Asset Allocation under Disappointment Aversion

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by

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Abstract

The present thesis examines one of the non–standard preferences, the theory of disappointment aversion (DA) from Gul (1991), within an asset allocation problem. Related to the area of decision–making under risk, it sheds light on: (i) at the global level, how the risk exposure reduces quantitatively in the presence of disappointment aversion; (ii) given the empirical data, what are the plausible levels of disappointment aversion around different financial markets; and (iii) how disappointment aversion interacts with both inherent risk attitudes (i.e., risk aversion, subjective probability weighting and cultural dimensions) and environmental stimuli (i.e., pleasant or unpleasant odours).

In Chapter 2, drawing upon the seminal study of Ang et al. (2005), we incorporate disappointment aversion (that is, extra aversion to outcomes that are worse than prior expectations) within a simple theoretical portfolio choice model. Based on the results of this model, we then empirically address the portfolio allocation problem of an investor who chooses between a risky and a risk–free asset using international data from 19 countries. Our findings strongly support the view that disappointment aversion leads investors to reduce their exposure to the stock market (i.e., disappointment aversion significantly depresses the portfolio weights on equities in all cases considered). Overall, our study shows that, in addition to risk aversion, disappointment aversion plays an important role in explaining the equity premium puzzle around the world.

In Chapter 3, we investigate investors' asset allocation when their utility consists of wealth utility and disappointment aversion utility in which gains and losses are calculated with respect to the expected wealth. We show that optimal investment proportions increase when disappointment aversion on the assets decreases, and that disappointment aversion increases when expected excess returns increase. When decreasing absolute risk aversion holds, disappointment aversion increase with wealth, which is supported by our empirical results with asset allocations in pension funds of 35 OECD countries. We also find that individualism is positively related to disappointment aversion. These results indicate that the overconfidence represented by their individualism leads to more disappointment when losses occur.

Chapter 4 aims to investigate the role of odours on DA in a monetary gamble task. We elicited the degree of DA based on an experimental procedure similar to Sokol-Hessner et al. (2009, 2013). Our study shows for the first time that unpleasant odours increase DA in a monetary gamble task. Such odour–related variations in individual DA were associated with hedonic evaluations of odours but not with odour intensity. Increased disappointment aversion while perceiving an unpleasant odour suggests a dynamic adjustment of aversion to losses. Given that odours are biological signals of hazards, such adjustment of disappointment aversion may have adaptive value in situations entailing threat or danger.

Chapter 5 concludes this thesis and points out further directions.

Contents

Preface

Elements of this thesis have appeared in the following publications:

Journal Papers:

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If there is something I have learned from this research during my Ph.D., it has to be the persistence to deal with failures. I will not forget: those days and nights I was struggling to model an idea, solve an equation or debug several lines of code. I will not forget those days and nights I made things right as the result of my countless attempts. Some say our potential mostly depends on talent; I say that according to my experiences, the attitude, the way we do things makes all the difference.

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Chapter 1

Introduction

1.1 General Introduction

The traditional finance paradigm relies heavily on an assumption of "fully rational agents". In the field of finance, the concept "rational" typically means two things: (i) people evaluate risk and make decisions based on the expected utility of Von Neumann and Morgenstern (1944), where their preferences are complete, continuing, transferable and independent across states; (ii) new information will be updated into their beliefs in the manner of Bayes' rules. Such settings make the traditional framework appealingly predictable because agents always make consistent choices to maximize their expected utility. However, recent facts about the cross section of average returns (i.e., equity premium puzzle (Mehra and Prescott, 1985; Mehra, 2008)) and inconsistencies of observed choice data (Allais, 1953; Ellsberg, 1961; Tversky and Kahneman, 1974) have promoted a rethink of investors' behaviour in terms of decision–making under risk. After years of effort, there has been an explosion of progress on so–called non–expected utility theories (Loomes and Sugden, 1982; Bell, 1985; Gul, 1991; Segal, 1987, 1989; Quiggin, 1982; Tversky and Kahneman, 1974) which makes it even clearer that people violate the assumption of expected utility theory when assessing risk.

During the early 1980s, behavioural finance eventually emerged, at least in part, in response to the financial anomalies that cannot be fully understood by traditional frameworks. Generally speaking, it argues that investors are not fully rational agents. Specifically, it investigates whether better explanations can be achieved by using a non–standard preference (i.e., situations where people do not evaluate risk according to the expected utility) and non–standard beliefs (i.e., situations where people's beliefs are subject to psychological biases and deviate from Bayes' law).

This study focuses on the implications of *non–standard preferences* from a behavioural perspective. In particular, it aims to rationalize the equity premium puzzle by considering behavioural components in the risk attitude, such as Gul's disappointment aversion theory, a version derived from a similar idea, loss aversion in prospect theory (Tversky and Kahneman, 1979, 1992). Moreover, a novel framework has been developed to estimate aggregate disappointment aversion quantitatively around different financial markets. We then analytically show how the disappointment aversion is related to other factors such as risk aversion and cultural variations. In addition to economic attributes, an experimental procedure is conducted to explore whether disappointment preferences are affected by external stimuli (i.e., pleasant & unpleasant odours). We use a few subsections below to briefly discuss the key concepts in this study.

1.1.1 The Equity Premium Puzzle

It stands to reason that equities should earn higher returns than risk–free assets in the long run. However, how can we know the historical equity premiums are at a reasonable level? Using Lucas's (1978) standard general equilibrium model, Mehra and Prescott (1985) firstly document how the required equity premium in the American market is only about 0.35%, which is inconsistent with the observed premium of 6.18%. Similar statistical differentials are documented for Australia, Canada, France, Germany, India, Japan, the Netherlands, South Africa, Sweden, and the UK (Dimson et al., 2008; Mehra, 2007). Table 1.1 lists the equity premiums for these countries.

[Insert TABLE 1.1 about here]

The equity premium puzzle arises as solely relying on risk aversion fails to explain the huge magnitude of equity premium. In order to necessarily match the observed equity premiums, risk aversion should reconcile itself to a value from 30 to 40, which Mehra and Prescott conclude is too high to be plausible. To put it another way, even though stocks are more attractive than relatively risk–free assets, investors appear to be so unwilling to hold stocks that they demand a substantial risk premium in order to hold the market supply.

According to the work of Mehra (2008), which is an excellent survey that organises the most effective solutions related to this puzzle, ongoing research and expansions of databases have promoted possible solutions in two broad categories. Either the existing data misdirected the problem to statistical illusions (empirical side) or else current models were short of responses to potential factors (theoretical side). On the empirical side, the existence of the puzzle has been questioned by several researchers who interpret the "abnormal" stock returns as a statistical illusion driven by common biases (e.g., survivorship, success and selection bias) or the use of non–stationary data (Fama and French, 2002; Dimson and Staunton, 2006). On the theoretical side, various risk–related explanations that have been proposed to stress the inability of the standard risk paradigm are: the risk–free rate puzzle (Weil, 1989); non–time separable utility (Epstein and Zin, 1991); economic catastrophe concerns (Barro, 2006); idiosyncratic and uninsurable income risk (Constantinides and Duffie, 1996); and habit formation (Constantinides, 1990; Abel, 1990; Campbell and Cochrane, 1999; Campbell, 2001).

1.1.2 The Preference of Loss Aversion and Probability Weighting

Instead of being "fully rational" during the decision–making process, a common question is: what is the best plausible alternative to describe how people think about risk? A famous answer from the behavioural perspective is the prospect theory of Tversky and Kahneman (1979, 1992). Fundamental to prospect theory is the preference of loss aversion, which suggests that (i) decisions are made according to the potential losses and gains rather than final wealth; (ii) agents evaluate potential outcomes based on a reference point; and (iii) the utility is steeper in losses than gains of the same magnitude. Formally, a value function with loss aversion can be shown in the following form:

$$U(x) = \begin{cases} x^{v^+}, & x \geq 0 \\ -\lambda(-x)^{v^-}, & x < 0, \end{cases}$$

where λ is the coefficient that controls the degree of loss aversion, v^+ and v^- are the curvature parameters. The function is believed to be concave for gains and convex for losses as the median values of v^+ and v^- are reported by Tversky and Kahneman (1992) as both being 0.88 while the median λ is 2.25.

Among many subsequent studies, the idea of loss aversion has been particularly successful in explaining the equity premium puzzle (i.e., Benartzi and Thaler, 1995; Barberis et al., 2001; Hwang and Satchell, 2010). The simple logic is that: as people are loss–averse, if stock market goes up in the next year, they will feel good; on the other hand, if the stock returns lead to losses in the next year, they will feel *very* bad. As a result of this kind of thinking, in addition to risk aversion, investors tend to consider stocks less favourably and require an extra premium in order to keep their holdings.

The concept of probability weighting is proposed in dealing with choice inconsistencies documented in subsequent research of prospect theory. As relying on only the objective probability weighting function is not sufficient to match the complexity of behavioural patterns observed in experimental investigations, people tend to overweight unlikely extreme outcomes. Quiggin (1982) introduces a rank–dependent utility model where weights depend on the true probability of an outcome as well as its ranking relative to other outcomes. The combination of rank and reference point dependent utility gives birth to a later version of prospect theory, the cumulative prospect theory (CPT) of Tversky and Kahneman (1992). CPT utilizes a transformed probability weighting function to account for the redistribution of decision weights that overweight small probabilities and underweight moderate and high probabilities. In particular, it is defined for gains and losses separately:

$$w^+(p) = \frac{p^{\gamma^+}}{\left(p^{\gamma^+} + (1-p)^{\gamma^+}\right)^{\frac{1}{\gamma^+}}}, \quad w^-(p) = \frac{p^{\gamma^-}}{\left(p^{\gamma^-} + (1-p)^{\gamma^-}\right)^{\frac{1}{\gamma^-}}},$$

where p is the cumulative probability of any possible outcome. With one extra curvature parameter γ ($0 < \gamma < 1$, γ^+ for gains and γ^- for losses), the weighting function allocates more (less) weight to unlikely (likely) events. In other words, tails of any distribution are over–emphasized while those outcomes around its peak are less valued.

Besides the weighting function in CPT, plenty of alternatives have been developed in the literature. For example, Prelec (1998) provides a single–parameter version of the weighting function, where the curvature parameter is identical for both the domains of losses and gains. This simplifies the function to:

$$w(p) = exp[-(ln(p))^{\gamma}].$$

According to the experimental work of Gonzalez and Wu (1999), despite its simplicity, the use of symmetric curvature fits the median data as well as the other separate–curvature models. Therefore, for the numerical investigations in Chapter 3, we use Prelec's weighting functions as our primary setting. For a demonstration here; suppose a stock has normally distributed annual returns with $\mu_r = 10\%$, standard deviation=0.1865, and let $\delta = 0.74$[1]. Figure 1.1 compares the CPT and Prelec's weighting functions to its original density function.

[Insert FIGURE 1.1 about here]

A glance at Figure 1.1 shows important attributes of the weighting function. Firstly, decision weights are underweighted for the region of more frequent events. As now small gains become less attractive, investors are less motivated to take further risks. On the contrary, fewer decision weights on tiny losses ease the panic of suffering. Investors therefore have a higher tendency to play with risks. Secondly, decision weights are exaggerated at the edges of the distribution. Investors become risk–seeking if they recognize a massive gain possibility, even if the chance of occurrence is small. On the other hand, additional concerns about those very unlikely huge losses make investors extremely safety–oriented, as now, in their view, a disaster–like outcome occupies more decision weight than it should do. Lastly, the modified density functions are highly non–linear, resulting in more severe sensitivity near $p = 1$, and $p = 0$.

1.1.3 Gul's Theory of Disappointment Aversion

The term "disappointment" was first used by Bell (1985) within the context of binary lotteries. According to Bell, disappointment is a psychological reaction to an outcome that fails to satisfy expectations held by the decision–maker. Consider

[1]Analogous to the estimation of Gonzalez and Wu (1999), in the rest of this study, $\delta = 0.74$ is adopted universally.

a lottery (x, p, y), which has a probability p of winning x and a probability $(1-p)$ of yielding y, $(x > y)$. The decision–maker's expectation depends on the expected pay–off of this lottery: $c = px + (1-p)y$.

The decision–maker will be disappointed if y occurs, which means he/she receives less than expected; the measure of such disappointment is:

$$d(c-y) = d(px + (1-p)y - y) = dp(x-y).$$

On the contrary, the outcome will be regarded as "elation" if x is received:

$$e(x-c) = e(x - px - (1-p)y) = e(1-p)(x-y),$$

where d (e) $(d \geq 0, e \geq 0)$ controls the proportional disappointment (elation) between the realised outcomes and expectations. The net psychological satisfaction that comes with the lottery can be expressed as:

$$p(e(x-c)) - (1-p)(d(c-y)) = (e-d)p(1-p)(x-y).$$

Finally, the overall utility function is based on the expected economic pay–off (consumption) and her/his psychological satisfaction:

$$U(\cdot) = [px - (1-p)y] + (e-d)p(1-p)(x-y).$$

Although Bell's model has intuitive appeal, it is restricted to binary lotteries only. Following his idea, Gul (1991) proposed the theory of disappointment aversion (DA) that is more general in describing decision–making under risk. At the core of Gul's framework, potential outcomes are further divided into elation and disappointment based on an endogenous reference point. People are supposed to be disappointment–averse: they are more sensitive to disappointment than elation of the same magnitude. Consider the following piecewise utility as a compact way to show the functional form of disappointment aversion:

$$U(x) = \begin{cases} \big(x_{t+h} - \mathbb{E}_t x_{t+h}\big), & x_{t+h} \geq \mathbb{E}_t x_{t+h} \\ A\big(x_{t+h} - \mathbb{E}_t x_{t+h}\big), & x_{t+h} < \mathbb{E}_t x_{t+h} \end{cases}.$$

Let h be the investment horizon while $\mathbb{E}_t x_{t+h}$ refers to the applicable reference point that all outcomes during $t + h$ will be compared with. The level of $\mathbb{E}_t x_{t+h}$ is determined by the certainty equivalent (the certain level of wealth that generates the same utility according to an investor's choices). Such a prospect–dependent feature means the reference point does not necessarily have to be positive when the market outlook turns stagnant. Additionally, Routledge and Zin (2010) allow the reference point to lie below the certainty equivalent. However, we maintain the scope of this study within the case where the reference point is equal to the certainty equivalent. With only one parameter richer than the expected utility, A $(A > 1)$ is the coefficient that controls the degree of disappointment aversion.

The preference of disappointment aversion is a derivative preference of loss aversion, as they both share many basic advantages compared with the expected utility such as: i) reference dependence; ii) diminishing sensitivity; iii) steeper value function of negative utility; and iv) probability weighting. However, the main difference stems from the way in which the reference point is determined in each case. In the case of loss aversion, a pre–set exogenous reference point is frequently applied, e.g., the *status quo* (see Tversky and Kahneman, 1979, 1992) and the risk–free rate (see Barberis and Huang, 2001; Barberis et al., 2001). In the case of disappointment aversion, the reference point is endogenously updated according to upcoming events. The choice of an exogenous or endogenous reference point is particularly relevant in applications of long–term investment horizons. For example, after examining US returns over the sample period 1926–1990, Benartzi and Thaler (1995) were forced to conclude that investors are myopic (they have a one–year investment horizon) in loss aversion. Otherwise, the levels of loss aversion would be too high to be plausible. Similar results can also be found in a longer sampling period of the US market, where Fielding and Stracca (2007) demonstrate that, under a fixed reference point, the loss aversion parameter is inflated to 25 at the 10–year horizon. In contrast, due to an endogenously updated reference point, the degree of disappointment averison only mildly increases to about 2.5.

1.2 Contributions and Structure

In the literature, the preference of disappointment aversion only appears in equilibrium models over consumption (Epstein and Zin, 1990, 2001). Within this thesis, we embed disappointment aversion into a typical asset allocation problem. In broad terms, we argue that the portfolio choices between risky assets and risk–free assets are jointly determined by risk aversion and disappointment aversion. In Chapter 2, by extending the seminal study of Ang et al. (2005) to the global scale, we have demonstrated to what extent the equity weights will drop in response to the presence of disappointment aversion among 19 different markets. With a sufficient level of disappointment aversion, investors may not even participate in the equity market.

In Chapter 3, we develop a formal treatment to measure aggregate levels of disappointment aversion in financial markets. In addition, based on predictions of the model, a cross–sectional investigation is conducted to explore potential determinants of disappointment aversion across a number of countries and regions. Chapter 3 reinforces the theoretical base of current literature in the following aspects. First, our approach not only allows investors to be disappointment–averse, but also accommodates expected utility as a special case. This setting grants us a stronger compatibility between our framework and the standard preferences. Second, our framework fully allows the advantage of a standard risk–value model (e.g., Jia and Dyer, 1996) to enhance the measurement of risk aversion. Third, due to the desire of tractability, previous behaviour portfolio models are often limited to a typical risky & risk–free portfolio (e.g., Benartzi and Thaler, 1995; Ang et al., 2005; Fielding and Stracca, 2007; Hwang and Satchell, 2010). Our approach allows separate assessments of multiple asset classes without upper limits. Fourth, the sensation derived from elation or avoided disappointment does significantly affect our utility – but so does the absolute pleasure of consumption we purchase with the wealth. Therefore, in contrast to prior formulations based on the value function defined solely based on gains and losses under risk, our approach makes explicit the way preferences also depend on absolute consumption levels. In line with Koszegi and Rabin (2007), we define the basic form of utility in Chapter 3, where the overall utility has two components: $U(c|r) = m(c) + n(c|r)$, $m(c)$ is a "consumption utility" typically stressed in economics and $n(c|r)$ is an "elation–disappointment utility" generated from risk–taking activities in terms of a reference point r.

From the empirical side, results in Chapter 3 argue that cultural differences can play an important role during the decision–making process under risk, which is consistent with the view that investors from different backgrounds frame their risk attitude in different ways and are subject to psychological biases (e.g., Chui et al., 2010; Beugelsdijk and Frijns, 2010; Frijns et al., 2013; Breuer et al., 2014). The cultural variation of DA challenges the traditional risk–based theories and contributes a new dimension to current behavioural literature. Additionally, consistent results are also found to support the assertion that investors tend to apply different rules to decide their holdings instead of assessing them as a portfolio. This tendency is classified as *narrow framing*, which is another popular idea among the behavioural studies (e.g., Berkelaar et al., 2004; Gomes, 2005; Barberis et al., 2006; Barberis and Huang, 2009).

Chapter 4 aims to investigate the impact of environmental stimuli (pleasant & unpleasant odours) on DA in a monetary gamble task. We elicited the level of DA based on an experimental procedure similar to Sokol-Hessner et al. (2009, 2013). Our study shows for the first time that unpleasant odours increase DA in a monetary gamble task. Odour–related individual variations in DA were associated with hedonic evaluations of odours but not with odour intensity. Increased disappointment aversion while perceiving an unpleasant odour suggests a dynamic adjustment of aversion towards greater sensitivity to losses. Given that odours are biological signals of hazards, such adjustment of disappointment aversion may have adaptive value in situations entailing threat or danger.

Chapter 5 provides the general conclusion and further directions of this study, which includes some realistic but also more complicated extensions, such as the general disappointment aversion (Routledge and Zin, 2010) which adopts a "fuzzy" reference point (outcomes become disappointment only if they fall sufficiently far below the certainty equivalent) and the dynamic portfolio choices over disappointment aversion (e.g., Barberis and Huang, 2009; De Giorgi and Legg, 2012). In particular, a more detailed discussion will be provided regarding the use of multiple reference points (Koop and Johnson, 2012).

1.3 Tables & Figures of This Chapter

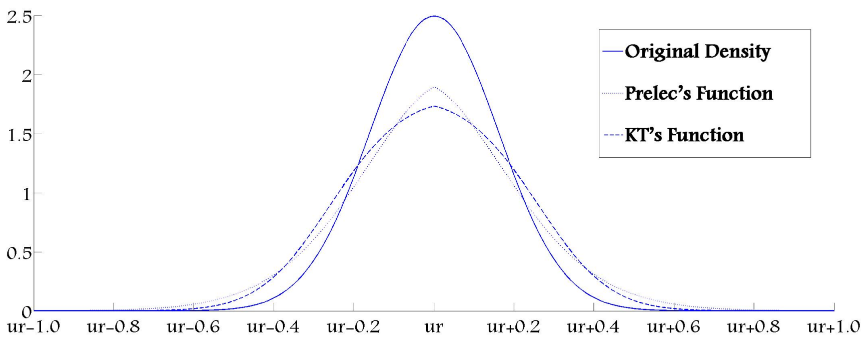
Table 1.1
Equity Premium in Selected Countries

This table presents real mean returns in selected countries. All data except India are sourced from the Global Investment Returns Yearbook 2012 distributed by *Morningstar*; data in India's refer to Mehra (2007).

