-cycle strategies dwindles when shocks to equity markets occur further away from retirement age

The positive impact of life-cycle strategies dwindles as shocks to equity markets occur further from retirement age. Comparing panels 1 to 3 in Table 7 allows for an assessment of the likelihood that life-cycle strategies provide higher retirement income than fixed-portfolio strategies when a negative shock to equity markets (of 10% or more) occurs just before retirement, within two years, or within five years of retirement.[32] Indeed, Table 7 shows that this probability is lower as shocks to equity markets occur further from retirement age. Moreover, when negative shocks to equity markets occur at some point in the five years before retirement, life-cycle strategies start to lose their attractiveness in addressing the impact of negative shocks to equity markets. For example, if the negative shock were to happen at age 60, people with a fixed portfolio could have an opportunity to recover should returns to equities become positive in the remaining four years before retirement; with a life-cycle strategy, the automatic reduction in equity exposure reduces the chances for recovery.

A higher initial exposure to equities increases the likelihood that life-cycle strategies will provide higher retirement income relative to fixed-portfolio strategies

With life-cycle strategies, an increase in initial equity exposure increases the likelihood of providing higher retirement income relative to fixed-portfolio strategies, given the same average-equity exposure. We can examine the impact of higher initial-equity exposures in life-cycle strategies by comparing the columns in Table 7 that show 44% average age-weighted exposure to equities with those that show 60% exposure. For instance, let us compare the columns in the first panel of Table 7 (when the shock to equity markets occurs in the final year before retirement): when the average equity exposure is 60%, rather than 44%, there is an increase in the percentage of cases in which retirement income from a life-cycle strategy (with a sharp decrease in equity exposure after age 55) is higher than from a fixed portfolio; and these results are independent of labour-market risk (for example, see 77% as opposed to 75%, in the last row). This result may arise from the fact that higher average-equity exposure may lead to higher accumulated assets just before retirement; therefore, if the investment strategy fails to reduce the exposure to equities just before retirement, the impact of a negative shock in the equity markets is also higher.

Table 7. Estimated probability that pension benefits based on various life-cycle strategies will be higher than those based on a fixed-portfolio strategy (assuming negative shocks to the stock market[1])

	Shock within the last year			Shock within the last 2 years			Shock within the last 5 years		
Average exposure to equity[2]	44%		60%	44%		60%	44%		60%
	Linear decrease	Sharp decrease	Sharp decrease	Linear decrease	Sharp decrease	Sharp decrease	Linear decrease	Sharp decrease	Sharp decrease
	No human capital risk								
Fixed real wage growth	48.1	76.1	77.6	44.3	67.4	69.0	31.4	51.0	52.6
	Full career								
High real wage growth	41.1	74.4	75.8	38.0	65.5	67.0	26.5	48.7	50.4
Medium real wage growth	48.5	77.8	78.8	45.0	69.2	70.3	31.9	52.8	54.4
Low real wage growth	55.6	80.9	81.6	51.6	72.0	72.8	37.0	56.0	57.4
	Spells of unemployment								
High real wage growth	42.5	75.4	77.0	39.3	66.5	68.0	27.3	49.8	51.5

Notes: Calculations assume a contribution rate of 5% over a 40-year period.

1. The negative shock to equity markets is defined as an annual fall in the return to equities of 10% or more in the year just before retirement, in any of the two years before retirement, or in any of the five years before retirement.

2. Life-cycle portfolios are designed such that the age-weighted average exposure to equities during the accumulation period is equal to that of the fixed-portfolio exposure to equity. We consider two different average exposures to equities: 44% and 60%. In the first case, the fixed portfolio has 44% invested in equities and 56% in government bonds, while the linear decrease starts with 100% allocated in equities, and the steep decrease starts with an equity allocation of 52% which is kept constant until the age of 55, decreasing linearly to zero from there. In the second case, the fixed portfolio has 60% invested in equities and 40% in government bonds, while the steep decrease starts with an equity allocation of 71% that it is kept constant until the age of 55.

Source: OECD Secretariat calculations.

The length of the contribution period reinforces the positive impact of life-cycle investment strategies

Finally, the length of the contribution period reinforces the positive impact of relatively straightforward life-cycle strategies. Table 8 shows the likelihood that retirement income will be higher with life-cycle strategies than with a fixed portfolio of equal average-equity exposure, for different contribution periods (20 and 40 years).[33] The table indicates that the shorter the contribution period, the more likely that replacement rates will be higher using a life-cycle strategy than a fixed-portfolio. Longer investment periods allow for losses in some years to be offset by gains in other years. Moreover, historically there have been more years with positive returns to equity than negative returns; the mean for the distribution of returns from equity investment has been positive -- the longer the investment period, the higher the likelihood of having positive accumulated returns from equities.

