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The Impact of Human Capital on Life-Cycle Portfolio Choice

Evidence for the Netherlands

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The Impact of Human Capital on Life-Cycle Portfolio Choice: Evidence for the Netherlands*

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Abstract: We study the impact of human capital on life-cycle portfolio choice using Dutch data. A distinction is made between the *riskless* view of human capital as having bond-like characteristics, and the *risky* conception of future wage income having stock-like properties. As in Benzoni, Collin-Dufresne, and Goldstein (2007) we study the welfare implications of portfolio choice when wage income and dividends are co-integrated. Based on Dutch data our analysis confirms the US results as the preferred equity allocation also shows a hump-shaped pattern.

Keywords: life-cycle investment, human capital, wage profiles, co-integration, vector error correction model, dynamic portfolio choice

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1 Introduction

The question of optimal life-cycle investment has received substantial attention in the academic literature. In the standard version of life-cycle investment it is originally assumed that human capital, which is defined as the discounted value of future labor income, can be seen as a risk-free asset (see e.g. Samuelson (1969), Merton (1971), Bodie, Merton and Samuelson (1992) and Campbell and Viceira (2002)). As a consequence, the optimal portfolio allocation over the life-cycle should be high in stocks in the beginning of the agent's career and declining afterwards. Since the agent has implicit holdings of human capital in his portfolio he should tilt his financial portfolio towards stocks so that his total dollar holdings of each asset equal the optimal holdings. The economic intuition is that early in life the fraction of human capital is high compared to the fraction of financial wealth. Young agents are less dependent on financial wealth for consumption since they have labor income as alternative income source. It is therefore affordable for them to take more risk with financial wealth then elderly agents who almost entirely depend on this type of wealth for their consumption. Based on this theory a common advice financial planners give to their clients is to invest in stocks according to the *100 minus age* rule (see e.g. Malkiel (1990)).

Recently several papers appeared in the academic literature stating that human capital ought to be seen as risky, even with stock-like properties (see e.g. Cocco, Gomez and Maenhout (2005) and Benzoni *et al.* (2007)). Empirical evidence shows that risky asset holdings over the life-cycle typically are 'hump-shaped': young agents progressively increase the stock holdings as they age, and decrease their exposure when retirement is approached. This is also referred to as the 'limited stock market participation' puzzle (see e.g. Ameriks and Zeldes (2004) and Campbell (2006)). This pattern contrasts with the common knowledge that young agents should place most of their savings in stocks and switch their holdings to bonds as they age. The Cocco *et al.* (2005) and Benzoni *et al.* (2007) studies raise doubts about the way of handling human capital as an implicit investment in the riskless asset. They tend to treat the risk profile of human capital as having stock-like properties. For example, Benzoni *et al.* (2007) show that a young agent will find himself overexposed to market risk in which case it will even be optimal for him to take a short position in the market portfolio. Hence, in the academic literature we can roughly classify the way of thinking about the nature of human capital in two groups. The group where it is assumed that human capital is riskless will be denoted by the *riskless view* on human capital. The group where this assumption is challenged will be denoted by the *risky view* on human capital. In order to study the welfare implications of different asset allocations over the life-cycle we model labor income following Benzoni *et al.* (2007) in which labor income and dividends are co-integrated. In this paper we specify the co-integration relation by means of a vector error correction model contrary to the, a priori assumed, mean-reversion way of modeling in Benzoni *et al.* (2007). For Dutch data we first test for co-integration before actually estimating any model, which makes our approach statistically more founded. Further, with our approach we do not have to assume that stock return volatility equals dividend growth rate volatility.

We find that the optimal asset allocation does not decrease with the age of the individual, but rather shows a hump-shaped pattern over the life-cycle as described earlier in the introduction. For countries in Continental Europe we observe increasing wage profiles while for Anglo-Saxon countries these profiles are hump shaped. This strengthens the argument for a hump-shaped asset allocation in

