The equity premium puzzle: new evidence on the optimal holding period and optimal asset allocation

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Abstract

Purpose – The purpose of this paper is to report new original evidence on optimal holding periods and optimal asset allocations (Benartzi and Thaler, 1995).

Design/methodology/approach – The authors employ a number of different value functions, a recent dataset, different markets, and varying investment horizons.

Findings – The authors report original evidence across markets and over-time, employing different value functions and varying investment horizons. The results results indicate that, during the past decades, the optimal holding period (seven months during the whole period and four/five months during crises) is not affected by the value function employed, is in accordance with the Myopic Loss Aversion hypothesis, is consistent across markets, but is sensitive to economic crises and shorter to that reported in Benartzi and Thaler (12 months). The optimal asset allocation is also different to that of Benartzi and Thaler during crises periods and/or assuming value functions with probability distortion.

Originality/value – The paper employs a number of different value functions, with and without probability distortion; it compares investor behavior in three important international markets (USA, UK, Germany); as a further robustness test the authors use various investment horizons.

Keywords Equity premium puzzle, Probability distortion, Prospect theory

Paper type Research paper

1. Introduction

One of the most interesting puzzles in financial economics is the equity premium puzzle, i.e. the observation that equity returns during the past century tend to be higher that bond returns. Many studies suggest that the premium is about 6 percent (Mehra and Prescott, 1985). The puzzle lies with the fact that the premium is so large that it cannot be explained by investor risk aversion. As discussed in Benartzi and Thaler (1995) a relative risk aversion coefficient of over 30 could explain the puzzle; however, theoretical and empirical estimates indicate that the coefficient is around 2. In other words, there is not a reasonable risk aversion parameter that can explain the puzzle (see also, Siegel, 1999). Benartzi and Thaler (1995) attempt to explain the puzzle employing prospect theory (PT) and the notion of myopic loss aversion (MLA). They separate the planning horizon (investment horizon) and the evaluation period (how frequently an investment is evaluated). For example, an investor with a long investment horizon and a three-month evaluation period will behave more as if she had an investment horizon of three months, rather than a long-term investor. They show that the magnitude of the equity premium is consistent with PT, if investors evaluate their portfolios annually.

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In this paper we report new original evidence on the optimal evaluation period (i.e. the period for which investors are indifferent between stocks or bonds) and the optimal asset allocation (i.e. the combination of stocks and bonds that maximizes utility). Our results are robust to various specifications of the value function, various investment horizons and across markets. More specifically, the paper contributes to the relevant literature in a number of ways. First, for the empirical analysis we employ a number of different value functions in order to examine whether the functional form is important for the robustness of the results. Benartzi and Thaler (1995) point out that the value and weighting functions are not as important as loss aversion; for instance, they argue, replacing objective probabilities with non-linear probability weights are not critical and should not alter the results (p. 83). In order to empirically evaluate this argument we employ three different value functions: the linear piecewise value function, the power value function of Kahneman and Tversky (1979), where we incorporate the notion of changing risk aversion, and the classical quadratic value function. Second, we introduce probability distortion on the cumulative probabilities using two of the most important non-linear probability weighting functions, that of Kahneman and Tversky (1979) and that of Prelec (1998). We are particularly interested to see whether investors distort probabilities and whether this distortion significantly affects the results.

Third, we investigate whether the increasing frequency and globalization of financial crises during the past three decades affect the results obtained by Benartzi and Thaler (1995). More specifically, they examine the period between 1926 and 1990, while we study the 1980-2014 period. The recent period contains events such as the stock market crash in 1987, the Gulf war (1990), the peso crisis (1994), the Barings collapse (1995), the Asian financial crisis (1997), the collapse of LTCM hedge fund (1998), the Russian debt moratorium (1998), the stock market bubble (1995-2000), the subprime crisis and the European financial crisis, among others. Thus, the questions we ask here are: first, whether the much more volatile capital market environment during the recent period leads investors to adjust their optimal holding period and optimal asset allocation; and second, whether investors behave differently during the three most important crisis periods during the past two decades.

Fourth, we do not only employ US data as in previous studies, but also compare the US results with results obtained from two other important international financial markets, UK and Germany. We want to see whether results can be generalized or are particular for each capital market. Differences in economic policies, economic cycles, macroeconomic policies, regulatory environments, capital market conditions, interest rates and Central Bank policies, among other factors, may affect the decision making process of capital market investors. Finally, as a robustness test, we employ many different holding horizons. In short, although we try to follow a similar methodology to that of Benartzi and Thaler, in order for our results to be comparable, we extend their study by employing many different value functions, incorporating changing risk aversion, loss aversion, probability distortion, different investment periods, different markets, and financial crises.

We find that: first, the optimal holding period seems to be unaffected by the value function employed and in accordance with the MLA; second, the optimal holding period (seven months during the whole period and four or five months during crises) is sensitive to both economic events and the length of the sample period but is different from that of Benartzi and Thaler (12 months); third, the influence of probability distortion is not significant, but it exists, indicating that investors do distort probabilities; fourth, the optimal holding period is different between markets and sub-periods; and fifth, the optimal asset allocation is similar to that of Benartzi and Thaler only in one case (US data, full sample, no probability distortion); during crises periods and/or assuming value functions with probability distortion leads to different optimal allocations for all markets.

Overall our results indicate that the intensity and the frequency of major economic events (i.e. events that result in global financial turmoil) lead investors to evaluate their portfolio more frequently. In addition, local economic factors seem to play a significant role since the results differ between markets, while probability distortion does not alter the MLA (in contrast to the argument of Blavatskyy and Pogrebna, 2006). Note that our results are consistent with empirical observations on the average holding period for equity investments. For instance, data from the New York Stock Exchange[1] suggest that during 1940 the average holding period for US stocks was around seven years, by 1987 this had fallen to under two years, and by 2007 it was approximately seven months; the trend is similar for stocks traded in the London Stock Exchange and other major exchanges around the globe (see among others, Allaire and Firsirotu, 2007).

Perhaps the recent advent of high-frequency trading and/or program trading (program trading participation in NYSE volume increased from 9.9 percent in 1989 to 37.5 percent in 2003), and the increase in share ownership in the USA which has risen from 4 percent (six million people) in 1952 to 29 percent (82 million people) in 2003, have both contributed to higher levels of trading (e.g. NYSE turnover ratio has risen from 12 percent in 1960 to 141 percent in 2009)[2] and higher financial market instability. The finding of shorter optimal holding periods for equity investments can perhaps be explained by the globalization, intensity, and frequency of financial market crises during the recent decades; frequent crises introduce higher levels of uncertainty and volatility, prompting investors to evaluate their portfolios more frequently. The rest of the paper is organized as follows: Section 2 discusses the extant literature on the equity premium puzzle; Section 3 presents the data and the methodology; Section 4 presents the results; Section 5 concludes the paper.