Table 8. Estimated probability that pension benefits based on various life-cycle strategies will be higher than those based on a fixed-portfolio strategy for two different contribution periods (assuming a negative shock to the stock market[1])

	Entire random sample (10,000 obs)		Negative stock market shock (15%)[1]	
	Contribution period		Contribution period	
	20 years	40 years	20 years	40 years
Life-cycle investment strategies				
Linear decrease with age[2]	28.6	24.1	67.0	48.1
Sharp decrease after age 55[3]	34.7	35.2	77.9	76.1

Notes: Calculations assume a contribution rate of 5% over a 20- and a 40-year period. Life cycle portfolios are designed such that the average exposure to equities during the accumulation period (20 or 40 years) is equal to the fixed-portfolio average exposure to equities (44%). (1) The negative shock to the stock market is defined as an annual fall in equity markets of 10% or more in the year just before retirement. (2) The initial allocation is 100% to equities if 40 years, or 95% if 20 years of contribution. The allocation to equities falls inversely with age to equal 100% in bonds at the time of retirement. (3) The initial allocation of 52% or 60% to equities (depending on contributing for 40 or 20 years, respectively), is kept constant during the most of the accumulation period and decreases to zero only in the last 10 years before retirement.

Source: OECD Secretariat calculations.

V. Retirement Income in a World of Uncertainty under Different Macroeconomic Scenarios

This section examines the impact on retirement income of deflation and stagflation, which cause returns on equities and unemployment to worsen

This section examines the impact on retirement income of deflation or stagflation, as returns on equities and unemployment worsen. The discussion in this section is split between a scenario with low inflation and low growth (*deflation*), and another one with high inflation and low growth (*stagflation*). This section assesses the impact on retirement income derived from DC pension plans in a world of uncertainty, under these two scenarios. The starting assumption is that employment and wages are uncertain, as are returns on investment, inflation, discount rates and life expectancy. However, if the economy moves into deflation or stagflation, some aspect of uncertainty actually is reduced. That is, as the growth of the economy slows in both scenarios, the chances that an individual will suffer unemployment are much higher than assumed in the previous sections of this report. In addition, average return on equities also becomes lower under both scenarios. Finally, the analysis covers a 40-year accumulation period, but the duration of deflation or stagflation episodes is assumed to be no more than a decade.

Deflation and stagflation have a strong impact on the adequacy of retirement income

Deflation and stagflation have a strong impact on the adequacy of retirement income in a world of uncertainty. Table 9 shows median accumulated assets, median retirement income, and median replacement rates for each scenario. The impact of each scenario depends on whether stagflation or deflation occurs during the first decade of entry into the labour market (age 25 to 34), during the middle decade of the career (age 40 to 49), or during the last decade before retirement (age 55 to 64). A comparison of the data across rows shows that nominal retirement income, and the nominal value of assets accumulated, are both higher under stagflation than under the other two scenarios. Yet, this result reflects a type of monetary illusion, as inflation is much higher given a scenario of stagflation. Therefore, the replacement rate may provide a more accurate picture in this case. Focusing on the replacement rate, both deflation and stagflation lead to lower replacement rates.

The impact on retirement income of a decade of stagflation is higher than the impact of a decade of deflation

But the impact on retirement income of a decade of stagflation is higher than the impact of a decade of deflation. Looking again at median replacement rates across the rows, suggests that replacement rates fall further with stagflation than with deflation, independently of whether these scenarios occur early, in the middle, or at the end of one's career. Higher unemployment and lower returns to equities, which characterise both scenarios, explain the fall in median replacement rates. However, the high inflation scenario has a higher negative impact on relative retirement income because high inflation has a proportionately higher impact on final wages than on assets accumulated.

The impact of either deflation or stagflation is worse when they occur at the end of someone's career

Moreover, the impact of either deflation or stagflation is worse when they occur at the end of someone's career. A comparison of the three panels in Table 9 shows the impact of deflation or stagflation when they occur early, in the middle or late in an individual's career. When deflation or stagflation episodes occur early in an individual's career, median replacement rates can be 4 to 7 percentage points lower, respectively, than in the absence of such episodes. When deflation or stagflation occurs in the middle of one's career, replacement rates fall 8 to 17 percentage points, and as much as 9 to 22 percentage points when either scenario occurs in the last decade before retirement.