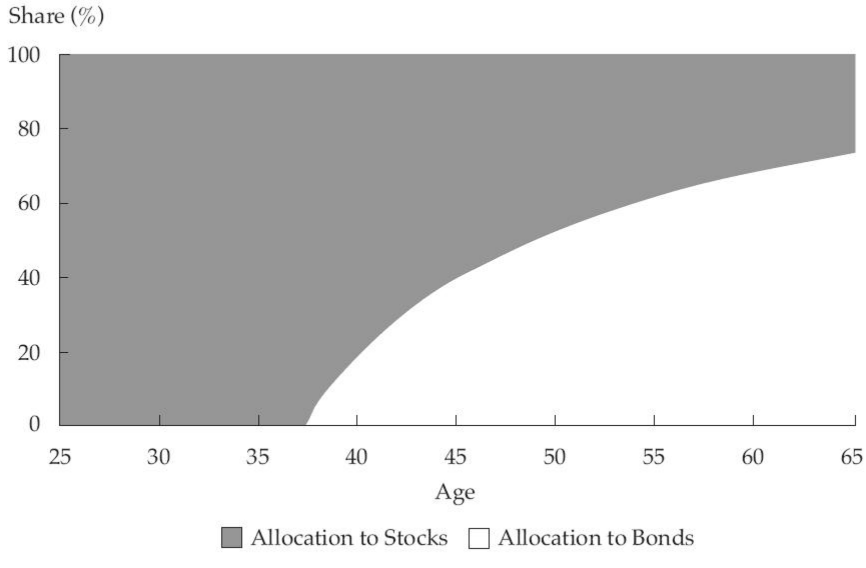
Continental Europe. As human capital declines at a lower rate during the final years before retirement, the implicit bond holding will be relatively high during those final years, which causes the investor to hold a lower fraction in the risky asset early in the career and a higher fraction in the later part of the career. As the agent ages the process of co-integration has less time to act which means that labor income becomes less risky, and hence acquires more bond-like (i.e. riskless) properties.

Our main conclusions can be summarized as follows. Using Dutch data the hump-shaped allocation performs better compared to more traditional allocations such as the *100 minus age* allocation. This confirms the findings of Benzoni *et al.* (2007). An additional element for a hump-shaped asset allocation is that the allocation profile serves as a minimum regret portfolio against extreme market conditions. The remainder of this paper is organized as follows. In Section 2 we discuss the two views in the academic literature on life-cycle investment, emphasizing the underlying assumptions about the characteristics of human capital. The results are discussed in Section 3. Finally, Section 4 concludes.

2 Life Cycle Theory and Human Capital Risk

Roughly speaking we can extract two views on human capital from the academic literature. The more *riskless view* as we will call it here means that human capital acts like a risk-free asset and hence can be treated as though the agent has an implicit holding in this asset[1]. Papers which study this kind of human capital are Merton (1971), Bodie *et al.*(1992), Heaton and Lucas (1997), Jaganathan and Kocherlacota (1998), Campbell and Viceira (2002), and Viceira (2008). A survey of recent academic literature on financial planning over the life-cycle can be found in Bovenberg, Koijen, Nijman, and Teulings (2007).

Figure 1: Fraction of financial wealth invested in stocks and bonds over the life-cycle when human capital is riskless. Source: Ibbotson, Milevsky and Zhu (2007)



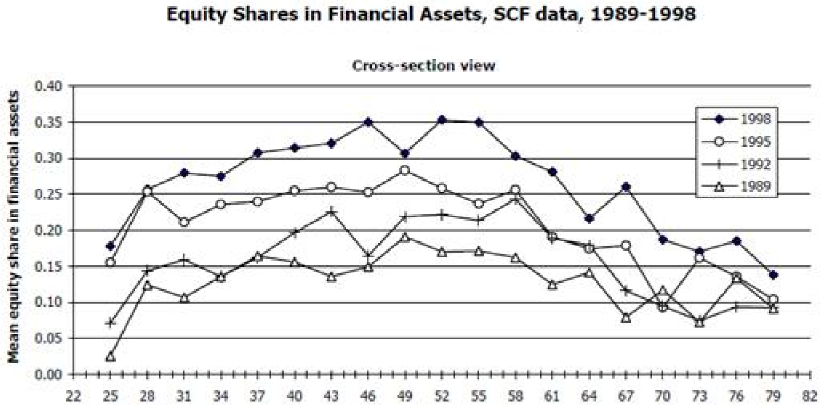
The main conclusion of the riskless view is that the optimal portfolio holdings in the risky asset will

[1]We assume the existence of a riskless asset and in our analysis we will take the bond for that purpose.