2. Literature review

Mehra and Prescott (1985) first report that in the USA between 1889 and 1978 the average real rate of return on T-Bills is 0.80 percent per year while the average real rate of return on equities is 6.98 percent per year; in other words the equity premium is 6.18 percent per year. Later studies use datasets that start as early as 1802 and span until 2005, and still find that the average US equity return (inflation adjusted) has been approximately 7.67 percent while the return on the risk free asset has been 1.31 percent; thus the average premium has been approximately 6.36 percent (Mehra, 2006, p. 5). This premium is significantly greater than the premium that can be expected from standard neoclassical models; for instance a relative risk aversion coefficient of over 30 could explain the puzzle, however, theoretical and empirical estimates indicate that the coefficient is around 2 (see Benartzi and Thaler, 1995).

Note, however, that not all studies agree on the magnitude of the historical equity premium. For instance, Siegel (1999) finds an equity premium of 1 to 2 percent per annum and argues that the previously reported premium is due to an underestimation of the risk-free return and an overestimation of equity returns. Dimson *et al.* (2008) use data from 17 countries and a world index for a 106-year period and find that the premium is approximately 3-3.5 percent, using the geometric mean to calculate returns. Also, consensus estimates of academic economists suggest an equity premium of

6-7 percent per year which may fluctuate from 2 to 13 percent depending on pessimistic and optimistic scenario forecasts (Welch, 2000). Fama and French (2002) use fundamentals and estimate the equity premium using the growth rates in dividends and earnings for the period between 1951 and 2000, and find a premium of 2.55 and 4.32 percent, respectively. Jagannathan *et al.* (2000) use a variation of the Gordon equity valuation model and find that the equity premium for the period between 1926 and 1970 was indeed approximately 7 percent; between 1970 and 1999, however, the equity premium has been 0.7 percent, on average (for more detailed reviews see also Kocherlakota, 1996; Mehra, 2008).

Many studies attempt to provide an explanation for the puzzle, using a range of theoretical approaches, testing methodologies, and data. For instance, Rietz (1988) allows for the effects of low probability and unobserved market crashes and argues that this explains high equity risk premia and low risk-free returns. Mehra and Prescott (1988), however, point out that the scenarios examined in Rietz are extreme, e.g. a consumption decline of the magnitude assumed in Rietz (e.g. above 25 percent) has not taken place in the USA (where the highest decline has been 8.8 percent). Epstein and Zin (1990) emphasize the role of "first-order risk aversion" as an explanation to the puzzle: in the expected utility framework where utility is linear, the risk premium for small gambles is proportional to the variance ("second-order" risk aversion); they term as "first-order" risk aversion the case where the risk premium is proportional to the standard deviation. They employ the dual theory of choice within a multi-period framework and assuming "first-order risk aversion" they show that the model leads to a moderate equity premium.

A different approach is adopted by Constantinides (1990) who argues that the puzzle is resolved if one relaxes the time separability of the classical expected utility theory preferences in order to allow for consumption complementarity, i.e. habit persistence. His model suggests that a subsistence rate of 80 percent of the recent consumption rate explains the equity premium puzzle. In a similar spirit, Otrok *et al.* (2002) provide an explanation of the puzzle employing an intertemporal consumption-CAPM with habit formation, while Meyer and Meyer (2005) also show that a habit formation utility function may eliminate the puzzle. Chapman (2002), however, shows that it is pre-1948 data that drive the explanatory power of the habit formation model and that the growth rate in consumption exhibits different behavior pre- and post-1948. Chapman employs post-1948 data and finds results inconsistent with the habit formation explanation of the puzzle. Other studies suggest that household and national accounts data reflect basic consumption and tend to overestimate risk aversion: Ait-Sahalia *et al.* (2004) use data on luxury goods consumption and show that with this data the equity premium is reduced.

Ebrahim and Mathur (2001) use the standard power utility function but instead of modifying preferences they allow for heterogeneous investors, segmented markets, and optimal leverage and show that their model explains the equity premium puzzle. Other studies indicate that market frictions (e.g. inability of investors to diversify their portfolios) and informational asymmetry explain a significant proportion of the premium (Zhou, 1999). Longstaff and Piazzesi (2004) present a model where the equity premium reflects three types of risk (consumption-risk, event-risk, corporate-risk) and show that their model implies an equity premium much larger that the premium implied by standard models. Ang *et al.* (2005) use a model that assumes disappointment aversion preferences and asymmetric aversion to gains vs losses; they show that the large equity premium is reconciled with a typical asset allocation to equities of about

60 percent (see also Gul, 1991). Benninga and Protopapadakis (1990) suggest that the puzzle is resolved if the time preference factor is above one and reasonable leverage ratios exist in the market.

Benartzi and Thaler (1995) attempt to explain the puzzle employing PT and the notion of MLA and show that the magnitude of the equity premium is consistent with PT, if investors evaluate their portfolios annually. Blavatskyy and Pogrebna (2006), report experimental findings that support the notion that the percentage of subjects who do not invest at all in a risky asset is higher when the lottery is evaluated frequently while the percentage of subjects who invest all of their initial endowment is higher when lottery is evaluated less frequently. However, the majority of subjects invest an intermediate fraction of their endowment in both frequent and infrequent evaluation cases, a finding inconsistent with MLA. This result seems robust to the use of many different utility functions. Blavatskyy and Pogrebna also show that the effect of nonlinear probability weighting exactly offsets the effect of MLA, for the classical parameterizations of the cumulative PT. Other studies show that most people would invest an amount of their initial endowment to a risky lottery in both short and long evaluation periods but very few subjects would not invest at all or invest their entire endowment into risky lotteries (see Gneezy and Potters, 1997; Haigh and List, 2005).

3. Data and testing methodology

For the empirical analysis we employ a representative stock and bond portfolio for three important international markets, the USA (the S&P 500 Composite Index and the US Benchmark ten-Year DS Government Bond Index), the UK (the FTSE All Share Index and the UK Benchmark ten-Year DS Government Bond Index), and Germany (the DAX 30 Performance Index and the BD Benchmark ten-Year DS Government Bond Index) for the period between January 1980 and April 2014 (411 monthly price observations). Returns are defined as the first difference of the log price levels. Table I presents descriptive statistics for the sample data. For instance, the mean monthly return on the S&P500 index during the sample period is 0.0068 (standard deviation 0.0473), while the mean monthly return on the US Benchmark ten-year Government bond is 0.0010 (standard deviation 0.0006). This implies a monthly premium of 0.58 percent, or 6.96 annualized.