Table 9. The impact of different macroeconomic scenarios on retirement assets and income (with deflation or stagflation occurring at different periods prior to retirement)

	Early in their career			Middle of their career			End career		
	Assets accumu-lated	Retire-ment income	Replace-ment Rate	Assets accumu-lated	Retire-ment income	Replace-ment Rate	Assets accumu-lated	Retire-ment income	Replace-ment Rate
Full uncertainty[1]	2 401.1	174.6	36.3	2 401.1	174.6	36.3	2 401.1	174.6	36.3
Deflation	1 428.4	103.9	32.5	1 351.7	97.0	28.7	1 260.3	97.6	27.7
Stagflation	2 844.2	205.2	29.6	1 990.9	143.7	19.2	1 356.7	104.0	14.2

Notes: Calculations assume a contribution rate of 5% over a 40-year period. Assets are invested in a portfolio comprised of 60% equities and 40% government bonds. (1) This corresponds to the results presented in Table 2 above.

Source: OECD Secretariat calculations.

Policy should focus on individuals close to retirement if deflation or stagflation were likely to occur

Therefore, policy should focus on individuals close to retirement, if some of these negative economic scenarios were to occur. Earlier in this article, the results of the analysis supported the conclusion that employment policies should be concerned about the employment prospects of younger workers. The rationale is that unemployment spells early in an individual's career will result in a higher drop in retirement income than if unemployment were to occur later in the career, owing to the effects of compounded interest.

In this section, however, the analysis suggests instead that policy should focus on older workers, if either deflation or high inflation were to set in coupled with stagnant growth. Both scenarios would tend to increase unemployment, which again calls for employment policies that focus on younger workers. However, inasmuch as either scenario will also reduce the return on equities, the impact on unemployment is overshadowed by the portfolio-size effect (assets accumulated are higher the closer one is to retirement), suggesting that policy needs to focus on older workers as well.

The main policy recommendation for attenuating the impact of both deflation and stagflation would be to use life-cycle investment strategies as a default

The main policy recommendation for attenuating the impact of either deflation or stagflation is to use life-cycle investment strategies as a default. Implementing life-cycle strategies partially offsets the impact of deflation and stagflation, and the most effective life-cycle strategies maintain a high exposure to equities during the first decades of the accumulation period and reduce this sharply the decade just before retirement. Indeed, Table 10 below confirms this, in particular if the individual were to suffer deflation or stagflation in the decade before retirement, which is when his/her exposure to equities would be reduced. The last column of Table 10 shows that the life-cycle strategy would result in higher replacement rates than a fixed-portfolio strategy with the same age-weighted average equity exposure, in the case of deflation (33% against 28%), and of stagflation (17% against 14%).

Table 10. Replacement rates for fixed vs. life-cycle investment strategies under different economic scenarios (deflation and stagflation)

		Early in their career	Middle of their career	End career
Deflation				
	Fixed portfolio	32.5	28.7	27.7
	Life cycle	30.1	25.6	33.1
Stagflation				
	Fixed portfolio	29.6	19.2	14.2
	Life cycle	27.5	16.9	16.8

Notes: Calculations are based on a life-cycle strategy with 71% allocation to equities during the first three decades, falling sharply to 0% in the last decade before retirement, and a fixed-portfolio with 60% allocated to equities and 40% to government bonds. Both investment strategies have the same age-weighted average equity exposure (see box 2).

Source: OECD Secretariat calculations.

VI. Main Conclusions and Policy Recommendations

This article has assessed the impact of labour, financial and demographic risks on retirement income with the help of a stochastic model

This article has examined the impact of uncertainty on retirement income from DC pension plans -- uncertainty about employment and real-wage growth during one's career, as well as uncertainty about returns on investment, inflation, interest rates and life expectancy. To assess this, the article has modelled the probability of experiencing spells of unemployment and the probability of having different real-wage career paths, based on labour market data from OECD countries. This article has also modelled uncertainty about investment returns, inflation, interest rate, and life expectancy through stochastic processes using historical data since 1900. Moreover, the model has included positive correlations between economic conditions, employment prospects, and returns in the equity markets, as well as between inflation and government bond yields. As a result of 10 000 Monte Carlo simulations for each of those risks, the model provided probability distributions of pension assets accumulated, retirement income, and replacement rates. These distributions have permitted an assessment of the role of labour-market, financial-market and demographic risk, examining their interaction with different investment strategies, and determining the impact of both deflation and stagflation in a context of low growth.