Country	Period	Market Index	Risk–Free Security	Equity Premium
Australia	1900–2011	7.20%	0.70%	6.50%
Canada	1900–2011	5.70%	1.60%	4.10%
France	1900–2011	2.90%	-2.80%	5.70%
Germany	1900–2011	2.90%	-2.40%	5.30%
India	1991–2004	12.60%	1.30%	11.30%
Japan	1900–2011	3.60%	-1.90%	5.50%
Netherlands	1900–2011	4.80%	0.70%	4.10%
South Africa	1900–2011	7.20%	1.00%	6.20%
Sweden	1900–2011	6.10%	1.80%	4.30%
UK	1900–2011	5.20%	1.00%	4.20%

Figure 1.1
Probability Weighting Function vs. Original Density Function

This figure compares the KT's (Kahneman and Tversky) and Prelec's weighting functions to its original density function. The stock returns are supposed to follow a normal distribution with moments: $\mu_r = 10\%$, $standarddeviation = 0.1865$, and the curvature parameter is set to $\delta = 0.74$



Chapter 2

Disappointment Aversion and the Equity Premium Puzzle: New International Evidence

2.1 Introduction

A number of studies have shown that stocks outperform bonds over long horizons by a surprisingly large margin. For example, Mehra and Prescott (1985) report that the annual real return on the US stock market has exceeded that of bonds by about 6.36% over the last 116 years. This empirical regularity, commonly referred to as the "equity premium puzzle", is not unique to the US market but is also observed in other international markets. Dimson and Staunton (2006) and Mehra (2007) report a significant equity premium for several developed (e.g., UK–6.1%; Australia–8.5%; Germany–9.1%; Japan–9.8%) and developing markets (e.g., India–11.3%).

A large volume of empirical and theoretical research focuses on the origin and the drivers of the equity premium puzzle[2]. On the empirical side, the existence of a puzzle has been questioned by several researchers who interpret the "abnormal" stock returns as a statistical illusion driven by common biases (e.g., survivorship, success and selection bias) or the use of non–stationary data (Fama and French, 2002; Dimson and Staunton, 2006). On the theoretical side, various risk–related explanations have been proposed to stress the inadequacy of the standard risk paradigm: the risk–free rate puzzle (Weil, 1989); non–time–separable utility (Epstein and Zin, 1991); economic catastrophe concerns (Barro, 2006); idiosyncratic and uninsurable income risk (Constantinides and Duffie, 1996); and habit formation (Constantinides, 1990; Abel, 1990; Campbell and Cochrane, 1999; Campbell, 2001).

Behavioural finance has emerged in response to the failure of traditional models to fully explain investment behaviour. Its key assumption is that investors do not always make rational decisions (see Barberis and Thaler, 2003). Following a series of influential papers by Tversky and Kahneman (1974, 1979, 1992), a growing body of literature focuses on behavioural explanations of the equity premium puzzle. Fundamental to the prospect theory of Tversky and Kahneman (1979) is the concept of loss aversion, which refers to the tendency to

[2] DeLong and Magin (2009) and Mehra (2008) provide reviews on the equity premium puzzle and the various explanations that have been proposed in the literature.

prefer avoiding losses over acquiring gains. A similar, though not identical, concept of loss aversion is that of disappointment aversion. Gul (1991) develops an axiomatic disappointment aversion framework where agents form an endogenous expected certainty equivalent. Outcomes below that equivalent are treated as "disappointment". Since the reference point of disappointment aversion could possibly be higher than the *status quo*, even positive outcomes that lie below the reference point may still disappoint investors. Preferences that express disappointment aversion and loss aversion share the following three features: i) reference dependence; ii) diminishing sensitivity; and iii) a steeper value function of negative utility. The main difference stems from the way in which the reference point is determined in each case. In the case of loss aversion, a pre–set exogenous reference point is frequently applied, e.g., the *status quo* (see Tversky and Kahneman, 1979, 1992), and the risk–free rate (see Barberis and Huang, 2001; Barberis et al., 2001). In the case of disappointment aversion, the reference point is endogenously determined according to investors' former expectations (see Gul, 1991). Such a prospect–dependent feature is known as the certainty equivalent[3].

This study adopts a "behavioural" perspective and attempts to provide further insights into the drivers of the equity premium puzzle. In particular, drawing upon the portfolio choice model of Ang et al. (2005), we incorporate disappointment aversion within a simple theoretical asset allocation model. Based on the results of this model, we then empirically address the portfolio allocation problem of an investor who chooses between a risky and a risk–free asset. An important contribution is the international nature of our study. While Ang et al. (2005) focus exclusively on the US market over the period 1926–1998, our analysis is based on the Dimson–Marsh–Staunton (DMS) database distributed by *Morningstar*[4], which contains data spanning 112 years of history

[3]The choice of an exogenous or endogenous reference point is particularly relevant in applications that consider long investment horizons. For example (Fielding and Stracca, 2007), show that, under a fixed reference point, the loss aversion parameter is inflated to 25 at the 10–year horizon. In contrast, under a reference point that is endogenously determined, the disappointment aversion parameter only mildly increases to 2.5.

[4]Dimson et al. (2008) demonstrate that equity premiums around the world can be overstated due to a series of ex–post selection biases. Common forms of such biases include survivorship, success,

across 19 countries and is free of ex–post selection bias. This is important because the magnitude of the equity premium differs significantly across markets (see Dimson and Staunton, 2006; Mehra, 2008). Extending the study of the equity premium puzzle to the global market helps to understand whether such differences can be attributed to behavioural or non–risk–based explanations (e.g., differences in borrowing constraints, transaction costs, etc.). To our knowledge, this is the first paper to examine whether disappointment aversion plays a role in explaining the international equity premium puzzle.

Our findings strongly confirm the view that disappointment aversion leads investors to reduce their exposure to the stock market (i.e., disappointment aversion significantly depresses the portfolio weights on equities in all cases considered). Our analysis also helps to determine the optimal weights between the risky and risk–free assets for each considered markets. The key result that emerges from our study is that optimal equity proportions around the world are jointly determined by the levels of risk and disappointment aversion. Taken together, these findings enhance our understanding of the sources of the international equity premium puzzle.

The remainder of this chapter is organized as follows: Section 3.2 presents a simple asset allocation framework under disappointment aversion, which draws upon Ang et al. (2005). Section 3.3 provides details about the dataset utilized and Section 3.4 presents our results. Finally, Section 3.5 concludes this chapter.

2.2 The Disappointment Aversion Asset Allocation Framework

This section presents the classical asset allocation framework under preferences that exhibit disappointment aversion (see Gul, 1991; Ang et al., 2005). Drawing upon Ang et al. (2005), the utility maximization problem can be

and look–ahead. Given the nature of our study, which seeks to identify the drivers of the equity premium around the world, an overstatement or understatement of the magnitude of the equity premium could lead to misleading inferences. For example, an overestimated equity premium in one market would suggest excessive investments in equities. Then the degree of disappointment aversion would be exaggerated so that an "optimal" portfolio was maintained. The use of the DMS database ensures that such problems do not apply in our empirical analysis.

expressed as follows:

$$\max_{\alpha \in [0,1]} U(\mu_w). \tag{2.1}$$

The DA utility is defined by

$$U(\mu_w) = \frac{\int_{-\infty}^{\mu_w} U(W)dF(W) + A\int_{\mu_w}^{\infty} U(W)dF(W)}{Pr(W \leq \mu_w) + APr(W > \mu_w)}, \tag{2.2}$$

where μ_w refers to the certain level of wealth that generates the same utility determined by the optimal weights to equities. This is referred to as the certainty equivalent. $U(\cdot)$ is the CRRA power utility in the form of $U(W) = W^{1-\gamma}/(1-\gamma)$ [5]; A is the coefficient of disappointment aversion (where $0 < A < 1$[6]). $F(\cdot)$ is the cumulative distribution function for wealth W. The first–order condition (FOC) for the DA investor is given by the following expression:

$$\mathbb{E}\left[\frac{\partial U(W)}{\partial W}(exp(y) - exp(r))\mathbf{1}_{W \leq \mu_w}\right] + A\mathbb{E}\left[\frac{\partial U(W)}{\partial W}(exp(y) - exp(r))\mathbf{1}_{W > \mu_w}\right], \tag{2.3}$$

where **1** is an indicator function and $\mathbb{E}$ refers to the expected value of the certainty equivalent. According to Eq. (2.3) above, the DA utility function only concentrates on the differentiation between terminal wealth levels and μ_w, and neither previous losses nor gains will be taken into account directly. Let α represent the proportion of equity investment. The ending period wealth (denoted by W) is defined as follows:

$$W = \alpha W_0(exp(y) - exp(r)) + W_0 exp(r). \tag{2.4}$$

In this framework, the investor chooses between the risky asset y (i.e., equity) and the risk–free asset r (i.e., Treasury bills). The term α refers to the proportion of wealth invested in the risky asset while α^* is the optimal weight. If μ_w is known,

[5] Using different forms of utility, empirical studies with similar preferences find consistent results. For instance, within a classical power function, Barberis and Huang (2001) report a positive link between loss aversion and stock returns. Similarly, by utilising a standardized two–piece power function, Hwang and Satchell (2010) find a negative relationship between stock holdings and loss aversion.

[6] To ease the comparison with Ang et al. (2005), the coefficient A is placed in front of elation; this requires $0 < A < 1$ to over–weight the disappointment. However, in Chapters 3 and 4, the coefficient A is placed in front of disappointment so that $A > 1$ represents extra aversion to disappointment.

α^* can be calculated by solving Eq. (2.3). The tricky part is that μ_w is also a function of α, which means that a system of simultaneous equations has to be solved (Eqs. (2.2) and (2.3)). In this study, we develop an algorithm of numerical quadrature which converts Eqs. (2.2) and (2.3) into the following form[7]:

$$\mu_w^{1-\gamma} = \frac{\sum\limits_{s:W_s \leq \mu_w} p_s W_s^{1-\gamma} + A \sum\limits_{s:W_s > \mu_w} p_s W_s^{1-\gamma}}{Pr(W \leq \mu_w) + APr(W > \mu_w)}, \tag{2.5}$$

$$\sum_{s:W_s \leq \mu_w} p_s W_s^{-\gamma}(exp(y_s) - exp(r)) + A \sum_{s:W_s > \mu_w} p_s W_s^{-\gamma}(exp(y_s) - exp(r)) = 0. \tag{2.6}$$

Using Eqs. (2.5) and (2.6), one can solve the optimal asset allocation problem and determine the α^*. This can be done using a series of bisection searches to identify the correct excess return interval and as a result determine the optimal weights[8].

Solving the system above provides optimal weights that usually lie between the interval [0, 1]. A value of α^* that equals 0 implies that the optimal portfolio choice includes no exposure to the equity market (i.e., risky asset). A value of α^* that equals 1 implies that all wealth is invested in equities. Our model is not restricted to producing weights only within the [0, 1] interval. A negative weight implies that investors anticipate under performance of the equity market, leading them to take short (optimal) positions on equities. On the contrary, a weight greater than 1 indicates that the optimal strategy involves borrowing for the purchase of equity. As shown in Section 4.1, our algorithm produces optimal weights that are similar to those obtained by Ang et al. (2005) in the case of the US market. The aim of this chapter is to extend their framework to an international context and examine the role of disappointment aversion in the equity premium puzzle around the world.

2.3 Data and Descriptive Statistics

For the empirical analysis, we use the Dimson–Marsh–Staunton (DMS) database distributed by *Morningstar*. The main advantage of this database is that it is free of ex–post selection bias, a common problem in the empirical literature

[7] See Appendix for details.

[8] Further details about the bisection search procedure can be found in Appendix B.

on the equity premium puzzle. Our final sample is obtained by the 2012 Global Investment Returns Yearbook[9] and contains data spanning 112 years of history (from 1900 to 2011) across 19 countries: Australia, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, South Africa, Spain, Sweden, Switzerland, the UK and the US. Our final sample comprises more than 85% of total market capitalization around the world. In addition to the DMS database, we use return data from the Center for Research in Security Prices (CRSP) in order to replicate the findings of Ang et al. (2005) for the US market (see Section 2.4.1 for details). The main stock market index in each case represents investments in the risky asset. For the risk–free benchmark, we focus on T–bills issued in each country[10].

Table 2.1 presents some descriptive statistics of our data. The equity premium lies between 2.80% in Belgium and 6.50% in Australia. The annual equity return on the US (UK) stock market is 6.20% (5.20%); this represents a notable 5.30% (4.20%) premium over the US (UK) bills returns. At a global and European level, the out performance of stocks over T–bills is 4.50% and 3.70%, respectively.

An interesting finding that emerges from Table 2.1 is that higher returns are not always associated with higher volatilities (e.g., the highest volatility observed in the German stock market (at 32.20%) is associated with one of the lowest equity returns (at 2.90%)). One potential explanation is the following. Classic asset pricing models such as the capital asset pricing model (CAPM) of Sharpe (1964) and Lintner (1965) suggest that higher volatilities command higher equity premiums. However, the empirical evidence on the relationship between risk and return is still mixed and inconclusive. While a significant body of research supports the traditional positive return–risk trade–off (e.g., see Bollerslev et al., 1988; Harvey, 1989; Ghysels et al., 2005), another strand in the literature reports results that reject this view (e.g., see Campbell, 1987; Breen

[9]See Credit Suisse: Global Investment Returns Yearbook 2012. This report is associated with the work of Elroy Dimson, Paul Marsh and Mike Staunton, whose book Triumph of the Optimists (Princeton University Press, 2002) has had a major influence on investment analysis.

[10]Short–term T–bills (Treasury bills) are often backed by government finance which immunizes them from defaults. The rates of T–bills could be regarded as a pure representation of the cost of money. As a result, T–bills represent an appropriate proxy for the “risk–free” asset.

et al., 1989). A third group of studies further suggests that the relation between risk and return is time–varying (e.g., see French et al., 1987; Campbell and Hentschel, 1992). We argue that one needs to go beyond risk aversion to fully understand the nature of the risk–return trade–off. Put differently, investors are not only concerned about volatility when making investment decisions, but also about the frequency of outcomes that are worse than prior expectations. In what follows, we demonstrate that, in addition to risk aversion, disappointment aversion significantly suppresses equity holdings (i.e., investments in the risky asset). In this way, our findings provide useful insights into the ambiguous risk–return relationship.

[Insert TABLE 2.1 about here]

2.4 Empirical Results

2.4.1 Replicating the Optimal Portfolio Weights of Ang et al. (2005)

Before presenting the optimal portfolio weights for the cases considered in our sample, we provide some preliminary evidence that confirms the validity of the algorithm used in our study to solve the portfolio choice problem. In particular, we try to replicate the optimal weights of Ang et al. (2005) for the case of the US market. Given that our DA framework embeds an endogenous certainty equivalent (see Gul, 1991; Ang et al., 2005), the impact of the rebalancing period becomes less of an issue (see Benartzi and Thaler, 1995; Fielding and Stracca, 2007). We therefore focus on overall sample means to calculate the optimal weights. Table 2.2 presents the summary statistics of the data used in order to conduct such an exercise. Over the 1926–1998 period, equities generated a nominal rate of return of 2.66% per quarter (10.64% annualized). Over the same period, the annual rate of return for T–bills was 4.08%. As expected, equities exhibited a much higher standard deviation compared to T–bills (21.94% vs. 1.72%).

[Insert TABLE 2.2 about here]

Table 2.3 presents the optimal weights produced from our algorithm and compares them with those reported in Ang et al. (2005). For ease of comparison, we present results for different levels of risk aversion ($\gamma = 2$ and $\gamma = 5$) and disappointment aversion (from 0.65, which represents a high DA aversion, to 1, which represents no DA aversion). Our optimal weights are very similar to those reported in Ang et al. (2005). Some differences across certain values of A and γ are due to differences in the investment horizon considered (horizon effect). The weight differences (Diff) is obtained using (our weights – Ang's weights)/Ang's weight. it tend to decrease as disappointment aversion declines, and essentially disappear in the case when there is no DA aversion ($A = 1$). The results also show that our weights are comparable to the ones in Ang et al. (2005) for different levels of risk aversion ($\gamma = 2$ and $\gamma = 5$). Finally, it is interesting to note our A^* value (i.e., the lowest level of A before investors become unwilling to invest any of their wealth in the equity market) is identical to the one reported in Ang et al. (2005) (i.e., $A^* = 0.6030$).

[Insert TABLE 2.3 about here]

2.4.2 Optimal Portfolio Weights

Based on return statistics listed in Table 2.1 (sourced from Credit Suisse: Global Investment Returns Yearbook 2012), Table 2.4 reports the optimal portfolio weights for each of the 19 countries considered in our sample. For ease of comparison with Ang et al. (2005), it is reasonable to assume that relative risk aversion γ is somewhere between 1 and 4. We let the initial coefficient equal 2 and report how the optimal weights change for different levels of disappointment aversion. Panel A reports the results for Eurozone countries (Belgium, Finland, France, Germany, Ireland, Italy, the Netherlands, and Spain). Panel B reports the optimal weights for European countries from outside the Eurozone area (Denmark, Norway, Sweden, Switzerland and the UK) while Panel C reports the optimal weights for non–European countries (Australia, Canada, Japan, New Zealand, South Africa and the US) as well as two composite European and Global indices.

[Insert TABLE 2.4 about here]

The results support a strong negative relationship between the level of disappointment aversion and the optimal weight of equities. This holds for all countries considered. More specifically, the results in Panel A suggest that investors should keep their equity exposure to a level higher than 50% (i.e., from 50.1% in Belgium to 78.5% in France) when preferences do not exhibit disappointment aversion ($A = 1$). However, as the level of DA increases (i.e., A declines), the optimal weight on equities becomes significantly lower and reaches negative values for very high levels of DA (i.e., $A \leq 0.65$). Also, the results show significantly different A^* values across countries. For example, the presence of disappointment aversion depresses equity holdings more severely in Belgium ($A^* = 0.744$) than in France ($A^* = 0.629$).

The negative relationship between disappointment aversion and equity exposure is also obvious in Panels B and C. Investors in European countries from outside the Eurozone area exhibit preferences that are characterized by a strong disappointment aversion (i.e., $A^* > 0.677$ in all cases), leading to relatively low exposure to the equity market (e.g., the optimal weight turns to negative for the case of Denmark at intermediate levels of DA, i.e., $A = 0.75$). Finally, the results in Panel C confirm the negative relationship between the level of DA and equity exposure in the case of non–European countries and, also, for portfolios constructed on the basis of global/European equity indices. It is also worthwhile to note that investors in Australia exhibit the lowest level of $A^* = 0.566$ from all cases considered, which drives the high exposure to the equity market (within our hypothetical DA levels from 0.6 to 1, the optimal weight never becomes negative). Also, Japanese investors maintain very conservative equity holdings for most DA levels, but they start to purchase stocks just after A reaches 0.656, showing a greater "tolerance" than investors from Canada (0.665) and New Zealand (0.685). Taken together, the following inferences can be drawn so far. First, the highest stock holdings are always associated with the case of no DA ($A = 1$), with the equity market being incredibly attractive in countries such as Australia, Canada, the US and South Africa. Second, the optimal weights are significantly depressed as the level of DA increases. Third, when DA reaches very high levels, equity weights may even drop below zero, which means that an optimal investment strategy involves shorting (rather than holding) equities.

Figure 2.1 depicts A^* values against equity premiums. It seems that higher equity premiums lead to smaller A^* values for most countries. This implies that investors are less concerned about disappointment aversion when stocks significantly outperform T–bills. For example, France has a lower A^* than Belgium (0.629 vs. 0.774), which is due to a much higher equity premium observed in the French equity market (5.7% vs. 2.8%). Moreover, it is also evident that A^* values are driven not only by equity premiums but also by differences in stock market volatilities. Another example (see Finland vs. Italy) might help to explain this further. While both countries have an identical equity premium at 5.5%, the lower volatility of 29.0% in Italy (compared to 30.4% in Finland) leads into a lower A^* (0.657 vs. 0.658). The mechanism that drives such a relationship is straightforward. Better market conditions (in the form of higher mean returns or lower volatilities) make risky investments (exposure to the equity market) more appealing. Investors therefore tend to be more resistant towards disappointment aversion. Additionally, higher expectations toward future profit opportunities may also attract new investors. Such effects help to further reduce the value of A^*.