	S&P 500	US bond	FTSE	UK bond	Dax 30	Germany bond
Mean	0.0068	0.0010	0.0065	0.0019	0.0072	0.0011
Var	0.0022	0.0006	0.0025	0.0006	0.0039	0.0003
SD	0.0473	0.0249	0.0497	0.0246	0.0627	0.0174
Kurtosis	4.7577	3.2726	3.2142	2.3552	4.9883	1.4340
Skewness	−1.2424	0.0535	−1.1114	−0.0057	−1.4219	−0.3721
Sharpe ratio	0.1449	0.0419	0.1299	0.0782	0.1152	0.0660
Min	−0.2732	−0.1282	−0.2407	−0.1054	−0.3201	−0.0699
Max	0.1153	0.1127	0.1245	0.1068	0.1754	0.0616

Note: The table presents descriptive return statistics for a representative stock and bond portfolio for three important international markets, the USA (the S&P 500 Composite Index and the US Benchmark ten-Year DS Government Bond Index), the UK (the FTSE All Share Index and the UK Benchmark ten-Year DS Government Bond Index), and Germany (the DAX 30 Performance Index and the BD Benchmark ten-Year DS Government Bond Index) for the period between January 1980 and April 2014 (411 monthly price observations)

Table I.
Descriptive statistics

We use this data to compute historical monthly returns, and generate each asset's empirical cumulative distribution function without pre-assuming a specific distribution functional form (i.e. normal or lognormal). We use the resampling method so as to eliminate any correlation between bonds and stocks. Note that the sample period contains several important events that have generated significant volatility and turmoil in financial markets, such as the DOT.com bubble (1995-2000), the subprime crisis (2006-2009), and the European financial crisis (2009-2013). In order to gain deeper insight into investor behavior during crisis we also divide the full sample into smaller 5-year sub-samples and repeat the empirical analysis both for the entire sample period and for each of these sub-periods separately, i.e. we start with the full 411 months and then separate the period into 72-, 60- and 64-month sub-periods.

We first compute returns for 20 evaluation periods, e.g. periods for which an investor accumulates returns. This is done in order for our results to be comparable to earlier results (e.g. Benartzi and Thaler, 1995). Then, we obtain the prospective utility that an investor derives from each asset for a specific holding period by employing three different value functions: the piecewise linear, the piecewise power value function and the quadratic value function without any probability distortion; based on the results, we then choose the appropriate value function. More specifically, if the results are similar we employ the piecewise power as the objective function of our model; however, if results differ we employ more than one value functions.

Next we introduce probability distortion in the model, and consider two cases: first, we use as probabilities the objective ones; and second, we use as probabilities the probability weights resulting from a non-linear probability weighting function. In addition, in order to examine whether the choice of the weighting function affects the results we try two probability weighting functions, that of Kahneman and Tversky (1979) and that of Prelec (1998). If the results for these functions are pretty close we choose one weighting function, that of Kahneman and Tversky (1979) and we find the prospective utility using the power value function and the Kahneman and Tversky's weighting function.

We then find the optimal holding period, i.e. the period where an investor becomes indifferent between investing in bonds and stocks. For this optimal holding period we then find the optimal allocation between bonds and stocks, that is, the portfolio allocation that offers the maximum prospective utility. The process is as follows: we start by computing the prospective utility for an investor who holds a portfolio consisting only from bonds (100 percent of wealth in bonds) and then we compute all available portfolios in increments of 5 percent (e.g. 95 percent in bonds and 5 percent in stocks; 90 percent in bonds and 10 percent in stocks, etc.) to the other end of the spectrum, i.e. a portfolio that consists only from stocks (100 percent of wealth in stocks). This way, we create portfolios with bonds and stocks, the prospective utility of which we compute. The portfolio allocation that gives the maximum prospective utility is the optimal one. Note that the model is developed within the cumulative PT framework where returns are ranked in increasing order and the distortion is applied to the cumulative probability not to individual returns, and that estimating portfolios with 1 percent increments yields qualitatively similar results.

3.1 The models

In descriptive theories of decision making such as the PT and the subsequent cumulative prospect theory (CPT) three functions are needed: an outcome-transformation function, a probability-transformation function, and a function that combines the transformed outcomes with the transformed probabilities. In the CPT framework, outcomes are transformed through an S-shaped value function, concave for gains, convex for losses, and steeper for losses than for gains (loss aversion). The probabilities are transformed by an inverse S-shaped probability weighting function *w* while values and probability weights are combined through a rank-dependent weighting scheme.

In classical expected utility models, the decision makers weight probabilities linearly. The linear probability weighting is expressed mathematically as:

$$E(u(x)) = \sum_{i=1}^{N} p_i u(x_i) \tag{1}$$

In (1), x_i is the possible outcome and p_i the probability which is objective and common for all investors.

An alternative theory is PT. In PT models there is probability distortion in the sense that each outcome is weighted by a decision weigh, $w(p)$, which is subjective (for each agent) and arising from her personal information. The classical expected utility theory cannot capture phenomena such as probability distortion. The classical strictly concave utility function for totally risk averse investors is now replaced by an S-shaped value function which is increasing and concave for gains and increasing and convex for losses. The gains and the losses are determined by a reference point, (r_p) which is the first important parameter of the value function in a PT model. If returns are greater than the reference point they are considered as gains and if they are smaller than the reference point are considered as losses. PT investors are assumed to be risk averse for gains and risk seeking for losses. The value function is non-smooth, in contrast with the classical utility function.

In this paper we employ three different value functional forms. More specifically, we first employ the linear piecewise value function (also employed by Benartzi and Thaler, 1995) which is the piecewise-power value function of Kahneman and Tversky (1979) in the special case where u is linear ($\alpha^+ = \alpha^- = 1$):

$$u(x) = \begin{cases} -\beta(-x), & x \leqslant 0 \\ x, & x > 0 \end{cases} \tag{2}$$

Second, we employ the piecewise-power value function by Kahneman and Tversky (1979) with their estimates for parameters as $\alpha^+ = \alpha^- = 0.88$. This function can give a better picture of the change in investors' behavior from gains to losses and vice versa:

$$u(x) = \begin{cases} -\beta(-x)^{\alpha^-}, & x \leqslant 0 \\ x^{\alpha^+}, & x > 0 \end{cases} \tag{3}$$

Third, we employ the quadratic value function which is the classical quadratic value function of expected utility theory with a kinked point reflecting loss aversion such as the power value function. We use this functional form in order to see how a component of the classical EU analysis could be incorporated in the PT:

$$u(x) = \begin{cases} a_2x^2 - a_1x, & x \geqslant 0 \\ -\beta\left(a_2x^2 - a_1(-x),\right. & x < 0 \end{cases} \tag{4}$$

PT investors do not weight outcomes linearly but they tend to underestimate large and moderate probabilities and overestimate small probabilities instead. Based on this observation, Kahneman and Tversky (1979) proposed to replace the objective probabilities by decision weights using a non-linear, continuous and strictly increasing probability weighting function $w(\ )$ which is applied on the objective probabilities p w:[0, 1]→[0, 1] with $w(p)>p$ for small probabilities p and $w(p)<p$ for large probabilities p while $w(p)=p$ for $p=0$ and $p=1$. The Tversky and Kahneman (1992) probability weighting function is:

$$w(p) = \frac{p^{\gamma}}{\left(p^{\gamma}+(1+p)^{\gamma}\right)^{1/\gamma}} \tag{5}$$

In (5), $\gamma=0.69$ for losses and $\gamma=0.61$ for gains. Kahneman and Tversky extend PT to CPT, where the distortion is not applied on single probabilities anymore but on cumulative ones. In the CPT framework, the probability transformation is applied to the cumulative distribution functions so one can understand that this probability distortion depends on the cumulative distributions of the assets.