Findings: the impact of these risks is far from negligible. Moreover, life-cycle strategies help attenuate the risk of sharp falls in retirement income when a negative shock occurs just before retirement.

The main conclusions reached through this analysis can be summarised as follows:

- The impact of uncertainty on retirement income is quite large. The uncertainty stems from these risk factors: employment conditions and real-wage career paths, as well as uncertainty about investment returns, inflation, discount rates, and life expectancy. The benefit-shortfall risk between a situation of certainty and one of uncertainty is well above 50%. That is, there is close to a 60% probability that replacement rates in a world of uncertainty will be below the replacement rates given no uncertainty. Moreover, replacement rates are not highly concentrated around the replacement rate that results from conditions with no uncertainty. Furthermore, replacement rates for worst-case situations, which occur with only a 1% or 5% probability, are extremely low. Finally, the dispersion of replacement rates around the median replacement rate is relatively high.

- When assessing the impact of labour-market risk, there is a need to complement the replacement rate with a standard measure, based on the total amount of retirement income an individual is entitled to receive. Use of the replacement rate alone can give misleading signals. For example, individuals who suffer spells of unemployment may wind up with higher replacement rates than those with uninterrupted earnings streams, despite having lower absolute retirement income. The same can happen when individuals switch to different real-wage career paths.

- The examination of the relative impact of each of the risks considered shows that labour-market risk (either regarding employment prospects or real-wage growth career paths), as well financial-market risk (uncertainty about returns on investment and inflation) have the largest impact on the adequacy of retirement income.

- The timing at which unemployment occurs in one's career affects retirement income. Those who suffer unemployment earlier in their careers will have lower retirement income than those who endure it at the end of their careers.

- It is unclear whether a fixed-portfolio or relatively straightforward life-cycle strategies perform better in terms of the probability distribution of replacement rates.

- Yet, regulators and policy makers should seriously consider implementing life-cycle strategies, at least as defaults. Life-cycle investment strategies have a positive impact on retirement income from DC pension plans when a negative shock to equity markets happens just before retirement (as occurred in 2008). In these same conditions, life-cycle strategies also provide higher replacement rates than fixed-portfolio strategies. Most effective are life-cycle strategies with constant exposure to equities during most of the accumulation period, but which reduce this exposure to zero during the last 10 years before retirement. This is due to the *portfolio-size effect*: the biggest impact of negative-market outcomes occurs at the end of the accumulation period because this is when accumulated balances are at their highest level.

- The length of the contribution period also matters when the main concern is replacement rates for people close to retirement should a negative shock to the stock market occur. The positive impact of life-cycle strategies on replacement rates for people close to retirement when a negative stock-market shock occurs is higher for shorter contribution periods than for longer contribution and accumulation periods.

- Additionally, for individuals who suffer spells of unemployment and/or flat real-wage career paths, default life-cycle strategies are particularly beneficial in attenuating the drop in retirement income that would result from a negative shock to equity markets just before retirement.

- The impact of stagflation or deflation is worse for people in the final stages of their careers than for people who are just beginning to work. The implementation of life-cycle investment strategies does help to attenuate the impact of both deflation and stagflation.

- Examining the timing of unemployment suggests that employment policies may need to concentrate on younger workers, as unemployment early in a career has the largest impact on retirement income. However, if either deflation or stagflation were to occur, policy may need to be concerned about older workers as well, because the portfolio-size effect and low investment returns in both of these scenarios overcome the impact of higher unemployment. Consequently, policies should focus on all age groups as their retirement income is at risk, although for different reasons. Again, implementing default life-cycle investment strategies would help to attenuate the impact of uncertainty on retirement income.

- To conclude, in order to protect and ensure adequate replacement rates from DC pension plans in a world of uncertainty, policy recommendations need to focus primarily on the amount of contributions and the length of the contribution period. Life-cycle investment strategies address the problem of lower replacement rates for people close to retirement when a negative stock market shock occurs, but whether they address the problem of volatility is less clear-cut, and they definitively do not address the problem of adequate replacement rates.

Finally, the main policy recommendation for policy makers and regulators is:

- First, establish a target replacement rate for DC pension plans, based on the overall structure of the existing pension system in the country.