[Insert FIGURE 2.1 about here]

Figure 2.2 presents evidence supporting the view that optimal equity proportions are jointly determined by the levels of risk and disappointment aversion. Specifically, it provides a graphical representation of how the optimal weight is affected by changes in both the levels of DA and risk aversion. A separate graph is presented for each country considered. The 3D feature of these graphs facilitates an understanding of how different combinations of disappointment/risk aversion affect the level of equity holdings. The results suggest a negative relationship between risk aversion and equity exposure in cases when investors' preferences do not exhibit disappointment aversion (i.e.,

$A = 1$). For a given level of risk and disappointment aversion, equity exposure tends to increase either due to a higher equity premium or due to a lower standard deviation. Figure 2.2 also shows important differences in the shape of the 3D graphs across countries. This is mainly due to variations in risk and disappointment aversion, which both affect equity proportions in a non–linear way. More specifically, optimal equity holdings decline along with a higher risk aversion in a convex manner. This convexity is more pronounced at milder levels of disappointment aversion (i.e., when A values are greater than 0.85). In contrast, since the disappointment aversion parameter is multiplied by the disappointment–utility, an increasing disappointment aversion depresses equity holdings almost in a linear way. Furthermore, variations of disappointment aversion lead into a stronger impact on stock holdings when risk aversion is relatively low (i.e., for gamma values between 2 and 4). Overall, these findings strongly support the view that assessing investors' risk attitudes with both risk and disappointment aversion grants a more reasonable solution to the equity premium puzzle around the world.

[Insert FIGURE 2.2 about here]

2.5 Conclusion

Stocks have outperformed bonds over the last century by a surprisingly large margin (Benartzi and Thaler, 1995). Such outperformance cannot be fully justified in the context of standard portfolio choice models. Drawing upon the portfolio choice model of Ang et al. (2005), which allows for disappointment aversion (i.e., aversion to outcomes worse than prior expectations), this study attempts to provide a "behavioural" explanation for the worldwide equity premium. We firstly incorporate disappointment aversion in a simple theoretical portfolio choice model. We generate an algorithm of numerical approximation to solve the portfolio allocation problem and identify how optimal weights (i.e., equity exposure) relate to different levels of disappointment aversion. For the empirical analysis, we consider the Dimson–Marsh–Staunton (DMS) database from *Morningstar*, which covers 19 countries over the period 1900–2011 and is also free of ex–post selection bias. Our findings strongly support the view that, in addition to the risk aversion, disappointment aversion further leads investors to reduce their exposure to the stock market (i.e., disappointment aversion significantly depresses the weights of equities in all cases considered). We further show that optimal equity proportions are jointly determined by the levels of risk and disappointment aversion. Taken together, findings of this chapter enhance our understanding of the sources of the equity premium puzzle around the world.

2.6 Tables & Figures of This Chapter

Table 2.1
Descriptive Statistics of Worldwide Equity Premiums

This table presents information about the level of equity premium for all countries considered in our analysis over the period 1900–2011. All data is obtained from the Global Investment Returns Yearbook 2012 and are also annualized.

Countries	Equity Returns	Bills Returns	Equity premium	Equity S.D.
Australia	7.20%	0.70%	6.50%	18.20%
Belgium	2.40%	-0.40%	2.80%	23.60%
Canada	5.70%	1.60%	4.10%	17.20%
Denmark	4.90%	2.20%	2.70%	20.90%
Finland	5.00%	-0.50%	5.50%	30.40%
France	2.90%	-2.80%	5.70%	23.50%
Germany	2.90%	-2.40%	5.30%	32.20%
Ireland	3.70%	0.70%	3.00%	23.10%
Italy	1.70%	-3.60%	5.30%	29.00%
Japan	3.60%	-1.90%	5.50%	29.80%
Netherlands	4.80%	0.70%	4.10%	21.80%
New Zealand	5.80%	1.70%	4.10%	19.70%
Norway	4.10%	1.20%	2.90%	27.30%
South Africa	7.20%	1.00%	6.20%	22.50%
Spain	3.40%	0.30%	3.10%	22.20%
Sweden	6.10%	1.80%	4.30%	22.90%
Switzerland	4.10%	0.80%	3.30%	19.70%
UK	5.20%	1.00%	4.20%	19.90%
US	6.20%	0.90%	5.30%	20.20%
Europe	4.60%	0.90%	3.70%	21.50%
World	5.40%	0.90%	4.50%	17.70%

Table 2.2
S&P 500 and Treasury Bill Returns from CRSP

This table presents descriptive statistics on equity returns (from S&P 500) and Treasury bill returns (90–day T–bills) over the period 1926–1998. This data is obtained from CRSP and used to replicate the optimal weights of Ang et al. (2005) for the case of the US market. All data are quarterly. Excess returns refer to stock returns in excess of T–bill returns. Its quarterly mean and standard deviation are calculated using the excess return series. Then the quarterly excess returns are annualised by multiplying four. Likewise, the standard deviations of quarterly excess returns are annualised by multiplying two.

		Equity	T–Bill	Equity minus T–Bill
Mean	Quarterly	2.66%	1.02%	1.64%
	Annualized	10.64%	4.08%	6.56%
S.D.	Quarterly	10.97%	0.86%	10.99%
	Annualized	21.94%	1.72%	21.98%

Table 2.3
Replicating the Optimal Weights of Ang et al. (2005)

This table presents the optimal weights produced from our algorithm and compares them with those reported in Ang et al. (2005). For ease of comparison, we present results for different values of risk aversion ($\gamma = 2$ and $\gamma = 5$). The weight differences (Diff) is obtained using (our weights – Ang's weights)/Ang's weight.

	Curvature Parameter $\gamma = 2$			Curvature Parameter $\gamma = 5$		
A	Ang's weights	Our weights	Diff.	Ang's weights	Our weights	Diff.
1.00	0.927	0.932	0.539%	0.370	0.372	0.541%
0.95	0.833	0.839	0.720%	0.332	0.335	0.904%
0.90	0.734	0.741	0.954%	0.293	0.296	1.024%
0.85	0.628	0.638	1.592%	0.250	0.254	1.600%
0.80	0.517	0.528	2.128%	0.206	0.210	1.942%
0.75	0.398	0.411	3.266%	0.158	0.164	3.797%
0.70	0.271	0.286	5.535%	0.108	0.114	5.556%
0.65	0.136	0.153	12.500%	0.054	0.061	12.963%

Table 2.4
Optimal Portfolio Weights under Different A Values

This table reports the optimal portfolio weights for each of the 19 countries considered in our analysis. For ease of comparison with Ang et al. (2005), we set coefficient of risk aversion to 2 and report how the optimal weights change for different levels of disappointment aversion.

Panel A: Optimal Weights for Countries from the Eurozone

A	Belgium	Finland	France	Germany	Ireland	Italy	Nether-lands	Spain
0.600	-0.351	-0.118	-0.077	-0.103	-0.341	-0.120	-0.183	-0.343
0.650	-0.222	-0.016	0.056	-0.008	-0.208	-0.014	-0.041	-0.205
0.700	-0.101	0.079	0.180	0.082	-0.084	0.086	0.092	-0.076
0.750	0.014	0.168	0.296	0.166	0.033	0.180	0.218	0.047
0.800	0.122	0.253	0.406	0.246	0.144	0.268	0.336	0.162
0.850	0.225	0.333	0.509	0.322	0.249	0.352	0.447	0.271
0.900	0.322	0.408	0.606	0.393	0.348	0.431	0.552	0.374
0.950	0.414	0.480	0.698	0.461	0.442	0.506	0.651	0.472
1.000	0.501	0.548	0.785	0.525	0.531	0.577	0.745	0.565
A^*	0.744	0.658	0.629	0.654	0.736	0.657	0.665	0.731
ERP	0.028	0.055	0.059	0.057	0.030	0.055	0.047	0.031
S.D.	0.236	0.304	0.235	0.322	0.231	0.290	0.218	0.222

Table 2.4 (continued)
Optimal Portfolio Weights under Different A Values

This table reports the optimal portfolio weights for each of the 19 countries considered in our analysis. For ease of comparison with Ang et al. (2005), we set coefficient of risk aversion to 2 and report how the optimal weights change for different levels of disappointment aversion.

Panel B: Optimal Weights for European Countries outside the Eurozone

A	Denmark	Norway	Sweden	Switzerland	UK
0.60	-0.416	-0.291	-0.232	-0.35	-0.236
0.65	-0.269	-0.18	-0.097	-0.193	-0.08
0.70	-0.132	-0.076	0.029	-0.046	0.066
0.75	-0.002	0.023	0.148	0.092	0.203
0.80	0.12	0.117	0.26	0.222	0.333
0.85	0.236	0.205	0.366	0.345	0.454
0.90	0.345	0.289	0.466	0.461	0.569
0.95	0.449	0.369	0.561	0.571	0.678
1.00	0.548	0.444	0.651	0.676	0.781
A^*	0.751	0.738	0.688	0.716	0.677
ERP	0.027	0.029	0.042	0.033	0.042
S.D.	0.209	0.273	0.229	0.197	0.199

Table 2.4 (continued)
Optimal Portfolio Weights under Different A Values

This table reports the optimal portfolio weights for each of the 19 countries considered in our analysis. For ease of comparison with Ang et al. (2005), we set coefficient of risk aversion to 2 and report how the optimal weights change for different levels of disappointment aversion.

Panel C: Optimal Weights for non–European Countries

A	Australia	Canada	Japan	New Zealand	South Africa	US	World	Europe
0.60	0.125	-0.233	-0.113	-0.261	-0.037	-0.114	-0.19	-0.3
0.65	0.297	-0.052	-0.01	-0.104	0.102	0.04	-0.014	-0.156
0.70	0.458	0.118	0.087	0.044	0.232	0.185	0.151	-0.022
0.75	0.608	0.277	0.179	0.183	0.354	0.32	0.305	0.105
0.80	0.748	0.426	0.265	0.313	0.468	0.447	0.45	0.224
0.85	0.879	0.567	0.346	0.436	0.575	0.567	0.587	0.337
0.90	1.003	0.699	0.423	0.552	0.677	0.68	0.716	0.443
0.95	1.12	0.825	0.496	0.662	0.772	0.787	0.837	0.544
1.00	1.229	0.943	0.566	0.766	0.863	0.888	0.952	0.64
A^*	0.566	0.665	0.656	0.685	0.613	0.637	0.654	0.708
ERP	0.065	0.041	0.056	0.04	0.062	0.052	0.044	0.036
S.D.	0.182	0.172	0.298	0.197	0.225	0.202	0.177	0.215

Figure 2.1
Equity Risk Premium vs. Disappointment Aversion

This figure depicts the relationship between A^* and equity risk premium. For ease of comparison with Ang et al. (2005), we set the coefficient of risk aversion γ to 2.

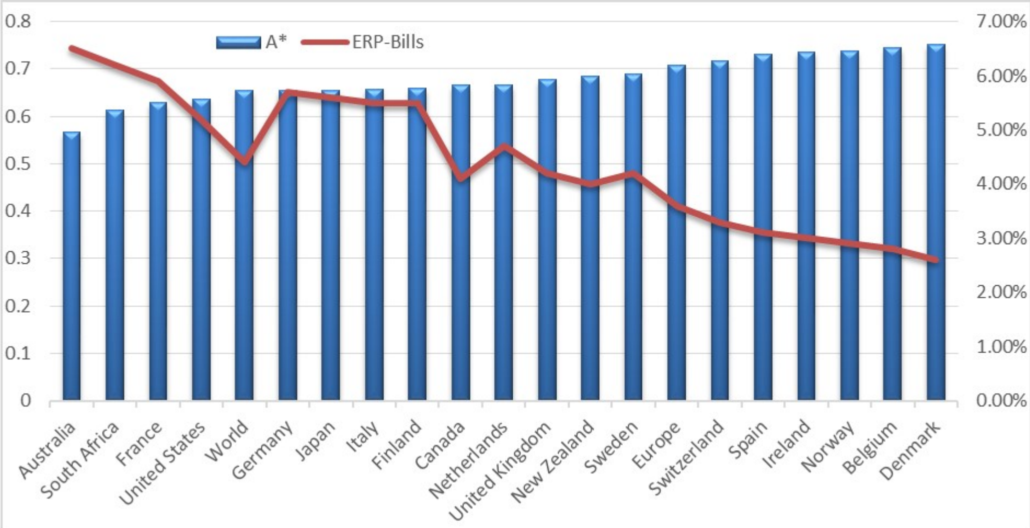
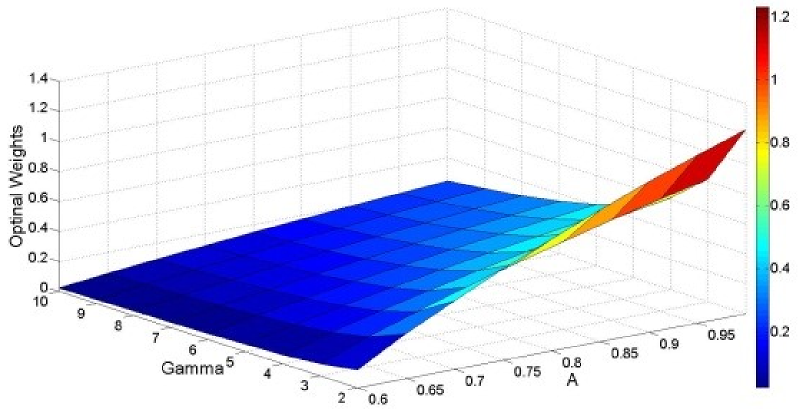
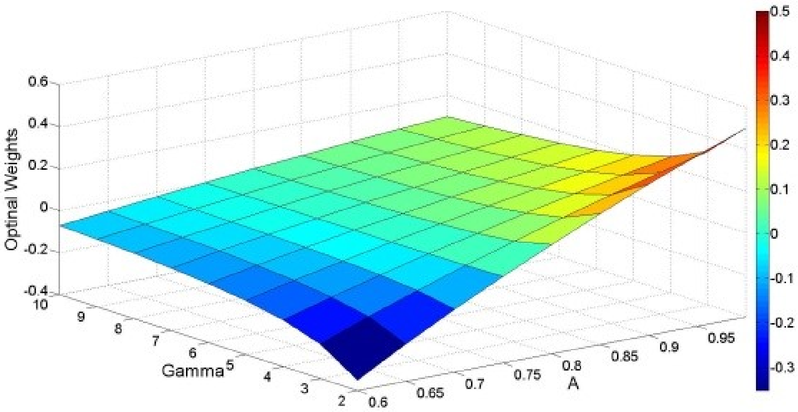


Figure 2.2
Optimal Weights under Different Risk and Disappointment Aversion

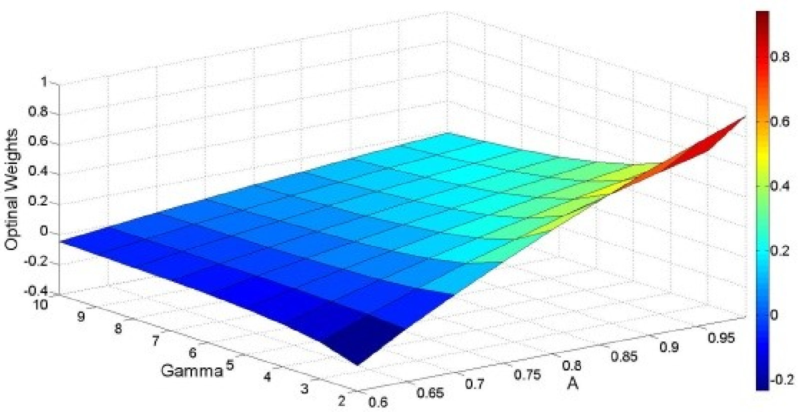
This figure presents the optimal weights for each case considered (19 countries and two indices) across different levels of risk aversion (γ) and disappointment aversion (A).



(a) Australia

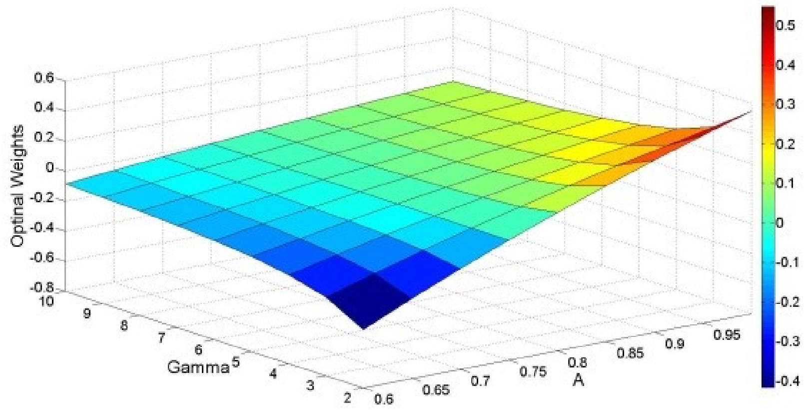


(b) Belgium

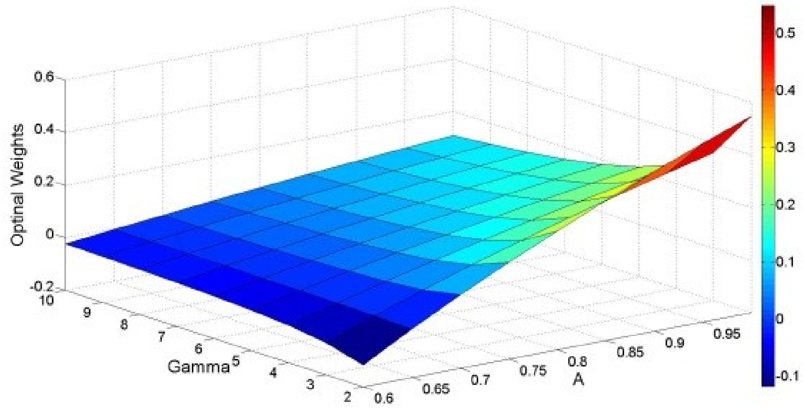


(c) Canada

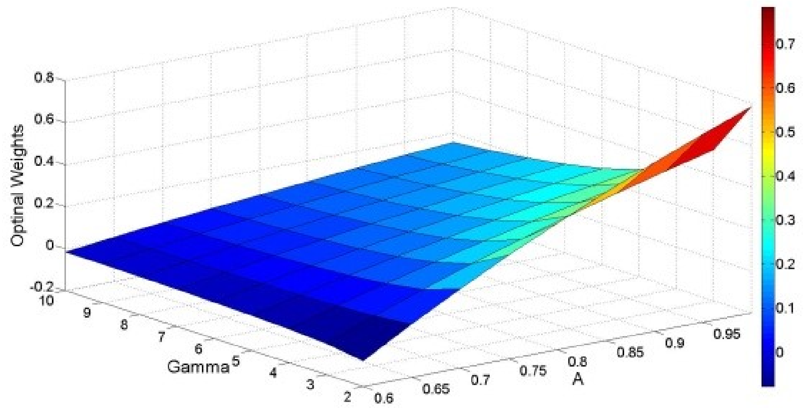
Figure 2.2 (continued)
Optimal Weights under Different Risk and Disappointment Aversion



(d) Denmark

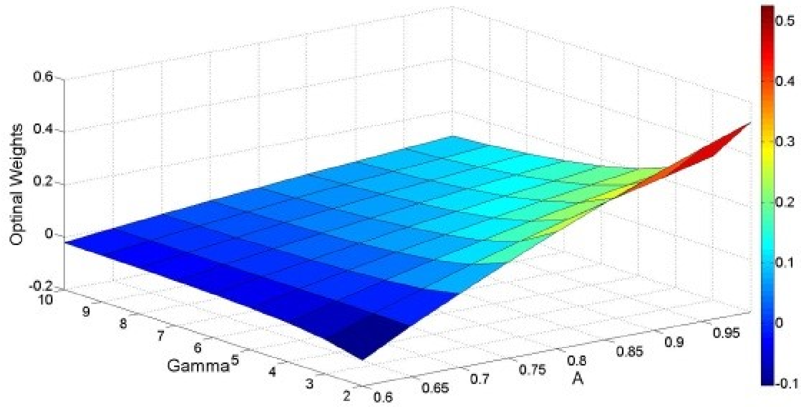


(e) Finland

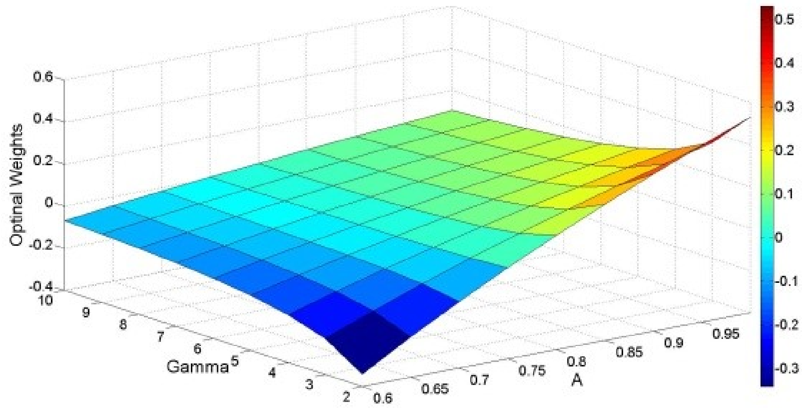


(f) France

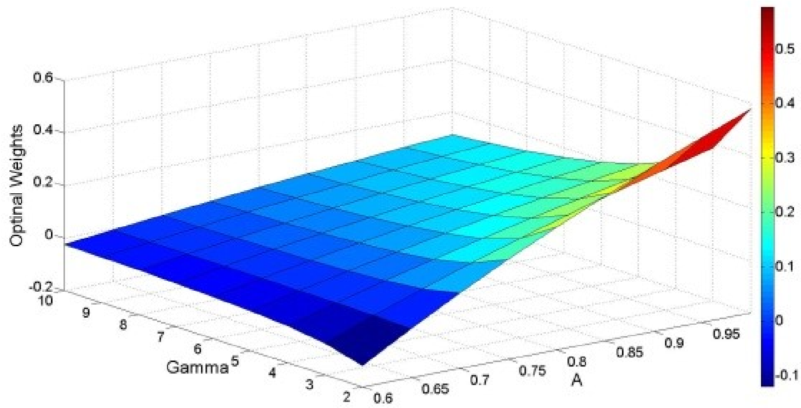
Figure 2.2 (continued)
Optimal Weights under Different Risk and Disappointment Aversion