generally be high early in the agent's working life and declines when the agent ages. Figure 1 displays the portfolio holdings over the life-cycle under the assumption of riskless human capital.The more recently developed view about the risk profile of human capital, which we will denote by *risky view*, challenges the assumption about human capital being risk less. Instead, different ways of modeling are presented in which the risky nature of human capital is reflected. Papers which study the effect of labor income risk on portfolio choice are Viceira (2001), Cocco *et al.* (2005), and Benzoni *et al.* (2007). The main conclusion of the risky view is that modeling human capital as having stock-like properties results in a lower or even negative fraction of financial wealth invested in stocks early in working life. As the agent ages this fraction becomes positive and increases until the age of 55 (cf. Benzoni *et al.* (2007)). As he approaches retirement the fraction in stocks will decline to the level it was before (see Section 2.1).

The resulting 'hump-shaped' allocation to stocks over the life-cycle is in line with empirical evidence. Ameriks and Zeldes (2004) and Campbell (2006) show that investors have low holdings in stocks when they are young. They increase the holdings as they age. The maximum allocation to stocks is reached when the participants are between 50 and 60 years old (see also Figure 2).

Figure 2: Equity Shares in Financial Assets, 1989-1998. Source: Ameriks and Zeldes (2004)



An important determinant in modeling household portfolio holdings, which we will not consider here, is the influence of housing on portfolio holdings. Papers which study these effects are Cocco (2005), Hu (2005), and Yao and Zhang (2004). The main result is that home-ownership crowds out stock market participation. Investment in risky housing substitutes for risky stocks, thereby partially helping to resolve the limited stock market participation puzzle[2].

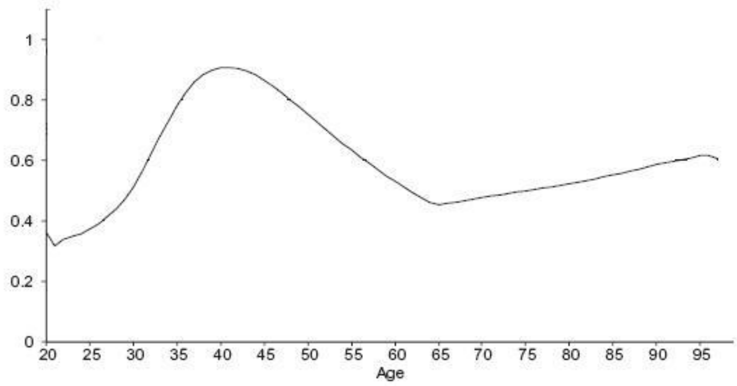
2.1 Two Ways of Modeling Risky Labor Income

Papers in which micro data is used to calibrate the individual labor income process are e.g. Viceira (2001), Campbell and Viceira (2002) and Cocco *et al.* (2005). These papers have in common that only unrealistically high correlations between shocks to labor income and stock returns can produce hump-shaped patterns in which young agents hold low risky asset holdings. However, Cocco *et al.*

[2]Another non-tradable asset which might have similar risk characteristics is privately owned business.

(2005) also allow for disastrous labor income shocks which means that the agent receives zero labor income with positive probability. Their study demonstrates that labor income risk actually has a minor effect on portfolio holdings while the empirical evidence on the value of the contemporaneous correlation between labor income innovations and stock returns is mixed. Cocco *et al.* (2005) also show that allowing for disastrous labor income shocks substantially lowers the average allocation to risky assets. Incorporating disastrous labor income shocks when modeling human capital therefore seems to be quite important in explaining data. Figure 3 displays the portfolio holding in the risky asset when incorporating such shocks. Considering all the extensions they investigated, the empirically

Figure 3: Fraction of financial wealth invested in stocks with a 0.5% probability of a zero-income realization. Source: Cocco *et al.* (2005)



calibrated probability of a disastrous labor income shock seems to work best[3].