- Then, set contributions and the length of the contribution period accordingly, keeping in mind that to reach adequate replacement rates people need to "contribute and contribute for long periods".

- And, afterwards, focus on asset-allocation strategies. In particular, if contribution periods are short or intermittent, or if there are concerns about replacement rates falling sharply for people close to retirement should a negative stock market occur, establish default life-cycle investment strategies that reduce exposure to equities in the last decade before retirement.

Notes

1. Antolin, P. (2010): "Private Pensions and the Financial Crisis: How to ensure adequate retirement income from defined contribution pension plans?" *Financial Market Trends,* Vol. 2009, No. 2, assessed the impact of these parameters on retirement income derived from DC pension plans, highlighting as well the volatility of retirement income from these pension plans.

2. Each of those random-generating processes has as first moments those of their historical distribution. Therefore, the basic statistical properties of each asset class, inflation, interest rates and life expectancy (mean, median and standard deviation) are based on historical data for 17 countries from 1900 until 2008, as provided by Credit Suisse [*Credit Suisse Global Investment Returns Yearbook* 2009].

3. Later on, this article relaxes this assumption by introducing life-cycle investment strategies.

4. Future work could include assessing the shortfall risk when using different payout arrangements. For example, an inflation-indexed life annuity where payments are indexed to inflation and are thus constant in real terms; a fixed programmed withdrawal where the assets accumulated at retirement are divided by the life expectancy at retirement; a variable programmed withdrawal, where payments vary according to capital gains of the remaining annual assets and life expectancy at each year in retirement; and, a combined arrangement mixing a variable programmed withdrawal and a deferred, inflation-indexed life annuity that starts paying at age 80.

5. The literature on displaced workers (Fallick, 1996; Chan, Sewin and Stevens, 2001*a*, *b*) finds that displaced workers are most likely to re-enter the labour market at lower wages than those they had previous to the displacement.

6. Economic theory suggests that nominal wages grow according to productivity gains and inflation. In practice, there are other factors to consider, for example, wage bargaining structures, market power and the level of unionization. The model used in this report assumes, in line with economic theory, that real-wage growth is determined only by productivity growth. And consequently, nominal wage growth results from real-wage or productivity growth and inflation growth.

7. Bosworth, B., G. Burtless, and C. E. Steuerle, (2000): "Lifetime Earnings Patterns, the Distribution of Future Social Security Benefits, and the Impact of Pension Reform", *Social Security Bulletin* 63(4): 74-98; Mitchell and Turner (2010), Chapter 5 in Antolin *et al.* (2010), *Evaluating the Financial Performance of Pension Funds*; and OECD (1998): *Employment Outlook*.

8. The model assumes low, medium, and high real-wage career paths (see Figure 1 above). It also uses the weighted average for the population (42% high, 55% medium and 3% low), as well as different probability ranges for each real-wage path determined by the variability of educational attainments and income levels across OECD countries.

9. The difference between assuming random inter-annual real-wage volatility, or not, lies in the shape of the distribution of retirement income. Assuming random inter-annual wages generates a distribution that is more flat (higher kurtosis), and that has shifted to the right (higher skewness). As a result, replacement rates at both ends of the distribution are more extreme. However, the main results in this article would remain unchanged.

10. When inflation and real-wage growth are positive during the time individuals' experience unemployment, nominal wages when re-entering employment are assumed to be the same as the last time the individuals were employed. However, when inflation and real-wage growth are negative, nominal wages when re-entering employment are adjusted downward, as well. Otherwise, being unemployed would be a positive wage factor when re-entering the workforce.

11. Taylor, M. and A. Booth (1996), "The changing picture of male unemployment in Britain", ESRC Research Centre on Micro-social Change, University of Essex; Dex, S. and A. McCulloch (1998), "The Reliability of Retrospective Unemployment History Data", *Work, Employment & Society*, Vol. 12, No. 3; and Schmillen, A. and J. Möller (2010), "Determinants of lifetime unemployment", IAB Discussion Paper 3/2010.

12. Bean, C. and J. Dreze (1990), *Europe's Unemployment Problem*, MIT Press, Cambridge, MAl Blanchard, O. (2005), "European unemployment: The evolution of facts and ideas", NBER 11750; Blanchard, O. and L. Summers (1986), "Hysteresis and the European Unemployment Problem", NBER Macroeconomics Annual 1, Stanley Fisher (editor), MIT Press, 15–78.