Prelec (1998) proposed another probability weighting function, a two-parameter "compound invariant" functional form:

$$w(p) = \exp(-\beta(-\text{In}p))^{\alpha} \tag{6}$$

In (6), as the risk aversion parameter α decreases the function becomes more regressive, more sub-proportional and more S-shaped. These parameters determine the overweighting of small probabilities and the underweighting of large probabilities. Such a transformation inflates the large probabilities and deflates the small probabilities.

4. Results

4.1 US data

Figure 1 presents results for the US sample assets using a linear value function without probability distortion for the full sample period and the three sub-periods discussed above. The optimal holding period is at the point where the two lines cross and it is the evaluation period where an investor is indifferent between investing in stocks and bonds. Note that for the full sample period the optimal holding period is seven months (see also the Table II) while: first, for the 1995-2000 sub-period (DOT.com Bubble) the optimal holding period is six months; second, for the 2005-2009 sub-period (subprime crisis) the optimal holding period is five months; for the 2009-2014 period (EU crisis) the optimal holding period is four months. Figure 2 presents results for the US sample assets for a power value function without probability distortion and $a=b=0.88$ (Kahneman and Tversky). For the full sample period the optimal holding period is seven months while: first, for the 1995-2000 sub-period (DOT.com Bubble) the optimal holding period is six months; and second, for the 2005-2009 sub-period (subprime crisis) the optimal holding period is five months; for the 2009-2014 period (EU crisis) the optimal holding period is five months. Figure 3 presents results for the US sample assets for the quadratic value function without probability distortion. For the full sample period the optimal holding period is seven months while: first, for the 1995-2000 sub-period (DOT.com Bubble) the optimal holding period is five months; and second, for the 2005-2009 sub-period (subprime crisis) the optimal holding period is five months; for the 2009-2014 period (EU crisis) the optimal holding period is four months.

In other words, first, without probability distortion, for any time horizon and for all value functions the findings are in complete accordance with the MLA hypothesis. Thus, for evaluation periods smaller than the optimal holding (seven months) period,

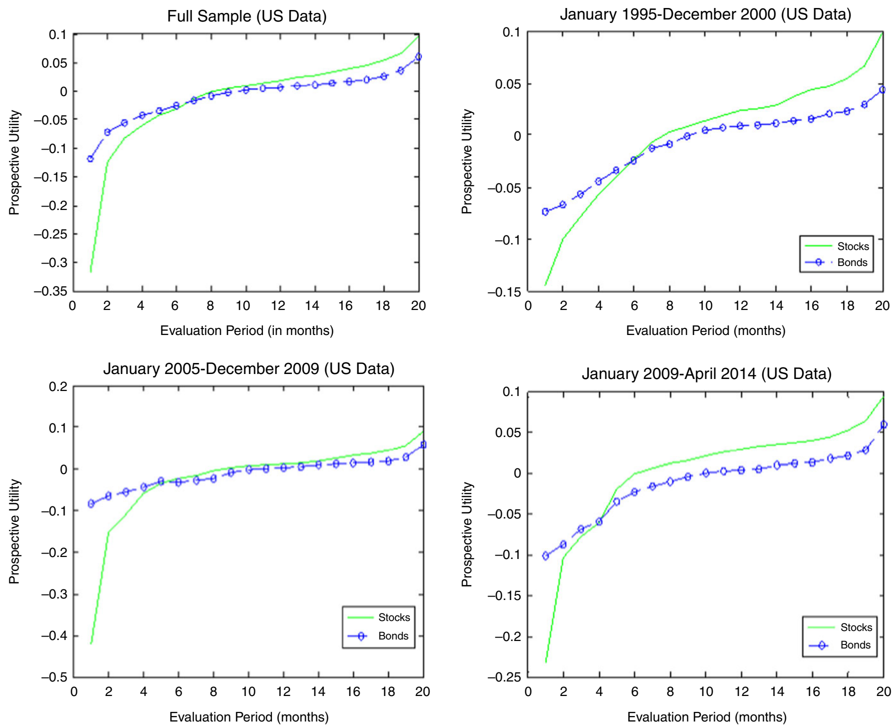


Figure 1. Optimal holding period results for a linear value function without probability distortion

Table II. Optimal holding period (in months) – US data

Panel A without probability distortion			
	Value function		
Period	Linear	Power ($a = b = 0.88$)	Quadratic
January 1980-April 2014 (411 months)	7	7	7
January 1995-December 2000 (72 months)	6	6	5
January 2005-December 2009 (60 months)	5	5	5
January 2009-April 2014 (64 months)	4	5	4
Panel B with probability distortion			
	Tversky and Kahneman (1992)	Prelec (1998)	
January 1980-April 2014 (411 months)	6	6	
January 1995-December 2000 (72 months)	4	4	
January 2005-December 2009 (60 months)	5	5	
January 2009-April 2014 (64 months)	5	5	

investors prefer to hold bonds, while for evaluation periods greater than the optimal holding period they prefer to invest in stocks.