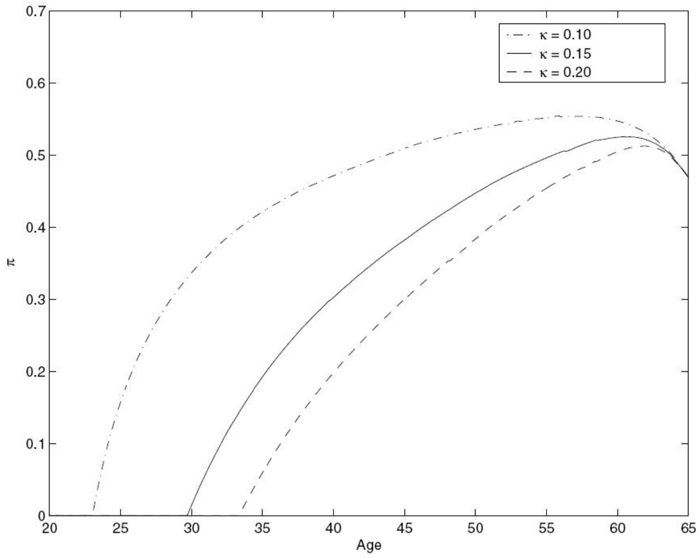
The above mentioned studies on stochastic labor income show that only unrealistically high contemporaneous correlations between labor income shocks and stock returns or including the possibility of a disastrous labor income shock can explain the level of risky asset holdings for young agents. Heaton and Lucas (1997) find a median correlation of 0.02, while Viceira (2001) shows that even if the contemporaneous correlation equals 0.25 the effect on optimal allocation is only small. These models also specify long-run correlations between stock market returns and human capital to be low or zero. This is a point of debate since it seems plausible to conjecture that a long period of high economic growth will be reflected by a strong stock and labor market performance in the long-run. Along these lines Benzoni *et al.* (2007) find evidence that aggregate labor income and dividends are co-integrated[4]. Their specification is in line with the empirical observation of low contemporaneous correlations between market returns and changes to aggregate labor income, but allows for a significantly higher long horizon correlation between human capital returns and dividends. In contrast to common thinking the results show that it is optimal for young agents to take a substantial short position in the risky

[3] For further details we refer to Cocco *et al.* (2005).

[4] Other studies which model along these lines are Baxter and Jerman (1997), Lettau and Ludvigson (2001) and Santos and Veronezi (2006).

asset, or at least do not participate in the stock market. In fact, the results display a hump-shaped pattern which is similar to the results when allowing for disastrous labor income shocks.

Figure 4: Life-cycle profile of stock holdings. Source: Benzoni *et al.* (2007)



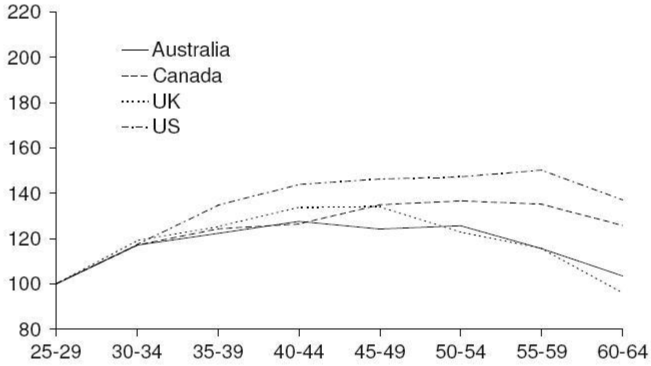
The authors' interpretation can be summarized as follows. Due to the co-integration between human capital and dividends, there exists long-horizon correlation between human capital returns and market returns. The level of exposure is controlled for by the mean-reversion coefficient κ. A large value indicates a high rate of mean-reversion, which means that there exists a strong relation between the two variables. This strong relation indicates a high level of long-term correlation. If the agent's remaining employment is larger then $\frac{1}{\kappa}$, in other words, if the agent is young his human capital is highly correlated with market returns, i.e. human capital has stock-like properties. Moreover, a young agent's total wealth mainly consists of human capital. Consequently, due to this long-run labor income risk the agent implicitly holds a large position in the risky asset. To offset his exposure to the risky asset, he will place (a large fraction of) his financial wealth in the riskless bond. However, as the agent ages the process of co-integration (i.e. *long-run* labor income risk) has less time to act, which means that labor income becomes less risky, and acquires more bond-like properties. Therefore, the fraction of financial wealth invested in the risky asset will have to increase to offset the larger implicit holding in the bond. Finally, as the agent approaches retirement two opposing effects are at work. First, we have that the process of co-integration has less time to act due to the agent getting older, as explained above. Second, because the agent reaches retirement his amount of human capital reaches zero. This means that the implicit bond position in his portfolio declines. This second effect will eventually become more important which causes the agent to reduce his holding in the risky asset to buy more bonds. In other words, co-integration makes human capital a close substitute for stocks, especially for younger agents which have long investment horizons. Hence, young agents invest less in stocks then older agents do. Figure 4 shows the results for different values of κ. For further details we refer to Benzoni *et al.* (2007)[5].