(g) Germany

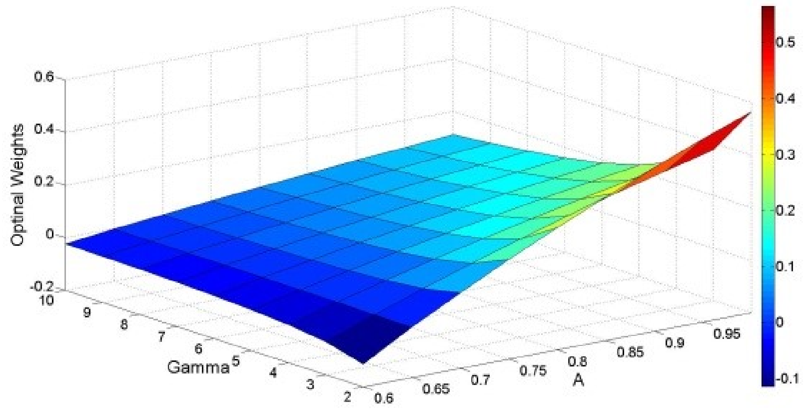


(h) Ireland

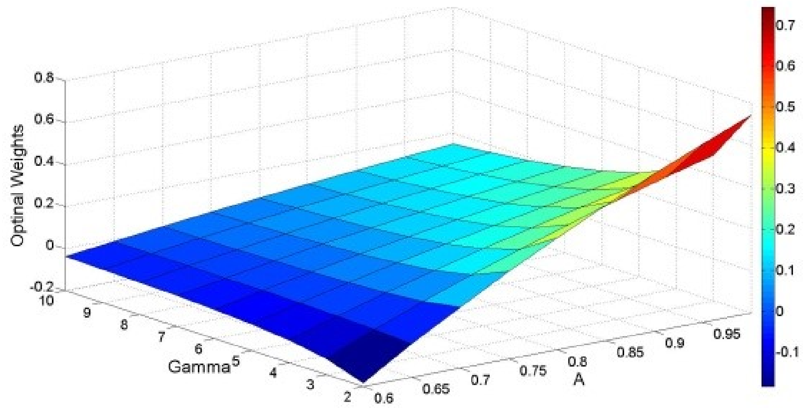


(i) Italy

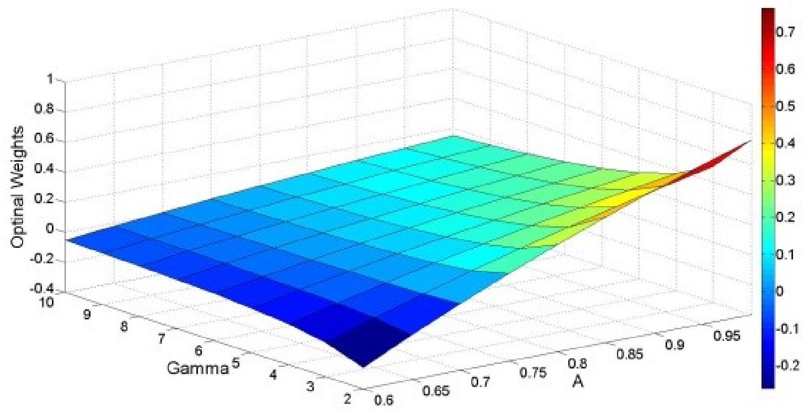
Figure 2.2 (continued)
Optimal Weights under Different Risk and Disappointment Aversion



(j) Japan

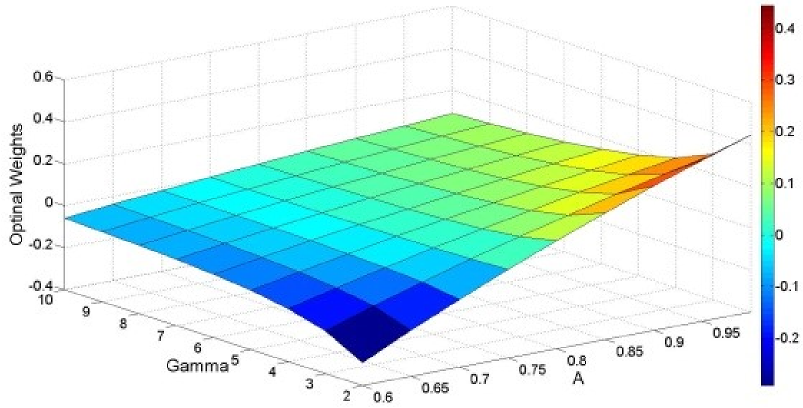


(k) Netherlands



(l) New Zealand

Figure 2.2 (continued)
Optimal Weights under Different Risk and Disappointment Aversion



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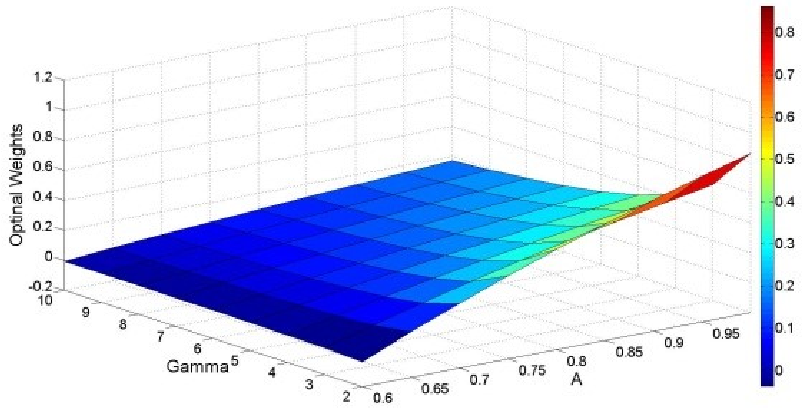
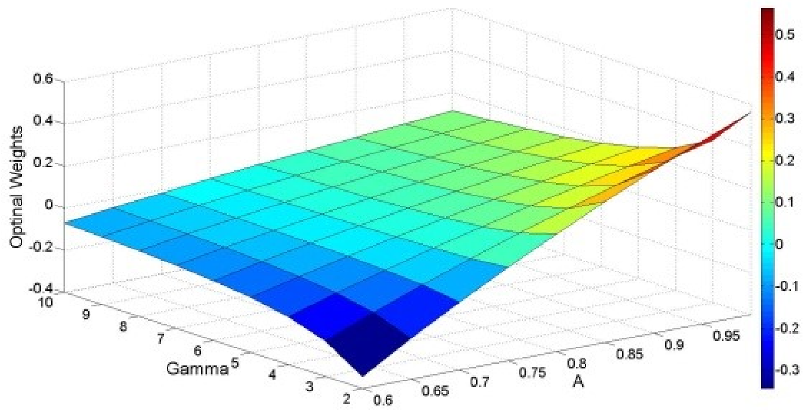
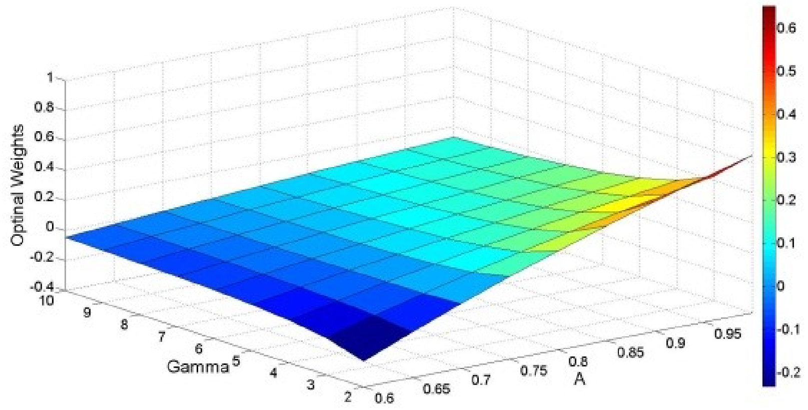


(n) South Africa

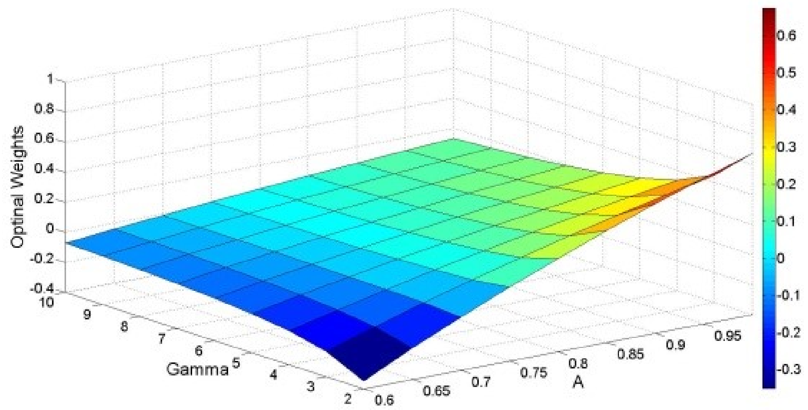


(o) Spain

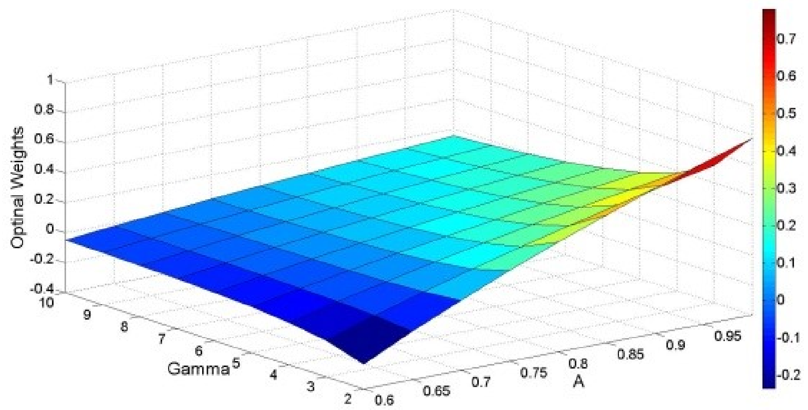
Figure 2.2 (continued)
Optimal Weights under Different Risk and Disappointment Aversion



(p) Sweden

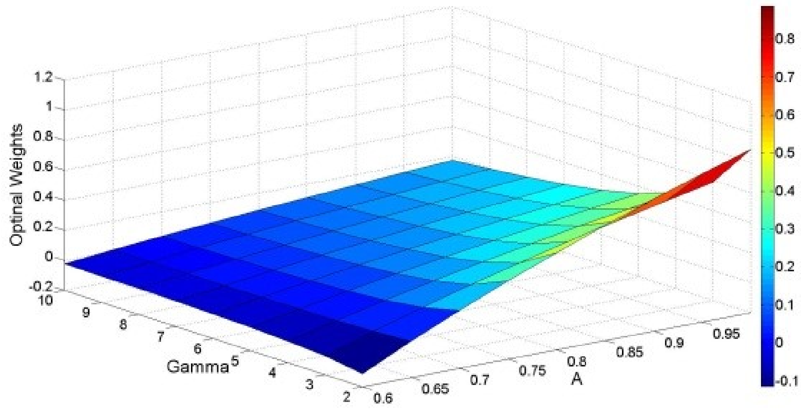


(q) Switzerland

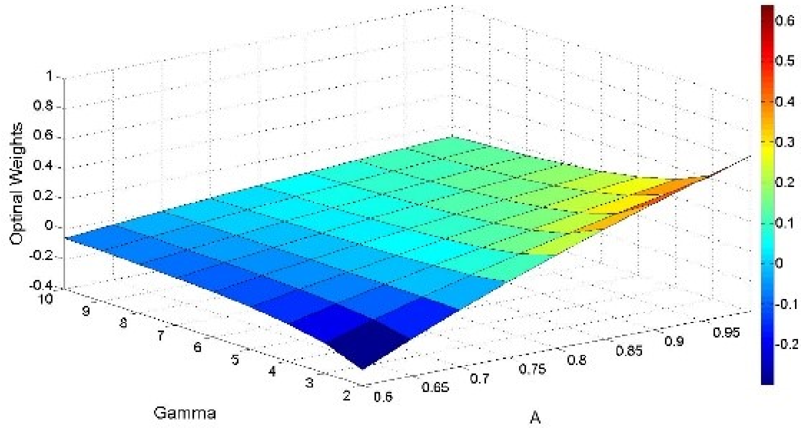


(r) United Kingdom

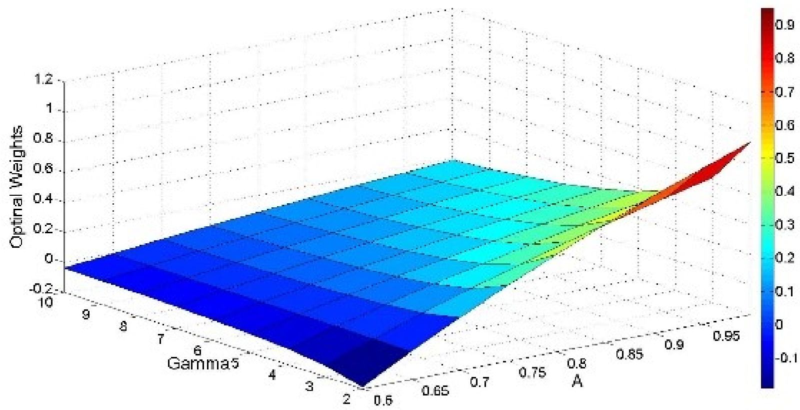
Figure 2.2 (continued)
Optimal Weights under Different Risk and Disappointment Aversion



(s) United States



(t) Europe



(u) World

Chapter 3

A Cross–Cultural Study of Financial Risk–Taking: Individualism and Disappointment Aversion around the World

3.1 Introduction

Since the introduction of disappointment aversion (DA henceforth) of Gul (1991), the DA utility together with loss aversion has been widely used for the explanation of investors' behaviour in financial markets. These utility functions, i.e., treating gains and losses rather than the total wealth and imposing heavier weights on disappointment (losses) than elation (gains), have attracted a lot of attention in the literature (e.g., Lien and Wang, 2002, 2003; Ang et al., 2005; Fielding and Stracca, 2007; Abdellaoui and Bleichrodt, 2007; Routledge and Zin, 2010; Gill and Prowse, 2012). However, the detailed specifications of these utility functions are not clear due to their unknown parameters, e.g., how investors' respond to disappointment. Other characteristics of DA utility such as the relationship between DA and risk aversion or changes in DA to wealth levels have yet to be investigated. The purpose of this chapter is to scrutinise investors' disappointment aversion and its impacts on asset pricing in order to answer these questions.

We propose a utility function that consists of wealth (consumption) utility as well as DA utility, as in Koszegi and Rabin (2007) and Barberis (2013). The wealth utility reflects the absolute utility from wealth levels which has been used in economics and finance, whereas the DA utility depends on gains and losses calculated with respect to the (endogenous) expected wealth. Our overall utility would help avoid misleading results by ignoring either gains and losses or wealth levels (Barberis, 2013). By interpreting the DA utility as a risk measure (Jia and Dyer, 1996) and assuming that utility is additively separable as in Koszegi and Rabin (2007). We analytically obtain several interesting relationships between the optimal investment proportions, levels of DA and risk aversion, expected excess returns, elation, and disappointment. The analytical relationships are then tested using asset allocations of pension funds in 35 OECD countries.

We find that the effects of risk and disappointment on asset allocation are different. *Ceteris paribus*, optimal investment proportions in risky assets decrease when investors become more risk-averse, but increase when investors become more disappointment-averse. The former is well known: investors would not take additional risk unless properly compensated. The latter, however, seems counter-intuitive: investors who are more disappointment–averse would invest more in risky assets. But the counter–intuitive results are indeed consistent with the experimental findings of Abdellaoui and Bleichrodt (2007), because disappointment aversion increases when expected excess returns increase. That is, investors are particularly frustrated for suffering losses when they have a very good chance to win. Therefore, in bull markets when expected excess returns are high, both investment proportions in risky assets and disappointment aversion are high. With respect to wealth levels, if risk aversion decreases with wealth, i.e., decreasing absolute risk aversion holds, wealthier investors may feel more disappointment for losses.

These analytical results are supported by empirical results with asset allocation in pension funds of 35 OECD countries. The estimated DA levels (standard errors) of equities, bonds, and other investments (a portfolio of real estate, infrastructure, private equities and hedge funds) are 2.28 (0.31), 1.64 (0.17) and 1.93 (0.24), respectively. As predicted by the analytical results, DA is larger for equities whose expected returns are larger than those of the other risky assets. The large DA in equities could be a potential source of equity premium puzzle which is not well explained by risk.

The levels of DA are affected by wealth as well as individualism. As predicted by the analytical results, countries with larger wealth (measured by GDP) show higher levels of disappointment aversion for equities. Moreover, individualism of Hofstede (2001), a cultural character, appears to affect disappointment aversion. Individualistic countries appear to be more disappointment–averse than collectivistic countries. According to Van Den Steen (2004); Chui et al. (2010), individualistic investors tend to show more risk-taking activities in financial markets. Our results indicate that overconfidence of individualistic investors increases their expectations in risky assets, making themselves more disappointed for losses.

This study expands our understanding of disappointment aversion and its relationship with risk aversion and expected returns. The utility function we use for the asset allocation problem is a generalised one in the sense that it includes the aggregated wealth level as well as gains and losses. In contrast to other disappointment aversion utility functions defined solely over gains and losses, our utility also depend on the absolute pleasure of consumption purchased with wealth. Moreover, the assumption of additively separable utility allows us to apply the asset allocation problem for multiple risky assets[11]. In our framework, the overall utility is a linear combination of disappointment aversion utilities for multiple risky assets, and thus analysis becomes quite simple.

From the empirical side, our results show that cultural differences can play an important role in decision–making under risk, which is consistent with the view that investors from different backgrounds frame their risk attitude in different ways and are subject to psychological biases (e.g., Chui et al., 2010; Beugelsdijk and Frijns, 2010; Frijns et al., 2013; Breuer et al., 2014). In this study we show that disappointment aversion is also affected by cultural differences. The variation in disappointment aversion due to cultural difference challenges the traditional risk-based theories and contributes a new dimension to current behavioural literature.

The remainder of this chapter is organised as follows: in section 3.2 we propose our utility function and show how optimal asset allocation in risky assets are affected by risk and disappointment aversion. In section 3.3 we empirically test various analytical results developed in section 2. Section 3.4 focuses on discussions of the obtained results and concludes this chapter.

3.2 Disappointment Aversion in Asset Allocation

In this section, we propose a DA utility with subjective probability function and investigate how assets are allocated with respect to disappointment aversion. As in Koszegi and Rabin (2007), investors' utility is assumed to depend on their multi–dimensional wealth portfolios (bundle) as well as reference portfolios under the

[11] Because of tractability, most previous studies focus on asset allocation problems with two assets, i.e., Benartzi and Thaler (1995); Ang et al. (2005); Fielding and Stracca (2007); Hwang and Satchell (2010).

assumption that utility is additively separable across different asset classes. We propose some analytical results between investment patterns, risk aversion, and disappointment aversion.

3.2.1 The Disappointment Aversion Utility

The DA utility is embedded in the asymmetric preference towards outcomes that do not meet a person's prior expectation (disappointment) and those that exceed the expectation (elation): it predicts that the person reacts more sensitively to disappointment than to elation. Unlike loss aversion where the reference point is predetermined exogenously, the reference point in DA is endogenously decided depending on future return paths. Therefore, it is possible that the person still suffers disappointment even for a positive outcome if the outcome is lower than his expectations (reference points).