Second, the optimal holding period is sensitive to both economic events and the length of the sample period. For example, when the full period is employed the optimal

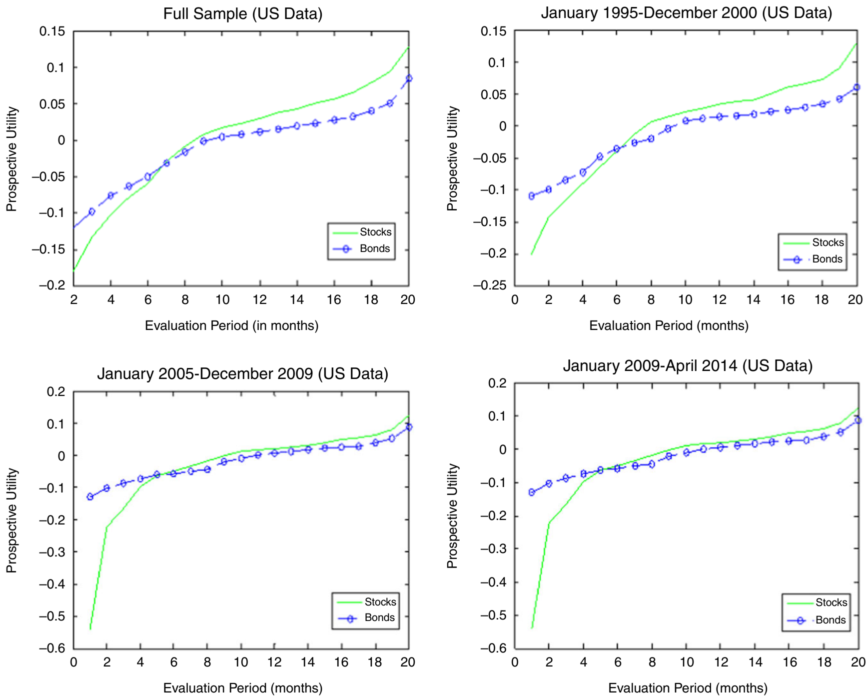


Figure 2.
Optimal holding period results for a power value function without probability distortion ($a = b = 0.88$)

holding period is seven months, while during the (much smaller) crisis periods the optimal holding period decreases to four or five months. It must be noted here that, as a robustness test, we employ different holding periods (15-months, 20-months, 80-months) and the results are qualitatively the same; this extends the results of Benartzi and Thaler, who did not examine varying time horizons.

Third, the optimal holding period in our results differ from those of Benartzi and Thaler; recall that they report an optimal holding period of 12 months with a sample that covers the period between 1926 and 1990. We believe that this is not due to the smaller sample size (i.e. 768 months vs 411 months in our study) but rather due to the different investment environment. That is, the intensity and the frequency of major economic events that lead to global financial turmoil are more significant during the recent period. For instance, the much shorter sample period in our study (1980-2014) contains events such as the stock market crash in 1987, the Gulf war (1990), the peso crisis (1994), the Barings collapse (1995), the Asian financial crisis (1997), the collapse of LTCM hedge fund (1998), the Russian debt moratorium (1998), the stock market bubble (1995-2000), the subprime crisis and the European financial crisis, among others. Thus, it is possible that the much more volatile capital market environment during the more recent period leads US investors to adjust (reduce) their optimal holding period.

Fourth, the optimal holding period seems to be unaffected by the value function employed; that is, the form of the value function does not play a role in the length of the optimal holding period, although we do observe differences in prospective utility. Thus, we will proceed with the rest of the analysis using the piecewise-power value

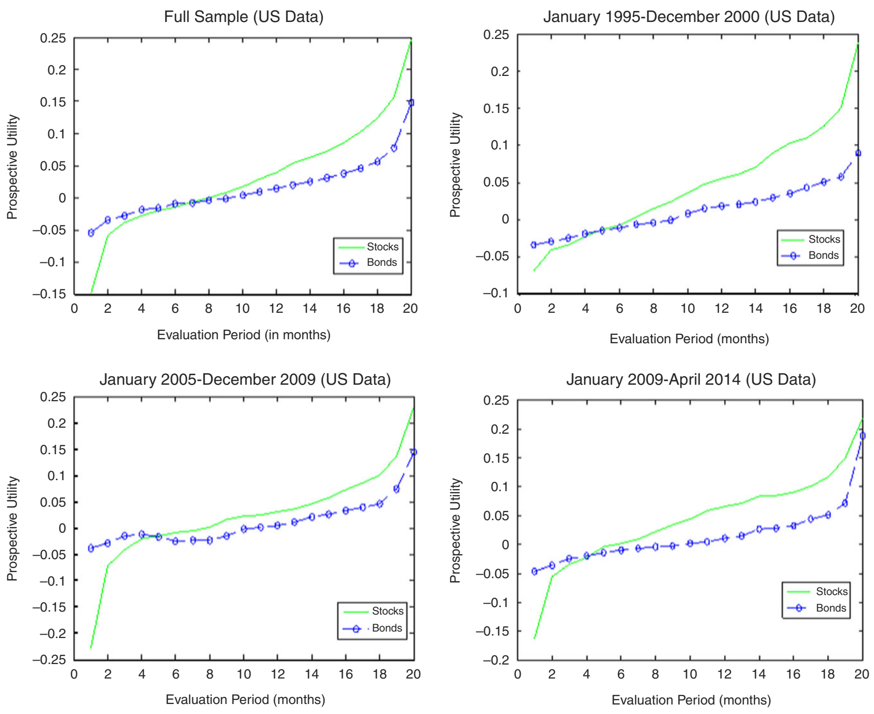


Figure 3.
Optimal holding period results for a quadratic value function without probability distortion

function as the objective function in the paper. This functional form is one of the most used functions in PT models and it is considered as the most representative for describing PT investors' behavior.

Next, we incorporate probability distortion in the analysis, in order to examine whether it affects the optimal period and the optimal allocation as a consequence. Benartzi and Thaler argue that it is not an important issue in resolving the equity premium puzzle and thus they use objective probabilities in their paper. Here we use the CPT method. The following Figures 4 and 5 present results (US data) for two power value functions: the Tversky and Kahneman (1992) probability weighting function ($a = b = 0.88$) and the Prelec (1998) probability weighting function, respectively.

The results for the Tversky and Kahneman function (Figure 4) indicate that for the full sample period the optimal holding period is six months while: first, for the 1995-2000 sub-period the optimal holding period is four months; and second, for the 2005-2009 sub-period the optimal holding period is five months; for the 2009-2014 period the optimal holding period is five months. The results for the Prelec function (Figure 5) indicate that for the full sample period the optimal holding period is 6 months while: first, for the 1995-2000 sub-period the optimal holding period is four months; and second, for the 2005-2009 sub-period the optimal holding period is five months; for the 2009-2014 period the optimal holding period is five months. These results indicate that, once more, the functional form of the value function does not affect the optimal solution. Thus, for the rest of the paper we use the probability weighting function of Tversky and Kahneman (1992) that captures all the significant characteristics of a probability weighting function such as the inverse S-shaped form and the "four-fold