[5] Note that Cocco *et al.* (2005) models the entire life-cycle of the agent whereas Benzoni *et al.* (2007) only models

2.2 Wage Profiles

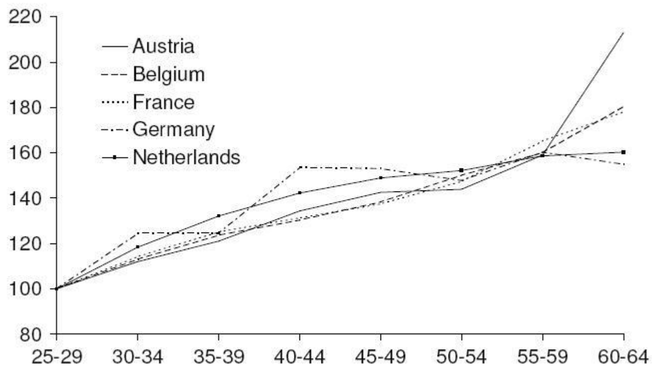
In this paper we discuss and compare results from Cocco *et al.* (2005) and Benzoni *et al.* (2007). We stress that the results as stated in those studies are obtained using hump-shaped wage profiles. These profiles are typically found in Anglo-Saxon countries (see Figure 5).

Figure 5: Wage profile by age for Anglo-Saxon countries. Source: Euwals, De Mooij, and Van Vuuren (2009)



Wage profiles in Continental Europe generally do not decline as retirement approaches. In the Netherlands for example we observe an increasing pattern (see Figure 6). We refer to Euwals, De Mooij, and Van Vuuren (2009) for more details. As we will use Dutch data to estimate our model this might have impact on the optimal life-cycle investment profile. Intuitively, the character of the wage profile, either hump-shaped or increasing, will influence the optimal asset allocation over the life-cycle as the relative size of human capital in total wealth differs per age.

Figure 6: Wage profile by age for Continental Europe. Source: Euwals *et al.* (2009)



For Continental European countries human capital will thus decline at a lower rate than in Anglo-Saxon countries. This means that the agent's implicit bond holding will be higher during those final years. This might cause the investor to hold larger fractions in the risky asset compared to the Benzoni

the agent's working life.

et al. (2007) results. Although we use the same way of modeling labor income risk, the results for e.g. the Netherlands could therefore be different from the US for the specific reason that the wage profile for Dutch employees behaves differently over the life-cycle.

3 Simulation Results

In this Section we analyze the welfare implications at the end of a person's working life for various life-cycle portfolios based on the two different views of human capital. We compare these results with the ones based on allocations in typical Anglo-Saxon and Continental European pension funds.

3.1 Portfolio allocations

The analysis is based on the following 5 stylized allocations:

1. *Anglo-Saxon*: Default 80% risky assets which is commonly used in Anglo-Saxon countries.
2. *Continental Europe*: Default 20% risky assets which is commonly used in Continental Europe.
3. *Life-cycle*: Traditional life-cycle theory allocation is based on the *100 minus age* rule of thumb (see e.g. Malkiel (1990)).
4. *Contrarian*: Several authors challenge the optimality of the standard life-cycle strategies. Shiller (2005) compares various strategies besides the traditional life-cycle and concludes that the results are disappointing for the life-cycle strategies. The stylized allocation is inspired by the naïve alternative strategies in Basu and Drew (2009) which allocate contrary to the traditional life-cycle theory. They use these strategies to test the hypothesis that the size of the portfolio should be taken into account when making asset allocation decisions.
5. *Hump-shaped*: Hump-shaped allocation which is based on Cocco *et al.* (2005) and Benzoni *et al.* (2007) with a zero allocation to risky assets early in the career (see Figures 3 and 4).

The stylized allocations are depicted in Figure 7.

In the Appendix we describe the models which have been used to generate the sample paths for the excess stock returns, labor income and dividends. We also describe the wealth characteristics as well as the utility function,which has been used to analyze the welfare implications.