While the asymmetric preference with respect to disappointment and elation is a core of the DA utility, consumption levels are also what people care about. For example, Koszegi and Rabin (2007) propose a utility function in which consumption utility is considered in addition to the utility from gains and losses. As argued by Barberis (2013), neglecting consumption surely leads to biased conclusions. Therefore, our DA utility $((u(W, \mu_s))$ consists of the typical wealth utility and the disappointment–elation utility[12]. Formally, we have:

$$u(W, \mu_s) = \mu_w - \varphi \left[A \mid W - \mu_w \mid^v I^- - \mid W - \mu_w \mid^v (1 - I)^- \right], \tag{3.1}$$

where μ_w is the expected wealth, W represents the end–of–period wealth, and I^- is an indicator variable that equals one when $W - \mu_w < 0$ and zero otherwise. For DA, $A > 1$ is required to give extra weights to the disappointment.

The first component of the DA utility is the expected end–of–period wealth μ_w which represents utility from consumption via wealth. Similar to the models of Koszegi and Rabin (2007), wealth utility (expected wealth) is differentiable and strictly increasing. Our DA utility increases linearly with expected wealth,

[12]For an application of DA utility in the asset allocation problem, we use the wealth level to represent future consumption which is readily observable.

satisfying the non–satiation condition and allowing our model to be tractable (Barberis, 2013). The second component inside the square brackets in Eq. (3.1), which we refer to as the disappointment–elation utility, represents utility derived from gains and losses. The disappointment–elation utility, is also interpreted as a "standard measure of risk" (Jia and Dyer, 1996) or a performance measure (Gemmill et al., 2004). The parameter, $\varphi > 0$, thus, shows the relative importance of risk in the utility and represents the *trade–off* relationship between wealth utility and risk: it is equivalent to a measure of risk aversion, which should decrease as wealth increases if decreasing absolute risk aversion holds. The curvature parameter, v, decides convexity or concavity of elation and disappointment with respect to gains and losses, respectively. As in many previous studies, the two curvature parameters for gains and losses are set equivalent to each other (e.g., see Tversky and Kahneman, 1992; Abdellaoui, 2000; Barberis et al., 2001; Ang et al., 2005; Abdellaoui and Bleichrodt, 2007). Finally, expected wealth is used as the reference point in this study. As pointed out by Koszegi and Rabin (2007), expected wealth is what people use to calculate gains and losses and is determined by rational expectations held in the recent past about outcomes.

3.2.2 Subjective Weighting Function

It is well–documented that people distort probabilities by disproportionately directing their attention to outcomes (Prelec, 1998). According to Tversky and Kahneman (1992), unlikely extreme outcomes are overweighted while highly possible events are underweighted. Quiggin (1995) introduces a rank–dependent utility model where weights depend on the true probability of an outcome as well as its ranking relative to other outcomes. The combination of rank and reference point–dependent utility gave birth to cumulative prospect theory (CPT), which utilizes a transformed probability weighting function to account for the redistribution of decision weights (Tversky and Kahneman, 1992).

In order to simulate investors' subjective weights, we use Prelec's (1998) single parameter version of the weighting function:

$$w(p) = exp[-(ln(p))^{\delta}], \tag{3.2}$$

where p is the cumulative probability of any possible outcome. With δ $(0 < \delta < 1)$, the weighting function allocates more (fewer) weights to unlikely (likely) outcomes. A number of weighting functions (e.g., Prelec, 1998; Abdellaoui, 2000; Luce et al., 2000; Bruhin et al., 2010) have been proposed but they are quite similar to the weighting function of Prelec (1998), (see Gonzalez and Wu (1999) for example).

Although the rationale behind the subjective weighting is different from risk attitude toward gains and losses, they are closely connected. To see this, assume a transformed density function for elation and disappointment, $\pi^{+}(x)$ and $\pi^{-}(x)$, respectively, as follows:

$$\pi^{+}(x) = w'(1-p)pdf(x),$$
$$\pi^{-}(x) = w'(p)pdf(x),$$

where $x = W - \mu_w$ represents gains or losses, $pdf(x)$ is the probability density function of x; $w'(1-p)$ and $w'(p)$ are the first derivatives of Prelec's (1998) weighting functions at the cumulative probabilities of $1-p$ and p, respectively:

$$W'(1-p) = \frac{\delta}{1-p}[(-ln(1-p))^{\delta-1}exp(-(-ln(1-p))^{\delta})], x \geq 0,$$

$$W'(p) = \frac{\delta}{p}[(-lnp)^{\delta-1}exp(-(-lnp)^{\delta})], x < 0,$$

Then the expected DA utility can be presented as:

$$U_{DA} = \mathbb{E}[u(W, \mu_w)] = \mu_w - \varphi[Apu^{-} - (1-p)u^{+}],$$

where p represents the cumulative probability at the reference point $(x = 0)$, i.e., $p = F(0)$, and

$$(1-p)u^{+} = \int_{0}^{\infty} x^{v}\pi^{+}(x)dx,$$
$$pu^{-} = \int_{-\infty}^{0} (-x)^{v}\pi^{-}(x)dx$$

The subjective weighting function is designed to replicate the probability distortion of outcomes, but alters the degree of risk attitude towards gains and losses for a given objective probability: for example, $x^v[w'(p)pdf(x)] = [x^v w'(p)]pdf(x)$. In other words, for a given objective probability, when combined with outcomes, the subjective weighting function creates concavity (risk aversion) for losses while it creates convexity (risk–loving) for gains. Even though the risk aversion for gains and risk–loving for losses are assumed for a given subjective weighting function, the net effects of the risk attitude and the subjective weighting function become unclear for a given objective probability.

Because of this lack of clarity between risk attitude and subjective weighting, it is difficult to estimate these two parameters simultaneously, i.e., the parameter of the weighting function and the curvature parameter. Moreover, as explained later, the DA parameter, A, is also closely associated with these two parameters. In order to minimize the difficulties in the estimation but keep the original rationale behind the DA utility and subjective weighting, we estimate DA for given subjective weighting and curvature. More specifically, we use $\delta = 0.74$ for the subjective weighting as in Gonzalez and Wu (1999) and Hofstede's (2001) "Uncertainty Avoidance" index for risk attitude, the details of which will be discussed later.

3.2.3 An Application to an Asset Allocation Problem

We consider an asset allocation problem for multiple asset classes, which is an extension of the typical asset allocation problem where only two types of assets (equity and risk–free asset) are considered (e.g., Ang et al., 2005; Fielding and Stracca, 2007; Hwang and Satchell, 2010). Suppose that the end–of–period wealth W is an outcome of a portfolio q where $\alpha_1, \alpha_2, ..., \alpha_n$ of wealth are invested in n types of risky asset, and the remaining $(1 - \sum_{i=1}^{n} \alpha_i)$ is invested in the risk–free asset. Short positions are not allowed in a typical asset allocation in pension funds, suggesting $0 \leq \alpha_i \leq 1$ for the i type of asset. Without loss of generality and for tractability, we assume that the initial wealth is 1. Let r_i and r_f

be the return of asset i and risk–free asset. Then, the end–of–period wealth is given by:

$$W = 1 + r_q = 1 + r_f + \sum_{i=1}^{n} \alpha_i (r_i - r_f),$$

and the expected wealth is:

$$\mathbb{E}(W) = \mu_w = 1 + \mu_q = 1 + r_f + \sum_{i=1}^{n} \alpha_i (\mu_i - r_f),$$

where $\mu_i \equiv \mathbb{E}(r_i)$ and gains and losses with respect to the expected wealth can be calculated by:

$$W - \mu_w = \sum_{i=1}^{n} \alpha_i (r_i - \mu_i). \tag{3.3}$$

For simplicity and tractability, the disappointment–elation utility (the second component in the equation) is assumed to be additively separable across different asset types as in Koszegi and Rabin (2007). Then each of the disappointment–elation utility can be specified with its own curvature and DA parameters. Previous studies show that asset allocation is not sensitive to changes in the curvature parameters (Ang et al., 2005; Abdellaoui and Bleichrodt, 2007), and thus we assume that curvature parameters are the same for different asset types. However, DA may be different for different asset types. For example, investors may be more disappointment–averse for a class of assets with a higher premium, which is more intuitive than assuming a single DA regardless of asset types. When the disappointment–elation utility is additively separable and disappointment aversion differs for different asset types, the expected DA utility in Eq. (3.1) appears as follows:

$$U_{DA} = \mu_w = \varphi \left[\sum_{i=1}^{n} A_i \alpha_i^v p_i u_i^- - \sum_{i=1}^{n} \alpha_i^v (1 - p_i) u_i^+ \right], \tag{3.4}$$

where the number of individual risky assets in the portfolio is n. More specifically, A_i and α_i are the level of DA of asset i and its investment proportion, respectively. Realised elation or disappointment of asset i is expressed as $x_i = r_i - \mu_i$, where $1 - p_i$ is the probability of having a positive x_i.

Proposition 1 *Under the above utility setting in Eq. (3.4), when* $v > 1$ *and* $\alpha_i \in [0,1]$*, the optimal investment proportion with respect to risky asset i exists as:*

$$\alpha_i^* = \left(-\frac{\varphi v \left((1-p_i)u_i^+ - A_i p_i u_i^- \right)}{\mu_i - r_f} \right)^{\frac{1}{v-1}} \tag{3.5}$$

Proof. Investors who try to maximise their expected DA utility have to decide each α_i for their overall utility. Namely, it is an optimization problem under n unknown variables. The gradient of the DA utility with respect to $\{\alpha_1, ..., \alpha_i, ..., \alpha_n\}$ written ∇U_{DA}, is a vector:

$$\nabla U_{DA} = \frac{\partial U_{DA}}{\partial \alpha_i} = (\mu_i - r_f) - \varphi v \alpha_i^{v-1} \left(A_i p_i u_i^- - (1-p_i)u_i^+ \right) = 0. \tag{3.6}$$

Then the optimal investment proportions $\{\alpha_1^*, ...\alpha_2^*, ..., \alpha_n^*\}$ can be obtained by solving $\nabla U_{DA}(\alpha_i^*) = 0$. Rearranging Eq. (3.5) for A_i, we have

$$A_i = \frac{\mu_i - r_f}{\varphi v p_i u_i^-}(\alpha_i^*)^{1-v} + \frac{(1-p_i)u_i^+}{p i_i u_i^-} \tag{3.7}$$

The second partials of U_{DA} are arranged into the ***Hessian*** matrix $H(\alpha)$:

$$H(\alpha) = \begin{pmatrix} \frac{\partial^2 U_{DA}}{\partial \alpha_1^2} & \frac{\partial^2 U_{DA}}{\partial \alpha_1 \partial \alpha_2} & \cdots & \frac{\partial^2 U_{DA}}{\partial \alpha_1 \partial \alpha_n} \\ \frac{\partial^2 U_{DA}}{\partial \alpha_2 \partial \alpha_1} & \frac{\partial^2 U_{DA}}{\partial \alpha_2^2} & \cdots & \frac{\partial^2 U_{DA}}{\partial \alpha_2 \partial \alpha_n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{\partial^2 U_{DA}}{\partial \alpha_n \partial \alpha_1} & \frac{\partial^2 U_{DA}}{\partial \alpha_n \partial \alpha_2} & \cdots & \frac{\partial^2 U_{DA}}{\partial \alpha_n^2} \end{pmatrix}$$

For critical points obtained in Eq. (3.5), a global maximum exists if the DA function is concave, i.e., $H(\alpha)$ needs to be *negative-definite*. Since for $i \neq j$,

$$\frac{\partial^2 U_{DA}}{\partial \alpha_i \partial \alpha_j} = \frac{\partial^2 U_{DA}}{\partial \alpha_j \partial \alpha_i} = 0, \tag{3.8}$$

$H(\alpha)$ becomes a diagonal matrix whose elements are:

$$\frac{\partial^2 U_{DA}}{\partial \alpha_i^2} = \alpha_i^{v-2} \varphi v (v-1) \left((1-p_i)u_i^+ - A_i p_i u_i^- \right),$$

which becomes

$$\frac{\partial^2 U_{DA}}{\partial \alpha_i^2} \mid_{a_i = a_i^*} = -(\mu_i - r_f)(v-1) < 0.$$

As expected, returns of risky assets should be higher than the risk-free rate, which means $\mu_i - r_f > 0$. Therefore the optimal investment proportion in Eq. (3.5) satisfies the necessary and sufficient condition when $v > 1$. QED

The results are interesting because $v > 1$ implies that investors are risk–seeking in gains and risk–averse in losses. Although simple models without the expected wealth or with the assumption of $v = 1$ are popular in the literature for their tractability, they often produce corner solutions in asset allocation problems (e.g., Ang et al., 2005; Hwang and Satchell, 2010). As in Barberis et al. (2001), this problem can be avoided by including the expected wealth and allowing $v > 1$.

The properties of DA can be further investigated with the following two propositions. These are useful when α_i is not known.

Proposition 2 *For the DA utility defined in Eq. (3.4), when α_i is restricted with $\alpha_i \in [0,1]$ and **Proposition 1** holds, then the lower bound of any "A_i" exists at*

$$A_i \geq \frac{\mu_i - r_f}{\varphi v p_i u_i^-} + \frac{(1-p_i)\mu_i^+}{p_i u_i^-}. \tag{3.9}$$

Proof. As we know $v > 1$ and $0 \leq \alpha_i \leq 1$, Eq. (3.5) gives

$$0 \leq \left(\frac{\mu_i - r_f}{\varphi v(A_i p_i u_i^- - (1-p_i)u_i^+)}\right)^{\frac{v-1}{1}} \leq 1$$

since $\frac{1}{v-1} > 0$,

$$(\mu_i - r_f) < \varphi v(A_i p_i u_i^- - (1-p_i)u_i^+),$$

and the result follows. QED

Proposition 3 *For each type of risky asset i in the optimal utility, the elasticity of "A_i" with respect to those of u_i^-, $(1-p_i)$, φ and the expected excess return $(\mu_i - r_f)$ is given by:*

elasticity with respect to u_i^-:

$$\frac{\partial lnA_i}{\partial lnu_i^-} = -1 < 0,$$

semi-elasticity with respect to $(1-p_i)$:

$$\frac{\partial lnA_i}{\partial(1-p_i)} = \frac{(\mu_i - r_f)\alpha_i + v\varphi\alpha_i^v u_i^+}{p_i(\mu_i - r_f)\alpha_i + (1-p_i)p_i v\varphi\alpha_i^v u_i^+} > 0,$$

elasticity with respect to φ:

$$\frac{\partial lnA_i}{\partial ln\varphi} = \frac{-(\mu_i - r_f)\alpha_i}{(\mu_i - r_f)\alpha_i + (1-p_i)v\varphi\alpha_i^v u_i^+} < 0,$$

and the semi-elasticity with respect to the expected excess return $(\mu_i - r_f)$:

$$\frac{\partial lnA_i}{\partial(\mu_i - r_f)} = \frac{\alpha_i}{(\mu_i - r_f)\alpha_i + \varphi v\alpha_i^v(1-p_i)u_i^+} > 0.$$

Proof. By differentiating Eq. (3.7) with respect to lnu_i^- , $(1-p_i)$, φ and $(\mu_i - r_f)$ we have the results. QED

The propositions suggest several important implications of the effects of market conditions on the level of DA; when the DA parameter A_i changes in proportion to its lower bound, it increases when the premium $\mu_i - r_f$ increases. When the ratio of elation to disappointment increases (the ratio of $(1-p_i)u_i^+$ with respect to $p_i u_i^-$) or when φ decreases. The results indicate that investors become more disappointment–averse as the premium (the expected return in excess of risk–free rate) increases in bull markets. This is consistent with the result that DA increases with the probability of gains (Proposition 3).

It is interesting to find in Proposition 3 that investors become more disappointment–averse if the chances of disappointment (losses) are expected to decrease. The results are comparable with the well–known house money effects (Thaler and Johnson, 1990) whereby investors tend to be more risk–averse after losses than after gains. However, our results differ from the house money effects because they depict the relationship between risk attitude and ex–ante disappointment.

We also find that wealthier investors who are less risk–averse become more disappointment–averse. When the disappointment-elation utility is interpreted as risk (Jia and Dyer, 1996), investors would become less risk–averse, i.e., a smaller value of φ, as their wealth increases, if risk aversion is expected to decrease with wealth (decreasing absolute risk aversion). This means that wealthy investors suffer higher disutility from disappointing outcomes despite their tendency of less risk aversion.

Proposition 4 *For the optimal utility in Eq. (3.5), the elasticities of α_i^* with respect to the optimal A_i, the premium $(\mu_i - r_f)$, and φ are given by*

$$\frac{\partial ln\alpha_i^*}{\partial lnA_i} = \frac{p_i u_i^-}{((1-p_i)u_i^+ - A_i p_i u_i^-)(v-1)} < 0,$$

$$\frac{\partial ln\alpha_i^*}{\partial ln(\mu_i - r_f)} = \frac{1}{v-1} > 0,$$

$$\frac{\partial ln\alpha_i^*}{\partial ln\varphi} = \frac{1}{1-v} < 0.$$

The semi-elasticity of α^* to p is given by

$$\frac{\partial ln\alpha_i^*}{\partial p_i} = \frac{A_i u_i^-}{((1-p_i)u_i^+ - A_i p_i u_i^-)(1-v)} > 0.$$

Proof. By taking the natural logarithm of Eq. (3.5) and differentiating with respect to corresponding variables, we have the results. QED

The result in Proposition 2 indicates that $(1-p_i)u_i^+ - A_i p_i u_i^- < 0$ since the risk premium should be positive. Therefore, when $v > 1$, Proposition 4 shows that the elasticity of the optimal investment in the risky asset decreases as DA increases. It also decreases when investors become more risk–averse. On the other hand, the elasticity of the optimal proportion in the risky asset increases with the expected premium or the probability of positive returns. The results are consistent with our intuition.

3.2.4 Disappointment Aversion and Individualism

Since the cross-cultural empirical work by Hofstede (2001), a growing number of studies have found how cultural characters affects asset pricing and financial risk-taking behaviour. For example, by conducting a cross-country investigation on foreign asset allocation of 26 countries, Beugelsdijk and Frijns (2010) demonstrate that more individualistic countries are more aggressive in foreign investment; Breuer et al. (2014) examine the risk-taking willingness from a total of 449 economic students via a specifically designed survey, and find that individualism increases financial risk-taking. Another set of papers, including Markus and Kitayama (1991); Van Den Steen (2004); Chui et al. (2010), suggests that individualism can lead to overconfidence, resulting in excessive over-optimism towards future returns. These empirical studies again support a positive relationship between individualism and risk-taking activities.

The risk-taking activities by individualistic investors are associated with DA. According to Chui et al. (2010), risk–return relationship perceived by investors is negatively driven by overconfidence. Our results in Propositions 2 and 3 show that DA increases when risk becomes less important, i.e., φ decreases. Therefore, if a risk-taking tendency increases with overconfidence as in the previous literature, our results indicate that overconfidence represented by individualism may lead to more disappointment when losses occur.

3.3 Empirical Tests

We test the analytical results in the previous section using asset allocation in pension funds across countries. In particular, DA is investigated if it is associated with cross-cultural character aspects such as individualism.

3.3.1 Asset allocation and Returns across Countries

We have collected asset allocations of pension funds across 35 countries for the period from 2005 to 2012[13]. The reason we use pension fund data is twofold. Fist, pension funds are key players in the global investment industry. According to OECD Pensions Statistics (2013), in 2012, institutional investors in the OECD totalled USD 78.2 trillion1 in 2012, with USD 30.0 trillion coming from investment funds, USD 24.5 trillion from insurance companies, USD 21.8 trillion from pension funds and USD 1.9 trillion from other investors (see Figure 3.1).

[Insert FIGURE 3.1 about here]

Secondly, the role of culture in pension fund managers' behaviour has only recently been investigated at the micro level (Beckmanna et al., 2008); controlling for the interaction of culture with DA at the aggregate level (i.e. the pension funds' sector as a whole in each country) in our study can offer novel insights in this debate by allowing us to better understand the issue at the aggregate level. The number of countries is restricted by the data availability of pension funds,

[13]Our original goal is to include asset allocations of pension funds from 2003 to 2012, so that it perfectly matches the sampling period of asset returns. However, this is not feasible because the data quality worsens rapidly for those years prior to 2005.

individualism, and returns of the asset classes we consider in this study. Four types of asset classes, i.e., *risk-free assets, stocks, bonds, and others*, are investigated with their 120 monthly returns for the sample period from 2003 to 2012.

The weights α_i^* in each asset type are collected from OECD Global Pension Statistics (GPS)[14], where national asset allocations of pension funds are maintained and updated annually. Table 3.1 reports the average weights on asset classes for each country during our sampling period. On average, 45.8% of pension funds is invested in bonds, followed by others (25.1%), and equities (20.6%). Investment in others tends to increase while the weight in equities decreases, in particular, after the financial crisis of 2008. Before the financial crisis of 2008, the proportion of other investments decreased from 32.09% (2005) to 21.24% (2008) while the equity weight increased from 16.10% (2005) to 21.59% (2008). However, their performance reversed after the crisis: until 2010, the weight in other investments rebounded to 28.61% whereas the equity exposure is still below the crisis-level at 21.52%. Proportions with respect to bonds and cash & deposits are relatively less sensitive to time.