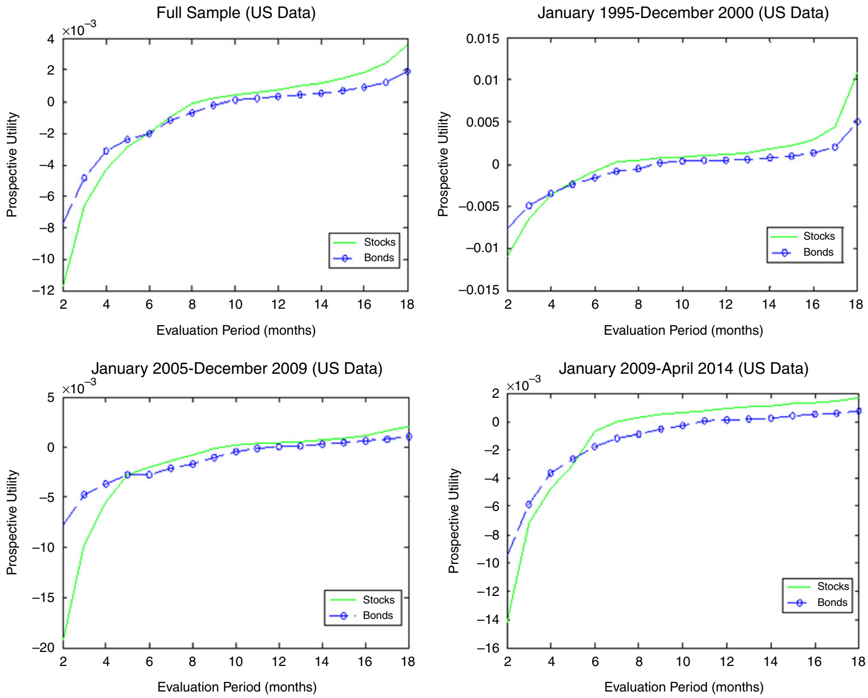


Figure 4.
Optimal holding period results for a power value function with probability distortion ($a=b=0.88$)

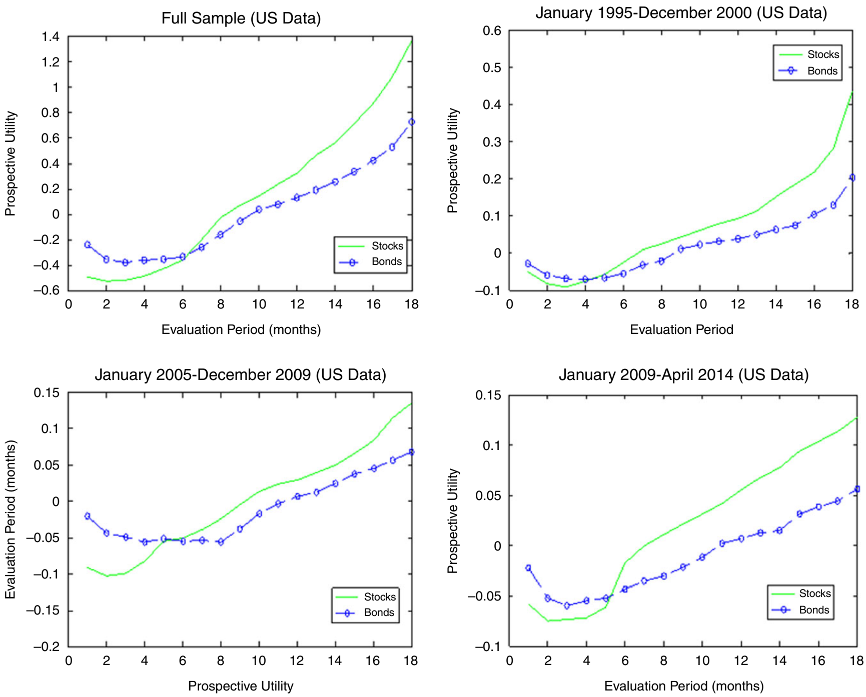
Source: Tversky and Kahneman (1992) probability weighting function

pattern of risk attitudes," i.e. risk-seeking for large-probability losses and small-probability gains, risk-aversion for large-probability gains and small-probability losses (Kahneman and Tversky, 1979).

The results for all value functions (with and without probability distortion) are summarized in Table II. The comparison of the results suggests that the influence of probability distortion is not significant, but it exists, indicating that investors do distort probabilities; they may overweight small probabilities and underweight large probabilities. Also, probability distortion does not alter the MLA effect, since, as our results indicate, the probability weighting functional form does not play a central role and both functional forms give the same solutions. So, from the first two sections of our analysis we conclude that the functional form of the value and the probability weighting functions is not crucial.

4.2 Major international markets: UK and Germany

For comparative purposes, Figure 6 presents optimal holding period results for the UK and Germany for value functions without and with probability distortion, for the full sample period. In order to save space we do not present analytical graphical analysis for UK and Germany, as we do for the US market; the plots are available upon request. Also, Table III summarizes the results for all three capital markets; in Panel A we present results without probability distortion (piecewise-power value function), while in Panel B we present results with probability distortion (probability weighting function; Tversky and Kahneman, 1992).



Source: Prelec (1998) probability weighting function

Figure 5. Optimal holding period results for a power value function with probability distortion ($a = b = 0.88$)

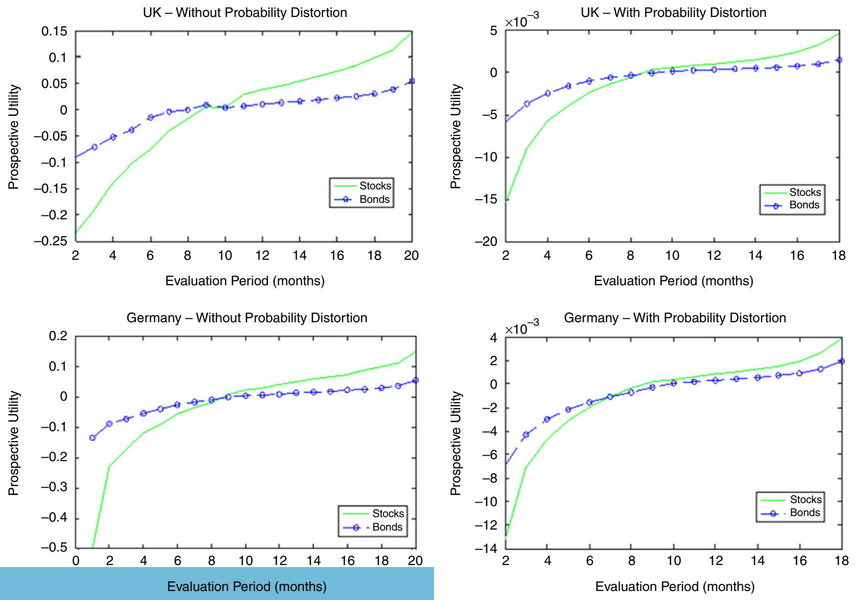


Figure 6. Optimal holding period results for major international capital markets (full sample)