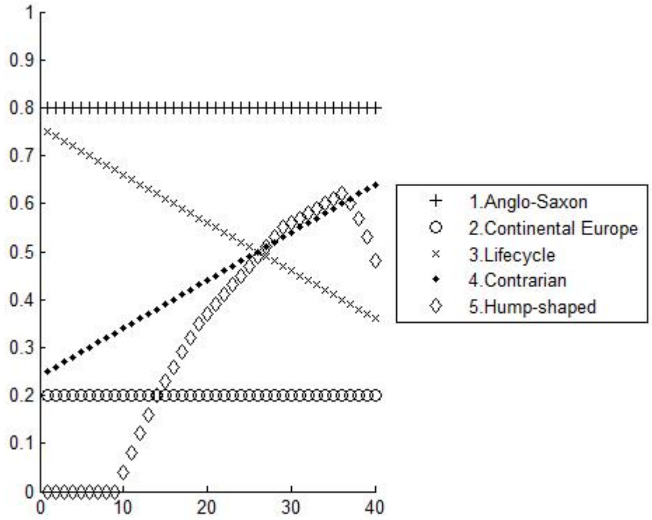
3.2 General results

Table 1 shows that for the benchmark case[6] it holds that the *Hump-shaped* allocation has the highest utility. This result confirms the findings of recent studies which challenge the assumption of human capital being riskless.

The hump-shaped allocation never performs really good or bad in more or less favorable market conditions. We can thus interpret this allocation as a *minimum regret* portfolio as this is the allocation that the agent would regret the least. Although the hump-shaped portfolio only performs best

[6]The benchmark settings are described in Appendix A-3

Figure 7: Allocation to risky assets.



in the benchmark case, it prevents the agent from bad performance in extreme market situations. We observe that in good market conditions (e.g. $\mu = 0.1$ or $\sigma = 0.05$) the *Contrarian* allocation has a slightly higher utility than the hump-shaped allocation. This is in line with the findings of Shiller (2005) and Basu and Drew (2009), as they find that portfolios which are either contrary to common life-cycle strategies (Basu and Drew (2009)) or always fully invested in stocks (Shiller (2005))result in a much higher expected final wealth. Both papers explain this by looking at the accumulation paths of wealth over the simulation period. They both argue that as these paths steepen when they move along the horizon, potential for fast growth of wealth comes only in the later years. If the agent encounters however successive years of bad returns at the end of his working life, this will produce severe results for the agent who employs a high equity allocation (see e.g. Ambachtsheer (2009)).

Finally we have also analyzed the results in rather extreme market conditions as well as for other degrees of risk aversion. The *Continental Europe* and *Anglo-Saxon* allocations result in the highest and the lowest utility, in line with one might expect. For example, if a person is very risk averse (i.e. $\gamma = 10$) the *Continental Europe* allocation performs best as this portfolio has the smallest (i.e. 20%) allocation to the risky asset. If market conditions are good (i.e. $\mu = 0.1$ or $\sigma = 0.05$) the *Anglo-Saxon* allocation performs best as this is the allocation with the largest (i.e. 80%) position to the risky asset.

4 Concluding Remarks

Nowadays financial planners often recommend individuals to use a simple rule of thumb when investing over the life-cycle: *100 minus age* percent should be invested in the risky asset. This rule is justified by the life-cycle theory in which the key assumption about human capital states that the expected present value of future labor income is risk-free. Hence, in the beginning of his career the agent has a large implicit position in the risk-free asset. To compensate for this he should place a large fraction of

Table 1: Simulation results for Netherlands.

The Table shows the utility at the end of the working life. The utility for the hump-shaped allocation is normalized to one in all settings to facilitate interpretation. Note that this allocation does not perform worst in any of the situations, and can thus be seen as a hedge to extreme market conditions. Numbers which are marked with a * indicate the preferred allocation under the stated circumstance.