[Insert TABLE 3.1 about here]

Returns of the four asset classes are obtained from the Thomson-Reuters DataStream database. Equity returns are calculated from the composite index of the major stock exchange in each country. The summary statistics of annualised log-returns of four asset classes are reported in Table 3.2. The average annual equity return (standard deviation) of the 35 countries is 9.38% (21.04%). Notably, although often accompanied by large volatilities, most of the emerging markets show higher returns in recent years. For example, the average annual returns of Brazil, Chile, Mexico, South Africa, Thailand and Turkey all exceed 15% (particularly the top return, 21.12% in Mexico), which are far beyond some of the developed market such as Japan (2.01%). However, equity performance in Greece and Slovenia is poor during our sample period.

[14]This dataset includes pension funds statistics with OECD classifications by type of pension plans and by type of pension funds. All types of plans are included (occupational and personal, mandatory and voluntary).

Bond returns are calculated with equal weight on the total returns of government and corporate bonds. Ten-year benchmark government bonds are used as government bonds[15]. On the other hand, the quality of corporate bond data is not as good as that of the government bond data, in particular among emerging markets. To mitigate this defect, we consider three international indices: FTSE Euro Corporate Bond Index[16]for those developed markets outside the Eurozone (Denmark, Hong Kong, Iceland, Japan and Norway); IBoxx Euro Corp. Bond Index[17] for countries within the Eurozone (Finland, France, Germany, Greece, Italy, Luxembourg, the Netherlands, Portugal, Slovenia and Spain); and finally, BofA–Merrill Lynch Emerging Markets Corporate Plus Index[18] for emerging markets (Mexico, Poland, Pakistan, South Africa, Thailand and Turkey). For the remaining countries (Australia, Canada, Chile, Israel, Korea, the UK and the US), country–specific indices can be found. The average annual bond return (standard deviation) for all countries is 6.29% (4.75%). As expected, the return difference in bonds is less than that of stocks. The highest average annual bond return comes from the Czech Republic at 12.98%, whereas the lowest is recorded at 2.94% in Greece.

In addition to stocks and bonds, significant proportions of pension funds are invested in other investment vehicles which include, but are not limited to loans, land and buildings, unallocated insurance contracts, hedge funds, private equity funds, structured products and other mutual funds. Such a wide variety poses enormous difficulties in tracking the performance of each asset class in each country. Moreover, details of investment proportions in these other investment

[15]The data of 10-year government bonds is non-applicable in the case of Turkey, hence a similar bond price index with a 5-year maturity is applied.

[16]The FTSE Euro Corporate Bond Index includes Euro-denominated issues from global corporate entities with all maturities ranging from 1 to 3 years to more than 15 years. Each bond is classified under the Industry Classification Benchmark (ICB). The index constituents are investment grade debt with a minimum rating of BBB-.

[17]IBoxx Euro Corp. Bond Index is prepared and published by Market, which is an ideal performance benchmark for fixed income research, asset allocation and performance evaluation. This index includes overall, rating and maturity indices, with a split into financial and non–financial bonds, and rating and maturity sub–indices for each.

[18]The BofA–Merrill Lynch Emerging Markets Corporate Plus Index tracks the performance of US dollar (USD) and Euro-denominated emerging markets' non–sovereign debt publicly issued within the major domestic and Eurobond markets. The index includes corporate and quasi–government debt of qualifying countries, but excludes sovereign and supranational debt. Other types of securities acceptable for inclusion in this index are: original–issue zero coupon bonds.

vehicles are not known. Therefore, we construct an index using MSCI World Real Estate [19], Dow Jones Brookfield GLB INFRA[20], S&P Listed Private Equity[21] and HFRI Fund of Funds Composite[22] for real estates, infrastructure, hedge funds, and private equities in US dollars, respectively. These four return series are equally weighted to create the “others” asset class, which are then converted to returns for each country using its exchange rate with respect to the US dollar. The average annualised return (standard deviation) for other investments is 8.44% (24.58%).

Finally, for the risk–free rates, we use 30–day T–bill rates. If T–bill returns are not available, 30–day interbank rates or repo–rates are used. Countries within the Eurozone share an identical interbank rate. All data is collected from the DataStream except the US, where a better alternative can be found in the Center for Research in Security Prices (CRSP). Notably, extremely high short–term interest rates are observed in some countries due to their particular financial policies or rapid capital growth. For example, the average risk–free rates in Brazil, Iceland, Mexico, South Africa and Turkey are all over 8.0%. In some cases, high risk–free rates produce negative excess returns for some countries rendering abnormal DA that will be discussed later.

[Insert TABLE 3.2 about here]

[19]The MSCI World Real Estate Price Index is a free float–adjusted market capitalization index that consists of large and mid–cap equity REITs across 23 developed markets, which generate a majority of their revenue and income from real estate rental and leasing operations. With 101 constituents, it represents about 85% of the REIT universe in each country and all securities are classified in the REIT sector according to the Global Industry Classification Standard.

[20]Dow Jones Brookfield GLB INFRA is maintained collaboratively by S&P Dow Jones Indices and Brookfield Asset Management. It aims to measure the stock performance of companies worldwide whose primary business is the ownership and operation of (rather than service of) infrastructure assets. To be included in the indices, a company must have more than 70% of estimated cash flows (based on publicly available information) derived from eight infrastructure sectors: airports, toll roads, ports, communications, electricity transmission & distribution, oil & gas storage & transportation and water.

[21]The S&P Listed Private Equity Index comprises the leading listed private equity companies that meet specific size, liquidity, exposure, and activity requirements. The index is designed to provide tradable exposure to the leading publicly–listed companies that are active in the private equity space.

[22]The HFRI Fund of Funds Composite is a series of benchmarks designed to reflect hedge fund industry performance by constructing equally weighted composites of constituent funds, as reported by the hedge fund managers listed within the HFR Database. The HFRI ranges in breadth from the industry–level view of the HFRI Fund Weighted Composite Index, which encompasses over 2000 funds, to the increasingly specific level of the sub–strategy classifications.

3.3.2 Individualism and Risk Aversion

In addition to the asset allocation data and return data, we use risk aversion and individualism of each country to investigate DA.

As reported in Ang et al. (2005) and Xie et al. (2014), and also discussed in the previous section, optimal asset allocations are jointly influenced by risk aversion and DA, and thus estimating the DA parameter (A_i) and the two risk aversion parameters (φ and v) at the same time is not a feasible option. In this study, we estimate the DA parameter for given (exogenous) risk aversion.

We refer to Hofstede's Uncertainty Avoidance (*unav*)[23] as a measure of risk aversion in each country. Although Hofstede (2001) does not directly link the uncertainty avoidance to the risk perception, several studies have accumulated abundant evidence about how it affects risk preferences. For example, Kwok and Tadesse (2006) show that countries with stronger uncertainty avoidance are characterized by a bank–based financial system (relatively risk–averse). In contrast, countries with milder uncertainty avoidance are characterized by a market–based financial system (relatively risk–seeking). Chui and Kwok (2008) suggest that uncertainty–avoiding nations tend to spend more money on life insurance. Frijns et al. (2013), empirically, show that firms located in countries with lower risk–tolerance (measured by uncertainty avoidance scores) require higher premiums on takeovers. Taken together the above findings suggest a positive relationship between uncertainty–avoidance and risk–aversion.

The two parameters (φ and v) are calculated using the following conversion:

$$\varphi = \frac{unav}{C_\varphi},$$

$$v = 1 + \frac{C_v}{unav},$$

where the the two parameters are initially set to $C_\varphi = 50$ and $C_v = 10$. As *unav* (φ) increases, risk becomes important in the DA utility, indicating a risk–averse attitude. Similarly, countries with higher *unav* show fewer risk–seeking patterns,

[23]The uncertainty avoidance reflects the extent to which people feel either uncomfortable or comfortable in unstructured situations. Unstructured situations may be novel, unknown, surprising, and different from usual.

i.e., lower v. Table 3.3 reports all countries' uncertainty avoidance scores along with the scaled set of (φ, v) with $C_\varphi = 50$ and $C_v = 10$. With respect to the 35 countries we consider in this study, the conversion makes the values of φ and v range as follows: $0.46 < \varphi < 2.24$ and $1.09 < v < 1.43$. More sets of C_φ and C_v are tested later to examine the robustness of our results.

[Insert TABLE 3.3 about here]

We use Hofstede's Individualism Index (Indv) to investigate if individualism has a relationship with DA. The index is based on a psychological survey of 88,000 IBM worldwide employees, and widely used in the literature as a measure of the degree to which individuals are integrated into groups[24]. In the spirit of Hofstede's Indv, we explore the extent to which cross–country variations in DA can be explained by this measure. The 35 countries are further divided into three groups: the Collectivism group includes countries with individualism indices less than 40; individualism scores between 40 and 65 are arranged into Median; the rest of countries with individualism indices over 65 are labelled to Individualism. All countries along with their individualism indices are reported in Table 3.4.

According to Table 3.4, the Indv–index is regionally orientated: most of the developed countries in Western Europe and North American fall into the Individualism group while the Collectivism group consists of many emerging markets from Asia, Eastern Europe, and South America. The Median group, on the other hand, stands in the middle of a mixture, including both developed and emerging countries from Asia, Europe and Africa.

[Insert TABLE 3.4 about here]

[24] A higher value of Indv indicates a more individualistic society, where individuals are expected to take care of only themselves and their immediate families. Its opposite, lower Indv scores, represent a collective society in which individuals can expect their relatives or members of a particular in–group to look after them in exchange for unquestioning loyalty. A society's position on this dimension is reflected in whether people's self–image is defined in terms of "I" or "we". Hofstede's Indv are calculated from six work–goal questions out of the total 14 questions about candidates' work and private life.

3.3.3 Cross–Country Disappointment Aversion

We estimate the level of disappointment aversion for each country using asset allocations in Table 3.1 and the subjective probability weighting parameter $\delta = 0.74$ using bootstrapping method. For each country, 120 monthly returns are randomly sampled with replacement from the historical 120 monthly observations of the ten year period from 2003 to 2012. Under the assumption that asset returns follow the normal distribution, a value of DA is calculated for the investment weight (average investment proportions over the period from 2005 to 2012). We repeat this process 1,000 times to obtain 1,000 estimates of DA for each asset class and country. Panels A, B and C in Table 3.5 report the average values of the 1,000 DA estimates for stocks, bonds and other investments, respectively. In addition, using the same bootstrapping method, we also calculate and report the minimal level of DA (A^-) defined in Eq. (3.9).

Glancing at these tables reveals some striking results. First, it is evident that higher DA is observed for equities than for bonds and other investments: global average values of DA are $\bar{A}_s = 2.28\ (0.31)$, $\bar{A}_{oi} = 1.93\ (0.24)$ and $\bar{A}_b = 1.64\ (0.17)$, where the subscript s, oi, and b represent stocks, bonds, and other investment respectively, and the numbers in the brackets represent standard errors. This is consistent with the results in Proposition 1 where DA is shown to increase with the expected excess return. The huge gap between the average DAs on stocks and bonds (2.28 vs. 1.64) helps to understand the potential sources of the equity premium puzzle (Mehra and Prescott, 1985). That is, the fear of being disappointed makes investors require higher returns for stocks than for bonds, and thus the equity premium can be explained by higher disappointment aversion.

By dividing 35 countries into three sub-groups depending on Hofstede's Individualism Index, Table 3.5 also provides a preliminary view of how individualism is associated with DA. It appears that countries in the Individualism group tend to exhibit higher DAs than those in the Median and Collectivism groups regardless of any asset type. In the following sections, we formally investigate the relationship between DA and individualism.

Abnormal levels of DA $(A < 1$ or $A > 4)$ that contradict the theoretical instinct may appear in all asset classes. In particular, due to rapid growth or monetary policies, extreme low levels of DA are more frequent in emerging markets as a result of high levels of risk–free rates. On the other hand, some of the developed markets exhibit enormous DA, such as Denmark, Sweden and Hong Kong. These countries are somehow much less risk–averse according to the *unav* index, Note that our propositions suggest a negative relationship between risk aversion and disappointment aversion (see also the results in the robustness test).

Abnormal DAs that contradict the theoretical instinct appear in all asset classes. For example, extremely low DA are more frequent to emerging markets as a result of high risk–free rates due to rapid growth or monetary policies. On the other hand, some of the developed markets exhibit large DAs such as Denmark, Sweden and Hong Kong. These countries are somehow much less risk–averse according to the *unav* index. This suggests a negative relationship between risk aversion and disappointment aversion (see also the results in the robustness test). Moreover, in some countries associated with negative premiums $(\mu_i - r_f < 0)$, investors have to be disappointment–seeking so that the observed proportions of asset can be held. In this way, the estimates may fall below the minimal level of DA. (i.e., $1 > A^{-} > A$).

[Insert TABLE 3.5 about here]

3.3.4 Individualism vs. Disappointment Aversion

To further investigate the relationship between individualism and DA, we conduct the following panel regression using asset allocation data from 2005–2012:

$$Ln(A_k) = \beta_0 + \beta_1 CGDP_{k,t} + \beta_2 DGDP_{k,t} + \beta_3 EFE_{k,t} + \beta_4 GDP_{k,t}/1000 + \beta_5 INDV_k + \beta_6 MCAP_{k,t}/1000 + \beta_7 MGDP_{k,t} + \beta_8 PSI_{k,t} + \beta_9 VEX_k + \varepsilon_{k,t},$$

the dependent variable is the DA of country k, which is calculated using annual returns. The log values of $A_{k,t}$ are used to minimise the effects of outliers in DA.

Most independent variables are time–varying except for *the level of individualism*, (Individualism Index, INDV) and stability of the aggregate economy (volatility of foreign exchange rate over the sample period, VEX). As in the studies of cross-country analysis, e.g., Chui et al. (2010), these are *the scale of financial resources* (credit to private sector, as the % of GDP, CGDP); *government's debt solvency or the aggressiveness of the governments' financial policy* (based on the debt to GDP ratio, DGDP);*economic openness* (overall economic freedom index published by the heritage foundation, EFE); *aggregate wealth level* (GDP in trillions, scaled down by dividing 1,000); *size of stock market* (market capitalization in trillions, MCAP), *relative size of stock capitalization* (ratio of market capitalization to GDP, MGDP, scaled down by dividing 1,000); and *political stability* (issued by the World Bank to reflect perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, PSI).

Table 3.6 reports the results[25]. First of all, we find strong evidence to support our hypothesis that DA *increases* with individualism for all asset classes. The coefficients of INDV are all significantly greater than zero at the 5% significance level. In addition to individualism, DA also increases in countries with more developed financial markets, i.e., greater credit scale (CGDP) or higher market openness (EFE).

Second, DA of equities appears to *increase* for wealthier nations (higher GDP). Since the rich are less risk–averse, this result indicates that risk aversion has negative relationship with DA, confirming our earlier result in Propositions 2. Interestingly, the effects of GDP on DA of bonds and other investments are negative. One explanation behind this opposite relationship is that when investment proportions in equities change, those in the other asset classes are affected in the opposite way and so does the relationship between DA of bonds and other investments and GDP.

Some other variables are quite mixed. For example, higher political risk (lower PSI) leads to stronger DA in equities. Conversely, this relationship is reversed

[25]Results in Iceland and Pakistan (only for other investmetns) are excluded from the regressions because of the negative DA.

in other investments. Moreover, PSI and MGDP do not affect DA in bonds. In addition, we find that DGDP is not relevant in explaining DA in bonds and other investments as well.

[Insert TABLE 3.6 about here]

3.3.5 Robustness Tests

Our results may be affected by the risk related parameters (φ, v) or the subjective weighting parameter, which we use from previous studies such as Hofstede (2001) and Gonzalez and Wu (1999). We test if our results are robust to different risk related parameters and various subjective weighting parameters.

Three different levels of φ are tested by setting C_φ=25, 50 and 100. When C_φ=25, the risk–return relationship parameter φ ranges from 0.92 to 4.48 for the 35 sampled countries while it drops down to the range from 0.2 to 1.1 when C_φ=100. Therefore, a smaller C_φ indicates that risk is more highly priced than a large C_φ suggests. Similarly, by setting C_v=1, 10, and 20 we can test the impact of different curvature parameters on the estimates of DA. A small value of C_v suggests that investors are nearly risk-neutral, i.e., v is close to one, whereas a large value of C_v increases the level of curvature for gains and losses. In addition to the above risk parameters, we also investigate the effects of subjective weighting parameter δ on the estimates of DA by changing the value of δ from 0.5 to 1. When δ=1, there is no subjective distortion in probability whereas a small value of δ indicates a significant bias in the probability density function.

A total number of nine cases by combining C_φ and C_v are reported in Table 3.7 for equities, bonds and others. As expected by Propositions 2 and 3, disappointment aversion for equities increases as φ decreases (C_φ increases). When investors are less risk–averse, they become more disappointment–averse. The results are in line with what we have found in this study: as wealth increases, investors become less risk–averse (because of the decreasing absolute risk aversion), but their disappointment aversion increases.

Our analytical results, however, do not clearly dictate the relationship between the curvature parameter v and disappointment aversion because of their non–linear relationship. The empirical results in Panels A.1, B.1 and C.1 of Table 3.7 show that when curvature increases, disappointment aversion also increases. Therefore, when investors are less risk–averse (i.e., both C_φ and C_v are large), they become disappointment–averse.

We conduct a series of regressions for different values of C_φ and C_v to review whether the positive relationship between DA and individualism holds. Selected results are reported in Panels A.2, B.2 and C.2 of Table VI for equities, bonds, and others, respectively. In most cases the coefficient of individualism is significantly greater than zero at the 5% level in most cases.

[Insert TABLE 3.7 about here]

The estimates of disappointment aversion with respect to the different values of subjective probability weighting parameter are reported in Table 3.8. In general when subjective weighting becomes severe, i.e., δ decreases, disappointment aversion increases. When extreme events are eventually overweighted, the fear from disaster-like outcomes increases, and so does disappointment aversion. The variation of statistical significance between DA and individualism is, in fact, similar to the variation from different (C_φ, C_v). In general, a positive relationship between DA and individualism is supported quite well for all values of δ from 0.5 to 1. However, the robustness of such relationships is sensitive to asset types. For example, in the case of equities, we observe that the effect of individualism becomes more pronounced with the increase in probability distortion. On the contrary, in the case of bonds, individualism tends to be more influential on DA for less probability weighting (δ closes to 1). Finally, the situation for other investments sits in the middle, where the most effective area to enhance the connection between DA and individualism is concentrated around δ=0.7.

[Insert TABLE 3.8 about here]

3.4 Discussion and Conclusion

Using an asset allocation problem, we investigate how optimal investment proportions are affected by disappointment aversion as well as risk aversion. As in Koszegi and Rabin (2007) and Barberis (2013), utility in this study is a combination of wealth (consumption) utility that has been widely used in the conventional economics and finance and DA utility that depends on gains and losses calculated with respect to the expected wealth. Under the assumption that DA utility is additively separable, we demonstrate how the optimal investment proportions are affected by disappointment aversion, risk aversion, and expected excess returns. DA has a negative relationship with risk aversion. It is well known that risk aversion decreases as wealth increases. What we find in this study is that when wealth increases, risk aversion decreases but DA increases.

We also show that DA increases with individualism, suggesting that overconfident investors would suffer more disutility when outcome falls below the expectation. As investors become less risk–averse and more confident as wealth increases, they tend to avoid disappointment more. This means that they require a higher premium for an asset to compensate disappointment if losses from this asset are high. The fact that highly individualistic cultures are demonstrating stronger DA is also interesting from a behavioural perspective, as it indicates that DA might help reduce overconfidence; if investors feel overconfident and suddenly become disappointed, such cognitive dissonance may force investors to cool down and re-evaluate their situation.

It is worth pointing out here that the sample composition only involves asset allocations from a very specific type of investors: professional pension fund managers. As research, in particular, among emerging markets has shown, the managers of pension funds are subject to strict regulatory regimes in terms of their asset selection and allocation; considering the fact that cultural factors (such as individualism and uncertainty avoidance) play an important role in pension funds' supervision and regulation Lecq et al. (2013), our study aims at empirically investigating whether the interaction of culture with DA allows us to better understand asset allocation decisions of pension funds at the aggregate level in each country.