13. The unemployment rate is then modelled as a function of yesterday's unemployment, the age of the worker and a financial-market shock. This shock is assumed normally distributed, with mean zero and variance one. It is also correlated with the state of the economy, and as a result, with equity returns. The coefficients of the model on unemployment rates are the result of estimating this equation using OECD data based on unemployment rates and age groups for all OECD countries since 1960.

14. For individuals who suffer spells of unemployment just before reaching retirement age, the last wage is the one corresponding to the wage earned the last time they were employed.

15. The shock used to introduce random inter-annual real-wage volatility around the career path is also correlated with the economy, so that real wages grow more in good times than in bad times. Consequently, real wage growth and unemployment are inversely correlated, while real-wage growth and equity returns are positively correlated. The results herein are from a model without random inter-annual real wage volatility around the career real-wage path. The main conclusions remain valid regardless of whether one introduces random inter-annual real wage volatility.

16. The retirement income or replacement rate in a world of certainty is the one resulting from using the median values for each of the risk variables.

17. An example of a worst-case scenario could be an individual with six years of unemployment at the beginning of his/her career, flat real-wage growth, average returns on investment of only 2%, and inflation at 5%.

18. This target replacement rate is calculated using the median rate of return on investment, discount rate, inflation and life expectancy of the data-generating process in our model, without spells of unemployment and the weighted average of the three different real-wage growth paths.

19. The density given in Figure 1 multiplied by 100 provides the probability.

20. Our model of the economy assumes that around 55% of all individuals have a medium real-wage growth career path, 42% high and 3% low. Moreover, only 40% of all individuals within a cohort may ever suffer a spell of unemployment; the chance of being unemployed is equal to the economy-wide average unemployment rate.

21. These two annual average real-wage growth rates correspond to the real-wage growth paths defined in Figure 1 above.

22. The representative individual in the table is the individual with a high real-wage growth career path.

23. The replacement rates, total assets accumulated and final salary are the result of our stochastic model, based on 10,000 simulations using aggregate economy-wide unemployment rates and the cohort probability of suffering spells of unemployment, in order to determine who is unemployed and when.

24. The weights are 55% for medium real-wage growth, 42% for high and 3% for low.

25. The exercise in Table 6 assumes that spells of unemployment occur in two consecutive years at the beginning of a worker's career (ages 28 and 29), in the middle (ages 45 and 46) and close to the end (ages 59 and 60). Hence, the amount of unemployment is the same in all cases examined.

26. A world of uncertainty is defined as: when labour, financial and demographic risks are all taken into account in the determination of retirement income.

27. Assuming that equity allocation decreases linearly with age, the maximum age-weighted equity exposure possible when starting with an equity allocation of 100% at age 25, is 44% (see Table in Box 2).

28. The age-weighted average equity exposure is provided as the reference point; consequently, all investment strategies in the table have the same age-weighted average equity exposure. The first panel is based on an average equity exposure of 44% in order to be able to include the linear-decrease life-cycle approach, while the second panel has a higher age-weighted average equity exposure of 60%.

29. This is done hypothetically by assuming fixed productivity growth of 2%, fixed inflation of 2%, a 5% contribution rate and a fixed portfolio return of 6%.

30. If the average equity exposure of different investment strategies were to be calculated by weighting according to the amount of assets accumulated in each period of the accumulation process, which is possible only with hindsight, the equity exposure of the life-cycle strategy in the early years would have to be higher in order to equal the average equity exposure of a fixed portfolio.

31. The model in this report suggests that around 15% of people could suffer a negative shock to equity markets of 10% or more in the year before their retirement, 26% in the two-year period before retirement, and 55% in the five-year period before retirement. Actual US and UK data on equity returns show that between 16% (UK) and 17% (US) of the last 109 years, there has been a negative shock to equity markets of 10% or more; among five-year periods, 57% of the time in the UK and 64% in the US there has been at least one year with a negative shock to equity markets of 10% or more.

32. It is important to stress that the likelihood of someone experiencing such a negative shock to equity markets is 15%, 26%, and 55%, corresponding to one, two or within five years before retirement, respectively.

33. Setting fixed contribution periods means that the results in Table 8 are based on full employment over one's career. The results in the table are also based on assuming a constant real-wage growth during one's career (in this case 2%). Therefore, Table 8 does not include labour-market risk -- only financial and demographic risks.