	benchmark	$\gamma = 10$	$\gamma = 2$	$\mu = 0.1$	$\mu = 0.01$	$\sigma = 0.4$	$\sigma = 0.05$
Anglo-Saxon	0.9611	0.7294	1.0048*	1.0490*	0.9217	0.7408	1.0535*
Continental Europe	0.9870	1.0764*	0.9898	0.9006	1.0320*	1.0877*	0.9445
Life-cycle	0.9987	1.0623	0.9954	0.9538	1.0210	1.0602	0.9721
Contrarian	0.9922	0.9426	1.0007	1.0069	0.9847	0.9526	1.0089
Hump-shaped	1.0000*	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

his financial wealth in the risky asset. As the agent ages his human capital declines which also declines the implicit bond position, meaning he should reduce his position to the risky asset and buy more bonds. The life-cycle asset mix has been challenged by the view that allocation to risky assets over the life-cycle should be hump-shaped of nature instead of declining. Recent evidence supports this claim (see e.g. Ameriks and Zeldes (2004)). The main explanation for the hump-shaped equity allocation pattern is that the long-term risk profile of human capital has stock-like features. This is reflected in low equity holdings early in career to compensate for the already high exposure to stock-like risk via human capital. The case for hump-shapes allocations is stronger in Continental Europe than in Anglo-Saxon countries as the wage profiles differ across these countries. Continental Europe typically has increasing wage-profiles over the career whereas Anglo-Saxon countries show up hump-shaped wage-profiles. Differences in wage-profiles lead to differences in size and decay of human capital over the career. As human capital in Continental European countries declines at a lower rate during the final years before retirement, one may expect that agent's implicit bond holding to be higher at the end of the career than in Anglo-Saxon countries.

To clarify the overall picture we summarize our main conclusions:

- The hump-shaped allocation performs better compared to more traditional allocations such as the *100 minus age* allocation.
- The hump-shaped allocation serves as a minimum regret portfolio against extreme market conditions.

It is clear that this area of research has to be exploited in several directions in the coming years. The world of pensions is a dynamic system. The plan structure has to be adapted constantly in order to fulfil the desires of the plans' participants and to ensure a financially stable system at the same time. We suggest further research on the impact of different wage profiles, social security systems and the use of dynamic optimization on the optimal asset allocation over the life cycle. As the current analysis is restricted to the accumulation phase, it would also be interesting to include the retirement phase into the analysis.

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Appendix

A-1 Model Specification

In this Section we present the model we will use for our analysis. We use the approach in Benzoni *et al.* (2007). In our paper we will however specify the long term relation between labor income and dividends / stock market by means of a vector error correction model instead of the mean-reversion way of modeling in Benzoni *et al.* (2007). Our approach is statistically more founded, as we first test for existence of the long-term relation before actually implementing this relation. In contrast, in the Benzoni paper they capture the co-integration relation by assuming a priori that the long term relation between labor income and dividends is a mean-reverting process.

A-1.1 Co-integration

Let aggregate labor income by denoted by L_t and define $l_t = \ln[L_t]$. The logarithm of dividends is defined as d_t. In order to capture the feature that contemporaneous correlations between dividends and aggregate labor income shocks are low, but that long-term correlations between these variables might be significantly higher, we model these variables using a vector error correction mechanism. In time series analysis, the finding that some linear combination of two individually non-stationary, $I(1)$ series itself is a stationary variable, $I(0)$, is denoted by *co-integration*. In our analysis it seems plausible to conjecture that at long horizons, labor income growth and stock market returns are likely to move together in a similar way. The stationary linear combination, $l_t - \beta d_t$, called the *co-integrating equation*, means that the two variables share a common trend. This can be interpreted as a long-run equilibrium relationship among the variables[7]. In order to model the co-integrating relation $y_t = l_t - \beta d_t$ we construct a vector error correction model (VECM). Such a model describes how the two series behave in the short-run consistent with a long-run co-integrating relationship. Estimation of the VECM consists of three steps: First we have to test whether our data is non-stationary. Second we test whether there exists co-integration between the series. The third step consists of estimating the error correction model using the estimated co-integration vector from step two.

Assuming that there exists a co-integrating equation, the VECM is given by:

$$\begin{aligned} \triangle l_{t+1} &= \alpha_1 + \gamma_1(l_t - a - bd_t) + \beta_{11}\triangle l_t + \beta_{12}\triangle d_t + \epsilon_{1t+1} \\ \triangle d_{t+1} &= \alpha_2 + \gamma_2(l_t - a - bd_t) + \beta_{21}\triangle l_t + \beta_{22}\triangle d_t + \epsilon_{2t+1} \end{aligned} \tag{A-1}$$

The second term denotes the error correction term which ensures that if l_t and d_t deviate from the long-run equilibrium, this term will correct the series through a number of partial adjustments. The parameters $\gamma_i, i = 1, 2$ measure the speed of adjustment towards the equilibrium.