3.5 Tables & Figures of This Chapter

Table 3.1
Asset Allocations of Pension Funds

Data in Table 3.1 comprises the asset allocations of pension funds in 35 markets which are derived from the OECD database. To save space, only arithmetic means are reported from the sampling period 2005–2012. The "Other Investments" category includes loans, land and buildings, unallocated insurance contracts, hedge funds, private equity funds, structured products and other mutual funds.

in %	Equities	Bonds	Cash & Deposits	Other Investments
Australia	25.17	9.47	10.71	54.64
Austria	30.53	50.83	9.06	9.58
Belgium	21.68	25.62	4.88	47.82
Brazil	16.50	22.37	0.05	61.08
Canada	29.85	30.90	3.40	35.85
Chile	26.07	48.23	0.35	25.35
Czech Republic	3.66	80.95	8.35	7.04
Denmark	19.69	60.61	0.55	19.15
Finland	41.10	39.54	1.50	17.87
France	34.68	47.39	7.63	10.30
Germany	11.24	35.74	2.86	50.16
Greece	4.38	50.40	39.72	5.50
HongKong	51.28	26.83	13.77	8.13
Hungary	9.32	64.09	2.51	24.07
Iceland	24.57	51.36	6.02	18.06
Israel	5.10	81.45	4.74	8.71
Italy	11.24	43.07	5.93	39.76
Japan	12.65	40.06	5.85	41.44
Korea	0.80	39.23	34.78	25.19
Luxembourg	0.64	33.27	9.98	56.11

Table 3.1 (continued)

in %	Equities	Bonds	Cash & Deposits	Other Investments
Mexico	14.79	82.47	0.29	2.45
Netherlands	34.54	39.87	3.16	22.42
Norway	28.59	57.28	3.60	10.53
Pakistan	27.55	43.77	26.21	2.46
Poland	31.75	63.18	4.08	0.99
Portugal	21.44	44.97	9.44	24.16
Slovenia	3.36	62.87	19.99	13.78
South Africa	21.26	6.78	5.80	66.15
Spain	13.84	58.82	13.52	13.81
Sweden	22.32	59.15	2.65	15.87
Switzerland	15.59	25.71	7.80	50.90
Thailand	11.42	72.13	12.95	3.50
Turkey	14.19	58.22	12.26	15.33
UK	35.32	24.42	2.78	37.48
US	45.99	21.37	1.30	31.33

Note: (1) Asset allocations for the year 2005 and 2012 in Brazil are not available, the sampling period for Brazil is reduced to 2006–2011.

(2) Since OECD does not have any records for France, mean asset allocations for France are replaced by another similar indicator: "Asset Allocations of Institutional Investors' assets"; the sampling period covers from 2008 to 2012.

(3) Asset allocations are not available in Greece for the years 2005 and 2006, data for these two years refers to "Asset Allocations of Institutional Investors' assets".

(4) Asset allocations are not available in Japan for the year 2005 and 2006, data for these two years refer to "Asset Allocations of Institutional Investors' assets".

(5) Asset allocations for the years 2005 and 2006 are not available. Therefore the sampling period for Pakistan is reduced to 2007–2012.

(6) Asset allocations for the year 2012 are not available. Therefore the sampling period for South Africa is reduced to 2005–2011.

(7) Asset allocations are not available in Turkey for the year 2007; another GPS indicator "Personal Pension Fund Assets" is applied as a replacement.

Table 3.2
Summary Statistics of Asset Returns

Equity returns are measured by the composite index of the major stock exchange in each country. Monthly price levels are obtained via DataStream and then converted into log–return. Bond returns are calculated with equal weight on the total returns of government and corporate bonds. Returns of other investments consist of four major assets on equal weights: real estates (MSCI World Real Estate), infrastructure (Dow Jones Brookfield GLB INFRA), hedge funds (S&P Listed Private Equity) and private equities (HFRI Fund of Funds Composite). Finally, risk–free rates are proxied by 30–day T–bill rates. If T–bill returns are not available, 30–day interbank rates or repo–rates are applied instead. The "S.D." column next to every asset type refers to the returns standard deviation.

in %	Equity	S.D.	Bond	S.D.	Others	S.D.	Risk–Free
Australia	8.58	14.99	5.02	6.79	11.66	28.71	5.15
Austria	8.09	23.23	5.50	3.45	8.83	24.42	2.64
Belgium	8.53	19.30	5.67	3.86	8.83	24.42	2.64
Brazil	18.16	21.17	7.22	4.71	5.43	24.6	13.36
Canada	9.05	16.04	6.96	4.16	10.68	24.65	2.42
Chile	15.21	14.73	6.39	2.49	10.60	26.15	0.31
Czech Republic	15.61	20.16	12.98	13.28	11.52	26.8	2.19
Denmark	10.68	19.01	6.27	4.03	8.81	24.31	2.98
Finland	3.45	23.49	5.46	3.44	8.83	24.42	2.64
France	6.67	17.70	5.35	3.56	8.83	24.42	2.64
Germany	9.22	18.98	5.45	3.56	8.83	24.42	2.64
Greece	-4.02	30.28	2.94	14.5	8.83	24.42	2.64
Hong Kong	12.75	22.55	4.42	2.10	7.71	16.87	2.00
Hungary	7.30	24.72	8.09	8.03	7.79	29.66	7.67
Iceland	-7.21	47.70	5.03	2.15	1.77	27.94	9.66
Israel	9.50	17.79	6.14	2.96	9.65	22.54	4.53
Italy	2.25	19.32	5.05	4.00	8.83	24.42	2.64
Japan	2.01	18.49	4.62	2.83	10.32	18.26	0.16
Korea	13.20	21.67	6.89	2.32	8.97	27.35	3.65
Luxembourg	12.61	14.00	3.030	3.67	8.83	24.42	2.64
Mexico	21.12	17.07	7.99	4.67	6.18	25.73	6.95
Netherlands	4.51	20.75	5.62	3.61	8.83	24.42	2.64
Norway	13.53	24.07	6.21	3.62	9.95	25.80	3.98
Pakistan	17.42	28.92	9.58	5.09	1.82	18.64	7.46
Poland	10.22	22.96	7.75	5.56	10.32	30.40	6.07
Portugal	4.08	18.09	4.97	7.46	8.83	24.42	2.64
Slovenia	-0.10	19.72	4.01	2.33	8.83	24.42	2.64
South Africa	16.77	17.17	9.56	5.95	4.62	30.09	8.22
Spain	6.82	19.42	4.54	4.35	8.83	24.42	2.64
Sweden	11.93	18.76	6.00	3.86	9.35	27.06	2.50
Switzerland	6.87	14.14	5.49	3.37	11.55	23.35	1.05
Thailand	17.55	25.65	6.12	4.65	10.60	20.50	2.59
Turkey	20.20	31.28	10.21	5.28	5.47	27.91	12.73
UK	8.36	15.47	7.06	4.29	7.04	23.27	3.78
US	7.36	17.54	6.52	6.39	7.69	16.81	2.40
Global Average	9.38	21.04	6.29	4.75	8.44	24.58	4.10

Table 3.3
Hofstede's Uncertainty Avoidance Index around the World

Table 3.3 lists the Hofstede's uncertainty avoidance index (*unav*) for 35 countries around the world. Columns on the right refer to the applicable risk aversion parameters φ and υ.

	unav	φ	υ
Australia	51	1.02	1.20
Austria	70	1.40	1.14
Belgium	94	1.88	1.11
Brazil	76	1.52	1.13
Canada	48	0.96	1.21
Chile	86	1.72	1.12
Czech Republic	74	1.48	1.14
Denmark	23	0.46	1.43
Finland	59	1.18	1.17
France	86	1.72	1.12
Germany	65	1.30	1.15
Greece	112	2.24	1.09
HongKong	29	0.58	1.34
Hungary	82	1.64	1.12
Iceland	50	1.00	1.20
Israel	81	1.62	1.12
Italy	75	1.50	1.13
Japan	92	1.84	1.11
Korea	85	1.70	1.12
Luxembourg	70	1.40	1.14
Mexico	82	1.64	1.12
Netherlands	53	1.06	1.19
Norway	50	1.00	1.20
Pakistan	70	1.40	1.14
Poland	93	1.86	1.11
Portugal	104	2.08	1.10
Slovenia	88	1.76	1.11
South Africa	49	0.98	1.20
Spain	86	1.72	1.12
Sweden	29	0.58	1.34
Switzerland	58	1.16	1.17
Thailand	64	1.28	1.16
Turkey	85	1.70	1.12
UK	35	0.70	1.29
US	46	0.92	1.22

Table 3.4
Hofstede's Individualism Index around the World

Table 3.4 lists the Hofstede's individualism index for 35 countries around the world. The individualism index is the degree to which individuals are integrated into groups. On the individualist side (higher scores), people are supposed to fit a society where individual opinions are emphasized; on the collectivist side (lower scores), everyone is expected to act as part of a team and look after one another.

Collectivism		**Median**		**Individualism**	
Country	Indv	Country	Indv	Country	Indv
Pakistan	14	Japan	46	Germany	67
Korea	18	Spain	51	Switzerland	68
Thailand	20	Israel	54	Norway	69
Chile	23	Austria	55	France	71
Hong Kong	25	Hungary	55	Sweden	71
Portugal	27	Czech Republic	58	Denmark	74
Slovenia	27	Iceland	60	Belgium	75
Mexico	30	Luxembourg	60	Italy	76
Greece	35	Poland	60	Canada	80
Turkey	37	Finland	63	Netherlands	80
Brazil	38	South Africa	65	UK	89
				Australia	90
				US	91

Table 3.5
Disappointment Aversion over Different Assets

Table 3.5 contains the average DA (standard error) and the minimal level of DA (standard error) for each country with respect to equities, bonds and other investment, respectively.

Equity

Collectivism Group	A	standard error	A^{-}	standard error
Panel A.1				
Brazil	1.6423	0.0288	1.5171	0.0223
Chile	2.6680	0.0167	2.4584	0.0147
Greece	0.3999	0.0272	0.5843	0.0208
Hong Kong	5.4644	0.0890	4.4995	0.0744
Korea	2.5143	0.0353	1.8748	0.0198
Mexico	2.7867	0.0224	2.4070	0.0178
Pakistan	2.3137	0.0389	2.0776	0.0311
Portugal	1.1438	0.0160	1.1359	0.0136
Slovenia	0.6128	0.0256	0.7516	0.0173
Thailand	3.6115	0.0441	2.8180	0.0320
Turkey	1.8433	0.0336	1.6697	0.0283
Group Average	2.2728	0.0343	1.9813	0.0266
Panel A.2				
Median Group	A	standard error	A-	standard error
Austria	1.7949	0.0322	1.6275	0.0267
Czech Republic	3.2595	0.0351	2.4387	0.0227
Finland	1.1360	0.0393	1.0972	0.0318
Hungary	0.9650	0.0314	1.0005	0.0239
Iceland	-2.1624	0.0895	-1.3589	0.0642
Israel	1.7406	0.0249	1.5113	0.0181
Japan	1.1716	0.0205	1.1702	0.0159
Luxembourg	3.5760	0.0347	2.2352	0.0173
Poland	1.3782	0.0212	1.3500	0.0190
South Africa	3.1152	0.0424	2.5834	0.0315
Spain	1.5130	0.0225	1.3617	0.0182
Group Average	1.5898	0.0358	1.3652	0.0263
Panel A.3				
Individualism Group	A	standard error	A-	standard error
Australia	1.8248	0.0356	1.5931	0.0254
Belgium	1.5922	0.0199	1.5039	0.0166
Canada	2.6231	0.0380	2.2290	0.0311
Denmark	8.7294	0.1879	4.9091	0.0936
France	1.4491	0.0184	1.3867	0.0168
Germany	2.1735	0.0348	1.8120	0.0245
Italy	0.9088	0.0275	0.9474	0.0208
Netherlands	1.4505	0.0397	1.2997	0.0313
Norway	3.0511	0.0512	2.5658	0.0410
Sweden	6.4639	0.1103	4.2880	0.0628
Switzerland	2.2135	0.0298	1.9073	0.0221
UK	2.7614	0.0594	2.2857	0.0424
US	2.1161	0.0398	2.0160	0.0337
Group Average	2.8736	0.0533	2.2110	0.0355

Table 3.5 (continued)
Disappointment Aversion with respect to Bond, Panel B

		Bond		
Collectivism Group	A	standard error	A^{-}	standard error
Panel B.1				
Brazil	0.0364	0.0067	0.2088	0.0055
Chile	1.7876	0.0048	1.7234	0.0045
Greece	1.0369	0.0107	1.0347	0.0101
Hong Kong	3.7967	0.0292	2.7767	0.0185
Korea	1.4314	0.0049	1.3864	0.0044
Mexico	1.1276	0.0058	1.1246	0.0057
Pakistan	1.3458	0.0094	1.3071	0.0084
Portugal	1.2063	0.0069	1.1911	0.0064
Slovenia	1.1670	0.0037	1.1585	0.0035
Thailand	1.6167	0.0084	1.5860	0.0080
Turkey	0.7092	0.0071	0.7272	0.0066
Group Average	1.3874	0.0089	1.2931	0.0074
Panel B.2				
Austria	1.4755	0.0055	1.4317	0.0050
Czech Republic	2.2852	0.0166	2.2490	0.0161
Finland	1.6228	0.0097	1.5317	0.0086
Hungary	1.0561	0.0093	1.0531	0.0088
Iceland	-0.4215	0.0080	-0.2441	0.0070
Israel	1.2018	0.0040	1.1968	0.0039
Japan	1.5244	0.0041	1.4747	0.0038
Luxembourg	1.0696	0.0081	1.0595	0.0069
Poland	1.1770	0.0057	1.1685	0.0054
South Africa	1.5849	0.0217	1.3377	0.0125
Spain	1.2259	0.0051	1.2124	0.0048
Group Average	1.2547	0.0089	1.2246	0.0075
Panel B.3				
Australia	0.9969	0.0229	0.9980	0.0144
Belgium	1.3580	0.0045	1.3097	0.0039
Canada	2.4458	0.0135	2.1320	0.0106
Denmark	4.7817	0.0549	4.0418	0.0442
France	1.3348	0.0043	1.3069	0.0039
Germany	1.5415	0.0068	1.4623	0.0058
Italy	1.3705	0.0059	1.3311	0.0052
Netherlands	1.7895	0.0095	1.6637	0.0079
Norway	1.5912	0.0120	1.5288	0.0107
Sweden	3.5418	0.0330	3.1209	0.0275
Switzerland	2.1141	0.0104	1.8815	0.0082
UK	3.0668	0.0285	2.3816	0.0191
US	2.3795	0.0214	1.9864	0.0153
Group Average	2.1778	0.0175	1.9342	0.0136

Table 3.5 (continued)
Disappointment Aversion with respect to Other Investments, Panel C

Other Investment

Collectivism Group	A	standard error	A^{-}	standard error
Panel C.1				
Brazil	0.0992	0.0275	0.2098	0.0270
Chile	2.0497	0.0289	1.9330	0.0247
Greece	1.5695	0.0231	1.4330	0.0174
Hong Kong	5.3425	0.1549	3.1229	0.0645
Korea	1.5474	0.0300	1.4553	0.0247
Mexico	0.6489	0.0408	0.9598	0.0249
Pakistan	-0.0851	0.0381	0.3350	0.0228
Portugal	1.5258	0.0216	1.4306	0.0190
Slovenia	1.6565	0.0287	1.5732	0.0222
Thailand	2.6542	0.0482	2.0447	0.0291
Turkey	0.1876	0.0328	0.3038	0.0267
Group Average	1.5633	0.0431	1.3455	0.0276
Panel C.2				
Austria	1.9277	0.0421	1.7277	0.0301
Czech Republic	2.4116	0.0422	1.9887	0.0297
Finland	2.0964	0.0467	1.8721	0.0347
Hungary	0.9112	0.0341	1.0199	0.0288
Iceland	-0.7834	0.0632	-0.2444	0.0475
Israel	1.5806	0.0313	1.5090	0.0228
Japan	1.9954	0.0179	1.8596	0.0168
Luxembourg	1.7948	0.0315	1.7461	0.0294
Poland	1.4310	0.0426	1.3384	0.0257
South Africa	0.3548	0.0530	0.4597	0.0499
Spain	1.6900	0.0298	1.5512	0.0236
Group Average	1.4009	0.0395	1.3480	0.0308
Panel C.3				
Australia	2.1420	0.0555	2.0642	0.0482
Belgium	1.5631	0.0228	1.5069	0.0215
Canada	2.8329	0.0549	2.5147	0.0436
Denmark	6.3452	0.2225	3.5604	0.1084
France	1.7035	0.0304	1.5705	0.0232
Germany	1.8379	0.0345	1.8192	0.0312
Italy	1.7117	0.0303	1.6330	0.0277
Netherlands	2.2426	0.0528	1.9645	0.0401
Norway	2.4610	0.0693	1.9807	0.0459
Sweden	4.9511	0.1655	3.1676	0.0863
Switzerland	2.6512	0.0404	2.5312	0.0343
UK	2.1023	0.0828	1.9159	0.0602
US	2.2526	0.0455	2.0513	0.0355
Group Average	2.6767	0.0698	2.1754	0.0466

Table 3.6
Regression Results

The next few tables report the regression results corresponding to equities, bonds and other investments. We have to exclude countries that exhibit negative DA, which will cause problems when taking the natural logarithm. The dependent variables DA are average values of 1,000 DA computed from the bootstrapping method. Therefore, DA is not time–varying. Finally, risk parameters are set as $C_\varphi = 50$, $C_v = 10$ while the probability weighting parameter $\delta = 0.74$.

Panel A Equities

Adj R-squared:	0.37892 (0.02658)	
Variable	mean of the coef.	standard error
Intercept	-1.04235	0.04497
CGDP	0.00141	0.00011
DGDP	-0.00322	0.00011
EFE	0.01623	0.0005
GDP	0.06614	0.01249
INDV	0.00236	0.00014
MCAP	-0.0748	0.00831
MGDP	0.05391	0.00925
PSI	-0.08432	0.00378
VEX	0.15008	0.01918

Table 3.6 (continued)

Panel B Bonds

Adj R-squared:	0.20960 (0.02343)	
Variable	mean of the Coef,	standard error
Intercept	-1.28117	0.12284
CGDP	0.00163	0.00017
DGDP	0.0007	0.00022
EFE	0.01809	0.00168
GDP	-0.11411	0.01307
INDV	0.0026	0.00021
MCAP	0.07702	0.01271
MGDP	-0.05288	0.00546
PSI	-0.01067	0.00891
VEX	-0.13111	0.00763

Table 3.6 (continued)

Panel C Other Investments

Adj R-squared:	0.61400 (0.01130)	
Variable	mean of the coef	standard error
Intercept	-0.55181	0.0897
CGDP	0.0015	0.00013
DGDP	-0.0002	0.00014
EFE	0.01383	0.00132
GDP	-0.05358	0.01113
INDV	0.00163	0.00011
MCAP	0.02435	0.00945
MGDP	-0.09322	0.00993
PSI	0.08024	0.00713
VEX	-0.58568	0.00590

Table 3.7
Disappointment Aversion under Different Risk–Related Parameters

A wide range of risk–related parameters is used to examine the robustness between DA and individualism. Panels A.1, B.1 and C.1 list the global average DA for equities, bonds and other investments, respectively. For the robustness test, DA values are time–varying as they are calculated using asset allocation data in each year from 2005-2012. In order to avoid inconsistencies with former sections, the mean and standard deviation of asset returns are assumed to be constant over the sampling period of 2003–2012. Panels A.2, B.2 and C.2 report the results of the panel regression.