Table III. Optimal holding period (in months) – major international markets

Period	USA	UK	Germany
Panel A without probability distortion (piecewise-power value function)			
January 1980-April 2014 (411 months)	7	10	8
January 1995-December 2000 (72 months)	6	6	6
January 2005-December 2009 (60 months)	5	9	6
January 2009-April 2014 (64 months)	5	8	5
Panel B with probability distortion (probability weighting function, Tversky and Kahneman, 1992)			
January 1980-April 2014 (411 months)	6	8	7
January 1995-December 2000 (72 months)	4	4	4
January 2005-December 2009 (60 months)	5	9	6
January 2009-April 2014 (64 months)	5	8	6

An important result that emerges from Table III and Figures 1-6 is that, for all markets, the optimal holding period without probability distortion is greater than those with probability distortion. For shorter sub-periods (i.e. the last two sub-periods) the optimal holding periods without and with probability distortion are the same, while for longer horizons the optimal holding periods without probability distortion tend to be larger than those with probability distortion. It seems that probability distortion influences the optimal solutions by reducing their magnitude; this holds in all sub-periods.

Another interesting result is that for UK investors the optimal holding period is much longer and, in some cases, closer to the period reported by Benartzi and Thaler; for the full sample and without probability distortion the optimal period is ten months. The observation that the optimal holding period is different between markets and sub-periods suggests that (global and local) economic conditions play a significant role and drive people to evaluate with varying frequency their investments. Note that the DOT.com bubble affects all markets similarly since it is only during this period that the optimal holding period is equal for all markets with (six months) and without probability distortion (four months).

4.3 Optimal asset allocation

Figure 7 presents optimal asset allocation results for the US sample assets using the value function without probability distortion, for the full sample period and the three sub-periods discussed above. Note that for the full sample period the optimal asset allocation is 50 percent invested in stocks and 50 percent invested in bonds, while: first, for the 1995-2000 sub-period (DOT.com Bubble) the allocation is 60 percent invested in stocks and 40 percent invested in bonds; and second, for the 2005-2009 sub-period (subprime crisis) the optimal allocation is 60 percent invested in stocks and 40 percent invested in bonds; for the 2009-2014 period (EU crisis) the optimal allocation is 60 percent in stocks and 40 percent in bonds. Figure 8 presents optimal asset allocation results for the US sample using the value function with probability distortion. Note that for the full sample period the optimal asset allocation is 60 percent invested in stocks and 40 percent invested in bonds, while: first, for the 1995-2000 sub-period (DOT.com Bubble) the allocation is 70 percent invested in stocks and 30 percent invested in bonds; and second, for the 2005-2009 sub-period (subprime crisis) the optimal allocation is 70 percent invested in stocks and 30 percent invested in bonds; for the 2009-2014 period (EU crisis)

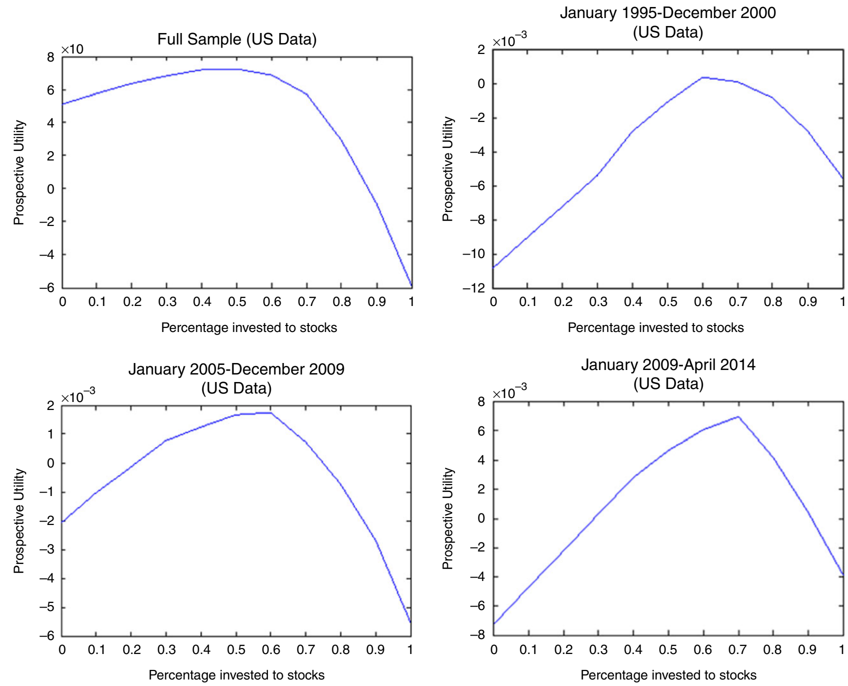


Figure 7.
Optimal asset allocation results without probability distortion (US data)

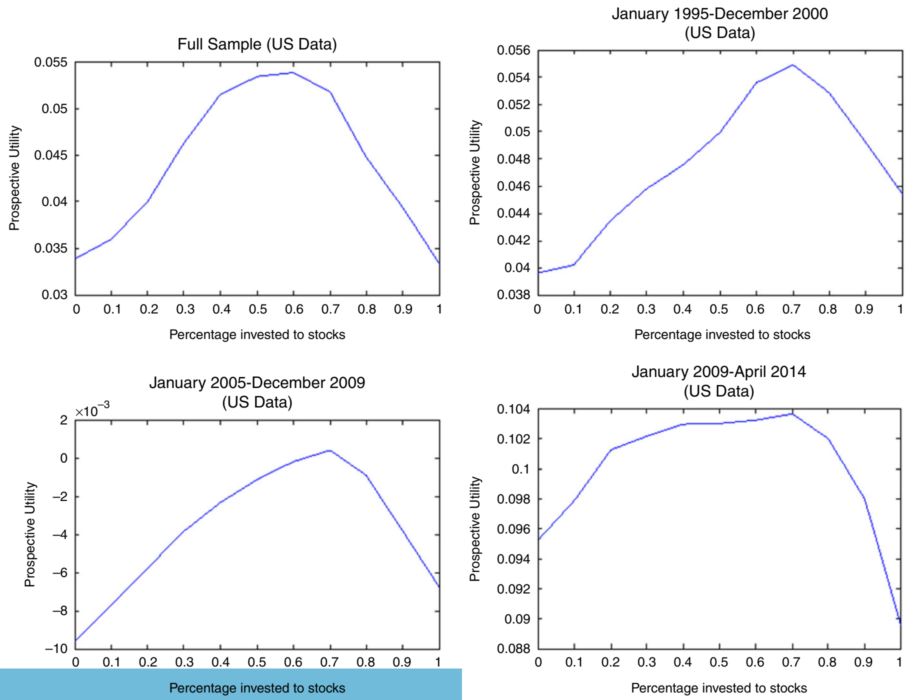


Figure 8.
Optimal asset allocation results with probability distortion (US data)

the optimal allocation is 70 percent in stocks and 30 percent in bonds. For comparative purposes, Figure 9 presents optimal asset allocation results for the UK and Germany for value functions without and with probability distortion, for the full sample period. In order to save space we do not present analytical graphical analysis for the UK and Germany, as we do for the US market; the plots are available upon request.