A-1.2 Financial market

To keep the analysis simple we assume that the financial market contains only two assets in which the agent can invest, a risky stock and a riskless bond. The riskless bond has a constant return $\bar{R_f}$.

[7]For a more elaborate discussion on co-integration and vector error correction models we refer to Hamilton (1994).

The risky stock has return R_t, and its excess return, defined as $R_t^e = R_t - \bar{R}_f$, is given by:

$$R_t^e = \mu + \eta_t \tag{A-2}$$

where $\eta_t \sim N(0, \sigma_\eta^2)$ i.i.d.

A-1.3 Agent's preferences

At each date $t \in [0, 40]$ the agent has to decide how much of his wealth to consume (c_t) and how to invest (x_t) the remaining wealth between stocks and bonds. Next period wealth is then given by:

$$W_{t+1} = L_{t+1} + (1 - c_t)W_t(x_t R_{t+1}^e + \bar{R}_f) \tag{A-3}$$

The power utility function is defined by

$$u(W) = \frac{W^{1-\gamma}}{1-\gamma} \tag{A-4}$$

with $u(W) = \ln[W]$ for $\gamma = 1$.

A-2 Estimation Results

We study yearly dividends (d_t) and excess returns on the MSCI Netherlands (R_t^e) from 1969 through 2008. Data is taken from Datastream. To construct a proxy for aggregate labor income, l_t, we use Dutch collective labor agreement index rates taken from CBS (Statistics Netherlands). Table A-1 presents descriptive statistics.

Table A-1: Summary statistics.

	$\triangle l$	$\triangle d$	R^e
mean	0.041	0.060	0.048
StdDev	0.036	0.065	0.224

We use the VECM model in (A-1) augmented with a deterministic trend motivated by research done by Arpaia, Prez and Pichelmann (2009). They show that the labor income share has declined from 1975 to 2005 for many European countries including the Netherlands, which suggests a negative trend coefficient. Therefore, we test for the presence of a deterministic time trend and, if necessary, include this trend in our VECM specification. The Johansen test results are in line with the findings of Arpaia *et al.* (2009) that the labor income share has declined from 1975 to 2005. The test rejects the null hypothesis of no co-integration between labor income and dividends and shows a positive and significant trend coefficient. This means that the term $l_t - a - bd_t$ in (A-1) will be adjusted by including a trend to $l_t - a - bd_t - ct$. The results for the various tests can be found in Minderhoud (2009).

Estimation results are presented in Table A-2. Apparently, including a time trend is of significant importance. This could be due to the fact that the deterministic trend helps explaining the decrease in the labor income share from the past years. Although the trend coefficient is rather small, it is significant and enhances economic interpretation. The exposures to the error correction term (i.e. γ_1 and γ_2 in (A-1)) are significant.

Table A-2: VECM estimates.

Table A reports the results for the long term equilibrium relation (i.e. EC_t). Table B shows the results for the VECM model (A-1) (t-statistics are given in brackets).

Table A

	l_t	*constant*	d_t	t
	1.000	-8.037	-1.423	0.062
			$[-3.09]$	[2.15]

Table B

	constant	EC_{t-1}	$\triangle l_{t-1}$	$\triangle d_{t-1}$
$\triangle l_t$	0.006	-0.041	0.800	0.010
	[1.34]	$[-3.68]$	[11.69]	[0.27]
$\triangle d_t$	0.057	0.107	-0.256	0.250
	[2.86]	[2.21]	$[-0.87]$	[1.56]

A-3 Simulations

For the benchmark case the riskless bond return $\bar{R_f}$, the mean excess return μ and the volatility σ_η in (A-2) are equal to 0.02, 0.04 and 0.22, respectively. The key parameter in the power utility function, the risk aversion parameter γ is set at 5. These values are in line with Bovenberg *et al.* (2007).

We simulate 100.000 sample paths each with a length of 40 years for the excess stocks returns, labor income and dividends. Firstly, the VECM estimates are used as input for simulating labor income and dividends by using (A-1). Next, we simulate excess returns by using (A-2). In order to simulate wealth dynamics we set the consumption level at a constant 50% per year[8]. Since we want to compare different asset allocations we can hold consumption constant in all simulations. Wealth dynamics are simulated by using (A-3). Finally the utility is derived using (A-4).

[8]Other levels of consumption will give similar results.