These results are summarized in Table IV. Note that Benartzi and Thaler report an optimal asset allocation of 50 percent in stocks and 50 percent in bonds; more specifically, they report that portfolios between 30 and 55 percent invested in stocks yield the same prospective utility but the most frequent allocation for their data are 50 percent in stocks. Our results suggest that investors are willing to invest in stocks a percentage higher than 50 percent at all periods, for all markets, and under any economic condition. Furthermore, during all sub-periods, investors' optimal allocation is approximately 60-70 percent in stocks and approximately 30-40 percent in bonds. Probability distortion results in an increase of 10 percent in optimal allocation concerning the percentage invested in stocks. This increase is observed for all markets during all periods except Germany where this increase concerns only the DOT.Com bubble period. As before probability distortion seems to influence optimal solutions; also the observation that the optimal allocations differ between markets and sub-periods reinforces our previous finding that economic conditions are important. The results in Tables I-III seem to suggest that there is a relation between optimal holding periods and optimal allocations: as the optimal period decreases the optimal allocation (percent invested in shares) increases.

5. Conclusion

In this paper we provide new original evidence on the equity premium puzzle in several economic environments, under different economic conditions, varying time horizons

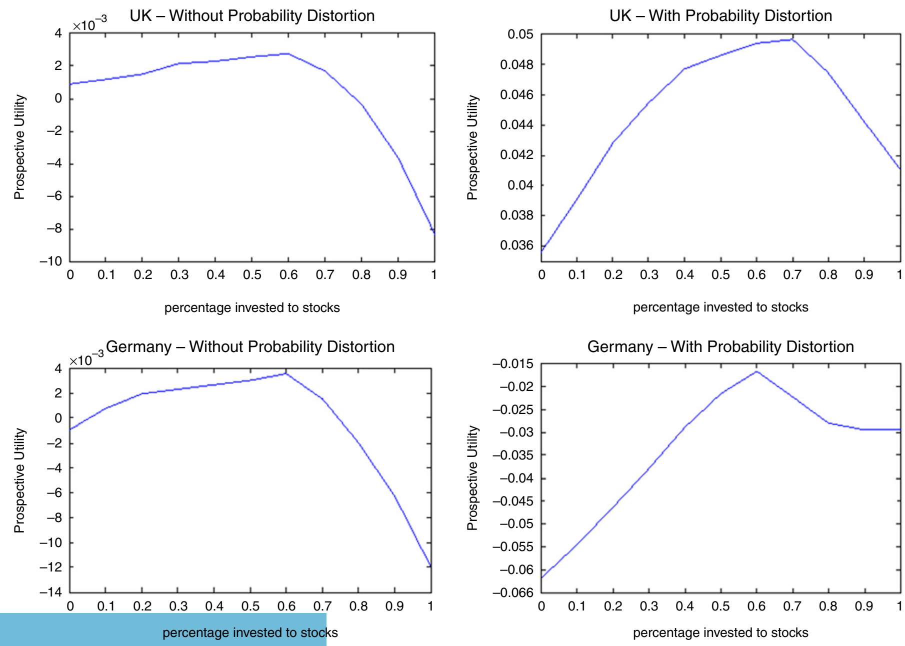


Figure 9.
Optimal asset allocation (major international capital markets)

Table IV. Optimal asset allocation (percent invested in stocks)

Period	USA (%)	UK (%)	Germany (%)
Panel A without probability distortion (piecewise-power value function)			
January 1980-April 2014 (411 months)	50	60	60
January 1995-December 2000 (72 months)	60	60	70
January 2005-December 2009 (60 months)	60	60	70
January 2009-April 2014 (64 months)	60	60	70
Panel B with probability distortion (probability weighting function, Tversky and Kahneman, 1992)			
January 1980-April 2014 (411 months)	60	70	60
January 1995-December 2000 (72 months)	70	70	80
January 2005-December 2009 (60 months)	70	70	70
January 2009-April 2014 (64 months)	70	70	70

where we incorporated many technical elements such as the changing risk aversion and the probability distortion. We conclude that there are several factors that must be taken into account in order to fully explain the equity premium puzzle. The time horizon is one of these.

First, all our optimal solutions are in accordance with the MLA hypothesis, but differ from those of Benartzi and Thaler. One of the basic elements of our analysis is the probability distortion. We find that the influence of probability distortion on the optimal solutions is not significant, but it exists, by reducing their magnitude; this holds for all sub-periods. Probability distortion, however, does not alter the MLA effect, as Blavatskyy and Pogrebna (2006) argue. Furthermore, our results indicate that the probability weighting functional form and the value functional form do not play a central role, since with any functional form we obtain the same solutions (although we do observe differences in prospective utility).

The optimal holding period is sensitive to both the investment environment and the length of the sample period. The observation that the optimal holding period is different between markets and sub-periods suggests that economic conditions play a significant role and drive people to evaluate with varying frequency their investments. Here too, probability distortion seems to influence optimal solutions. More specifically, probability distortion leads to a decrease of the optimal holding period and to an increase of the optimal allocation. As regards to the optimal allocation, our results show that investors are willing to invest in stocks a percentage higher than 50 percent at all periods, for all markets, and under any economic condition. Specifically, during all sub-periods, investors' optimal allocation is approximately 60-70 percent in stocks and approximately 30-40 percent in bonds. Probability distortion results in an increase of 10 percent in optimal allocation concerning the percentage invested in stocks. Finally, the results seem to suggest that there is a relation between optimal holding periods and optimal allocations: as the optimal period decreases the optimal allocation (percent invested in shares) increases.

Perhaps the recent advent of high frequency trading and/or program trading and the increase in share ownership in the USA, which has risen from 4 percent in 1952 to 29 percent in 2003, have both contributed to higher levels of trading and higher financial market instability. The finding of shorter optimal holding periods for equity investments can perhaps be explained by the globalization, intensity, and frequency of financial market crises during the recent decades; frequent crises introduce higher levels of uncertainty and volatility, prompting investors to evaluate their portfolios more frequently.

Notes

1. For a relevant discussion see Andrew Haldane, Executive Director, Financial Stability, Bank of England, "Patience and finance." Speech at the Oxford China Business Forum, Beijing, September 9, 2010. Available online at www.bis.org/review/r100909e.pdf

2. NYSE Factbook, www.nyxdata.com/Data-Products/Facts-and-Figures

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