Panel A.1			
C_φ	$C_v = 1$	$C_v = 10$	$C_v = 20$
$C_\varphi = 25$	1.3666	1.6745	2.5764
$C_\varphi = 50$	1.7332	2.3491	4.1527
$C_\varphi = 100$	2.4664	3.6981	7.3054
Panel A.2			
$(C_\varphi,\ C_v = 1)$	Coef.	t–stat	p–value
(25,1)	0.0011	1.7156	0.0877
(25,10)	0.0021	1.9461	0.0534
(25,20)	0.0037	2.0142	0.0453
(50,1)	0.0024	2.3774	0.0186
(50,10)	0.0043	2.7277	0.0069
(50,20)	0.0078	3.1007	0.0021
(100,1)	0.0063	3.3716	0.0009
(100,10)	0.0069	3.0655	0.0025
(100,20)	0.0060	0.2112	0.8342

Table 3.7 (continued)

Panel B.1			
C_φ	$C_v = 1$	$C_v = 10$	$C_v = 20$
C_φ	1.1516	1.3177	1.8706
$C_\varphi = 25$	1.3032	1.6354	2.7412
$C_\varphi = 50$	1.6064	2.2707	4.4823

Panel B.2			
$(C_\varphi,\ C_v = 1)$	Coef.	t–stat	p–value
(25,1)	0.0016	2.9617	0.0034
(25,10)	0.0036	3.1547	0.0018
(25,20)	0.0055	3.6105	0.0004
(50,1)	0.0032	2.6712	0.0081
(50,10)	0.0060	2.8007	0.0055
(50,20)	0.0060	3.3464	0.001
(100,1)	0.0023	2.2697	0.0244
(100,10)	0.0045	2.9573	0.0035
(100,20)	0.0078	3.1739	0.0017

Table 3.7 (continued)

Panel C.1			
C_φ	$C_v = 1$	$C_v = 10$	$C_v = 20$
C_φ	1.2844	1.4849	2.0519
$C_\varphi = 25$	1.5688	1.9798	3.1039
$C_\varphi = 50$	2.1376	2.9596	5.2077
Panel C.2			
$(C_\varphi,\ C_v = 1)$	Coef.	t–stat	p–value
(25,1)	0.0020	2.4112	0.0165
(25,10)	0.0033	1.8346	0.0676
(25,20)	0.0020	1.3611	0.1762
(50,1)	0.0025	2.3473	0.0198
(50,10)	0.0033	2.2362	0.0265
(50,20)	0.0030	1.6182	0.1085
(100,1)	0.0035	3.8728	0.0002
(100,10)	0.0044	3.1727	0.0017
(100,20)	0.0057	2.7419	0.0066

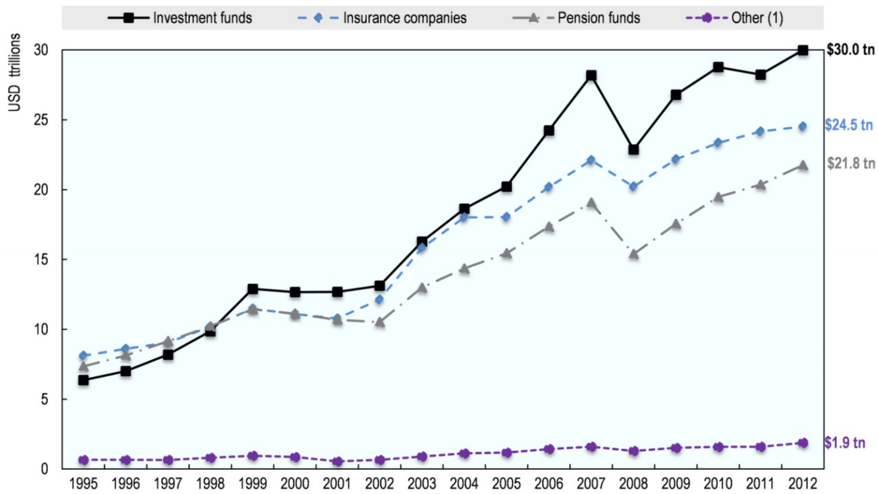
Table 3.8
Robustness Tests under Different Degrees of Probability Weighting

Table 3.8 compares the results of panel regression with respect to equities, bonds and other investments for δ from 0.5 to 1. For the robustness test, DA values are time–varying as they are calculated using asset allocation data in each year from 2005-2012. In order to avoid inconsistencies with former sections, the mean and standard deviation of asset returns are assumed to be constant over the sampling period of 2003–2012. Risk–related parameters equal default values: $C_{\varphi} = 50, C_v = 10$.

Equities				
φ	$\bar{A}_e$	Coef.	t–stat	p–value
0.5	2.7423	0.006	3.1741	0.0017
0.6	2.5282	0.005	2.9361	0.0037
0.7	2.3900	0.0044	2.7768	0.006
0.8	2.2992	0.0041	2.6706	0.0081
0.9	2.2395	0.0039	2.6170	0.0098
1.0	2.2009	0.0038	2.5676	0.011
Bonds				
φ	$\bar{A}_b$	Coef.	t–stat	p–value
0.5	1.8193	0.0037	3.0582	0.0025
0.6	1.7191	0.0035	3.0908	0.0022
0.7	1.6545	0.0065	2.5229	0.0122
0.8	1.6122	0.0053	3.0511	0.0026
0.9	1.5845	0.0048	3.2116	0.0015
1.0	1.5667	0.0046	3.2983	0.0011
Other Investments				
φ	$\bar{A}_{or}$	Coef.	t–stat	p–value
0.5	2.2647	0.002	1.3678	0.175
0.6	2.1095	0.0059	2.1721	0.0309
0.7	2.0094	0.0036	2.2517	0.0252
0.8	1.9437	0.0032	2.0194	0.045
0.9	1.9007	0.003	1.8732	0.0624
1.0	1.8729	0.0035	1.9483	0.0535

Figure 3.1
Total assets by type of institutional investors in the OECD, 1995-2012

Fgure 3.1 shows total assets of institutional investors in the OECD (in trillions), including investment funds, insurance companies, pension funds and other entities. Institutional investors totalled USD 78.2 trillion in 2012, with USD 30.0 trillion coming from investment funds, USD 24.5 trillion from insurance companies, USD 21.8 trillion from pension funds and USD 1.9 trillion from other investors (Source: OECD Global Pension Statistics, Global Insurance Statistics and Institutional Investors databases).



Chapter 4

Dynamic Disappointment Aversion in Different Odours: An Experimental Study

4.1 Introduction

People assign more weights to losses as compared to gains of equivalent nominal values. This tendency was firstly classified as loss aversion (LA) by Tversky and Kahneman (1979). Typically, in a trading situation, the value of a gain needs to be about twice as large as the value of a loss to be accepted (Tversky and Kahneman, 1992). Subsequent to the idea of KT's original setting, Gul (1991) proposed a more axiomatic generation named disappointment aversion (DA) by allowing the reference point to be endogenously determined.

DA affects a wide scale of behaviour, such as decision–making in portfolio choices (Benartzi and Thaler, 1995; Fielding and Stracca, 2007; Xie et al., 2014); willingness to participate in the futures market (Lien and Wang, 2002, 2003); extra volatilities in risk aversion and asset prices in the long run (Routledge and Zin, 2010; Bonomo et al., 2011) or the discouragement effect in a real effort competition (Gill and Prowse, 2012). A disappointment–averse agent, who is loss–averse around their reference point, has been also demonstrated in brain imaging studies, which have shown that amygdala (De Martino et al., 2010; Sokol-Hessner et al., 2013), ventral striatum and other brain regions (Tom et al., 2008) that mediate extra aversions to losses.

Although DA can be viewed as an individual's stable trait, possibly linked with monoaminergic systems in the thalamus (Takahashi et al., 2013), aversion to potentially unfavourable outcomes has also been shown to vary under the influence of emotions (Lerner and Keltner, 2001; Rottenstreich and Hsee, 2001) or cognitive–emotional appraisals applied during decision–making (Sokol-Hessner et al., 2009, 2013). Information about occurrence of adverse events has been reported to increase perceived likelihood of other adverse events (Johnson and Tversky, 1983). These studies suggest that DA may be dynamically adapted in response to instantaneous situational and affective influences.

The sense of smell informs us about the presence of both adverse cues such as fire, poisons, contaminated food or water, and appetitive cues such as food, group members or a safe, nurturing environment. Unpleasant odours have been shown to increase the aversive startle reflex (Miltner et al., 1994; Ehrlichman et al., 1997). Detection of unpleasant odours compared to pleasant odours occurs faster (Bensafi et al., 2002; Jacob and Wang, 2006; Boesveldt et al., 2010), and unpleasant odours are associated with a stronger autonomic arousal than pleasant odours (Brauchli et al., 1995; Alaoui-Ismaili et al., 1997). Odours have also been shown to shift hedonic evaluations of previously neutral visual stimuli towards negative or positive depending on the hedonic quality of the odour (Todrank et al., 1995). Further, odours activate a number of regions known to participate in decision–making including among others the orbitofrontal cortex (Rolls et al., 1996; Gottfried and Zald, 2005), anterior cingulate cortex (Savic and Gulyas, 2000; Ciumas et al., 2008; Rolls et al., 2010), amygdala (Zald and Pardo, 1997; Royet et al., 2000; Savic et al., 2000; Cerf-Ducastel and Murphy, 2003; Gottfried and Dolan, 2004), and anterior insula (Heining et al., 2003; Wicker et al., 2003; Rolls, 2005; Bensafi et al., 2007; Plailly et al., 2007).

The present study aimed to investigate the role of odours on DA in a monetary gamble task. We hypothesised that an unpleasant odour would increase DA relative to presentation of a pleasant or neutral odour. Low–intensity odours were administered during presentation of two prospects, one offering an uncertain gain and loss, and the other an assured zero or non–zero win.

4.2 Methods

4.2.1 Subjects

Thirty–two healthy subjects (18 females, 14 males), aged 25.7 ± 3.55 years (mean $\pm$ standard deviation), took part in the study. All subjects showed normal sensitivity to odours according to the Sniffin' Stick test battery (Hummel et al., 1997). Further, none of the subjects reported any history of a neurological or respiratory disorder, or any acute or chronic inflammation of the respiratory pathways. Subjects gave their written consent prior to the study. The procedures of the experiment were approved by the Research Ethics Committee of the University of Liverpool. Participants received £8 to compensate them for their travel expenses and time.

4.2.2 Procedure

Subjects sat in a dimly lit, sound-attenuated room. The air was continuously cleaned using a Blueair 203 Heppasilent Particle Filter system (Blueair AB, Sweden) to prevent accumulation of any odour residuals in ambient air. Subjects viewed stimuli on a 19–inch cathode ray tube monitor and rested their right hand on a computer mouse. Odours were delivered using a flow olfactometer (OL2, DancerDesign, United Kingdom) at a rate of 2.2 l/min. The olfactometer delivers constant flow of clean air or an odour using two polytetrafluoroethylene tubes of 2 mm diameter ending about 2 cm below the nostrils. The air flowed continuously through bottles containing either about 20 ml of propylene glycol (1,2–Propanediol 99%, Sigma–Aldrich Co., USA), or jasmine (Jasmin Flavour 10794272/2, Symrise GmbH, Germany), or methylmercaptan (Methylmercaptan 10786168/2, Symrise GmbH, Germany) which was diluted in propylene glycol at 1% concentration. These odours, tested in a pilot experiment (N=45, unpublished), yielded distinct pleasant (jasmine) or unpleasant (rotten egg) sensations of comparable subjective intensities without provoking any irritation to the nasal mucosa. To prevent droplets of solution propelling through the tubes of the olfactometer, a cellulose foam was inserted into the bottles. Odours were delivered in pulses of 4 s duration and in pseudo–random order such that an identical odour could not occur twice in a row. The randomisation procedure also maintained intervals between two presentations of the same odour long enough (>30 s) to prevent habituation (Jehl et al., 1994).

The experiment started with acquisition of subjective ratings for pleasantness, intensity and familiarity of each odour. Odour stimuli were presented for 4 s, and subjects rated each odour using three visual analogue scales shown on a computer screen. The intensity scale was anchored with labels “no odour”, and “very strong odour”. The pleasantness scale ranged from “very unpleasant” to “very pleasant”, and the familiarity scale from “not familiar at all” to “very familiar”. All ratings were measured on a scale ranging from 0 to 100.

4.2.3 Monetary Gamble Task

The monetary gamble task was similar to the task used in previous studies (Sokol-Hessner et al., 2009; Tom et al., 2008). Participants received an initial endowment of £25, and were informed that this amount of money was theirs to gamble, and that they could either increase or decrease their initial endowment depending on their luck during the experiment. They were also informed that 10% of gambles would be randomly selected from all trials at the end of experiment, and the difference between sums of wins and losses on those select trials would be added to or subtracted from their initial endowment of £25. Participants' earnings ranged from £6 to £15.

The experiment consisted of 240 gambles with an alternative assured win of zero and 60 gambles with a non–zero assured win. Eighty gambles with assured zero win showed any combination of 8 different gains and 10 different losses for each gain. Specifically, one risky gain denoted as g_i was draw from: £1.00, £2.00, £3.00, £3.50, £4.50, £5.00, £5.50 and £6.00; one risky loss denoted as l_i is calculated by multiplying a gain value by one of 10 coefficients in the range of 0.2 to 2.0 in steps of 0.2. These coefficients yielded ten gain/loss ratios as follows: 5.0, 2.5, 1.67, 1.25, 1.0, 0.83, 0.71, 0.63, 0.56, and 0.5. All permutations (n=80) of gains and losses were presented three times in random order, and each of three presentations of identical gambles was associated with a different odour (240 trials). Twenty trials with a non–zero assured win were also presented three times (60 trials), each time with a different odour. The assured win trials offered a risky prospect (P=0.5) of winning a larger amount of money and a prospect of a smaller assured win. The list of twenty pairs of assured wins and risky gains is given in Table 4.1. Trials were presented in random order for each participant. Due to the large number of trials, the experiment was split into three equal blocks of 100 trials lasting about 22 min each. Blocks were separated by resting periods of approximately 3 min.

[Insert TABLE 4.1 about here]

The stimuli were controlled using Cogent 2000 (UCL, London, United

Kingdom) program running in Matlab 7.8 (Mathworks, Inc., USA) environment. The trial structure is shown in Figures 4.1A and 4.1B. Each trial began with a fixation cross which was displayed for a variable time interval of one or two full respiratory cycles to allow synchronisation of the trial onset with onset of inspiration. Next, two prospects were displayed on the computer screen for 4 s. The left or right part of the screen showed two yellow text lines on a black background, e.g.: “You win 3.0”, “You lose 3.0”. The other half of the screen showed the value of an assured gain. While prospects were still displayed on the screen, two yellow rectangles were displayed in the absence of an odour for another 2.5 s. Participants were instructed to use this period to indicate their decision about the prospects by pressing the left or right mouse button to indicate which option they preferred, and they were also informed that if they did not press any button within the 2.5 s interval, that particular trial would be invalid. After indicating their choice using a computer mouse, the yellow rectangle situated below the selected prospect turned to green. If participants selected the risky gamble option (Figure 4.1B), a 2 s resting interval displaying a black screen was inserted, and feedback in the form “You won” or “You lost” was shown for 1 s. The feedback was followed by a 4 s resting interval before a fixation cross appeared and the next trial began.

[Insert FIGURES 4.1A and 4.1B about here]

4.2.4 Eliciting Disappointment Aversion

In behavioural economics, prospect theory (Tversky and Kahneman, 1979) describes how choices are made among different risky alternatives with given probabilities. This theory states that people make decisions based on the potential value of losses and gains rather than the final wealth level, and that people evaluate losses and gains using certain experience–based techniques. Disappointment aversion (Gul, 1991) is a popular generation of KT’s original setting. Instead of a pre–determined reference point in loss aversion, it captures the fact that people form their reference point endogenously based on their prior expectations. In this section, we employed a parametric method to estimate the level of DA using the utility function:

$$U(x) = \begin{cases} x^{v^+}, & x \geq 0 \\ -A(-x)^{v^-}, & x < 0. \end{cases}$$

Using the standard two–piece power function as a reasonable representation of the participants' utility, we can illustrate three main elements of the DA utility function. Firstly, the utility is reference dependent, where x represents the net satisfaction from each of the 300 (100 x 3 types of odours) risky gambles. Notably, subjects are supposed to define their elation $(x > 0)$ and disappointment in terms of their prior expectation with respect to a specific gamble, i.e., x equals the realised pay–off minus the expected value of each gamble. Secondly, utility of disappointment $(x < 0)$ is denoted by the DA coefficient "A", and it requires $A > 1$ so that investors are disappointment–averse. Thirdly, the two curvature parameters v^+ and v^- serve as the diminishing sensitivity to elation and disappointment, respectively. At the individual level, although most of the empirical studies have found that the utility shape is slightly concave for gains but convex for losses (see Fennema and Van Assen, 1998; Abdellaoui, 2000; Booij and van de Kuilen, 2009); it is also a common belief that the differences between v^+ and v^- should be small at the aggregate level. This assumption was supported by empirical estimations of median power coefficients $v^+ = 0.717$ and $v^- = 0.725$ using a four–step elicitation procedure (Abdellaoui and Bleichrodt, 2007). Likewise, Hwang and Satchell (2010) confirmed that only minor effects were brought in by varying the gap between v^+ and v^-. The main goal of this analysis is to explore the variation of DA during the decision–making process, therefore, we assuming the $v^+ = v^- = v$.

To initiate the elicitation process, we adopted the logit–function to predict the probability that participants would accept a risky gamble. Formally, the function can be written as:

$$F(p, x_e, x_d, x_c) = \Big(1 + exp\Big\{ - \mu\big(U(p, x_e, x_d) - U(x_c)\big)\Big\}\Big)^{-1}, \tag{4.1}$$

where the probability to receive a positive pay-off is regarded as p. During the whole procedure, $p = 1 - p = 0.5$ was maintained to ensure that there was no subjective distortion of the probability. Denote $x > 0$ as x_e and $x < 0$ as x_d, which is the expected elation or disappointment in terms of the expected value of a gamble (Bell, 1985), i.e., for a gamble i, $x_{e,i} = g_i - [pg_i + (1-p)l_i]$ or $x_{d,i} = l_i - [pg_i + (1-p)l_i]$. Then, x_c represents the gains for an assured win. Recall that x_c is only presented when there is no chance to lose, otherwise it is constrained to zero for most cases.

We further posit that participants combine their utility and probability in a linear manner, which implies $pU(x) = U(px)$. The logit parameter μ denotes the sensitivity to utility deviations. $\mu = 0$ indicates that the subject does not care about what they have been offered at all, making their choices completely random. On the other hand, an increasing μ suggests a greater reliance on rationality; participants tend to make choices based on some rules or calculations. At the extreme, all randomness will be eliminated when μ reaches infinity, which represents the utmost consistency in preferences over choices.

Three hundred choices were collected for each participant. Choice data was clustered based on odour type resulting in three sets, counting 100 choices each. Denote Z_i as the response related to the gamble i; Z_i equals 1 if the subject proceeds with the risky gamble, otherwise Z_i will remain zero. The log likelihood function for each odour condition is given by:

$$\sum_{i=1}^{100} Z_i \log\big(F(p, x_e, x_d, x_c)\big) + (1 - Z_i)\log\big(1 - F(p, x_e, x_d, x_c)\big). \tag{4.2}$$

The optimisation process involves finding a proper set of parameter values to maximize Eq. (4.2), which includes the disappointment aversion "A", risk aversion v, and the logit sensitivity μ. Since estimations of these parameters represent a non–linear fitting problem, a numerical approximation has been chosen as a reasonable solution. Specifically, the optimal values for the above parameters were handled using the Nelder–Mead simplex algorithm (see Nocedal and Wright, 2006), implemented in Mathematica 9.0 (Wolfram

Research, Inc., USA).

4.3 Results

The levels of DA, risk aversion v, and logit sensitivity μ from 32 subjects (numbered from OLA05–OLA036) are listed in Table 4.2. Due to erratic choices and unusually high/low values of DA ($A > 5$ and $A < 0.5$), two subjects (OLA012 and OLA018) were assessed statistically as outliers and removed from the sample. Thus, the final sample consist of 30 participants (16 females, 14 males) who are evaluated using one–way analysis of variance (ANOVA) for repeated measures with the three odour conditions as the within–subject factor. The degrees of freedom were corrected using the Greenhouse–Geisser ε correction to overcome any violation of the sphericity assumption.

[Insert TABLE 4.2 about here]

4.3.1 Odour Ratings

Odours differed significantly in their pleasantness according to a one–way ANOVA for repeated measures $(F(2, 58) = 517.1, p < 0.001, \varepsilon = 0.951)$. Jasmine $(77.8 \pm 1.95$, mean $\pm$ standard errors) was evaluated as more pleasant than both clean air $(52.2 \pm 0.9$; $t(29) = 12.7$, $p < 0.001)$ and methylmercaptan $(13.2 \pm 1.8$; $t(29) = 24.8$, $p < 0.001)$, whilst methylmercaptan was evaluated as more unpleasant than clean air $(t(29) = 18.6, p < 0.001)$. Odours also differed in their intensities $(F(2, 58) = 440.9, p < 0.001, \varepsilon = 0.828)$. Both jasmine $(64.6 \pm 2.8$,mean $\pm$ standard errors) and methylmercaptan (77.7 ± 1.97) were perceived as being stronger than clean air $(7.8 \pm 1.7, p < 0.001)$, and methylmercaptan was also perceived to be more intense than jasmine $(t(29) = 6.1, p < 0.001)$. Odours did not differ in their familiarity $(F(2, 58) = 0.51, p = 0.60, \varepsilon = 0.828)$. In the following content, for the ease of comparison, we found it would be more convenient to refer to the methylmercaptan as "rotten egg".

4.3.2 Odours and Disappointment Aversion

In the average of all three odours, 4 subjects were elation–seeking ($A < 1.0$), 8 subjects appeared to be elation–disappointment neutral ($A \in [1.0, 1.1]$), and 18 subjects exhibited significant disappointment aversion ($A > 1.1$). The total average DA was 1.23 ± 0.035 (mean $\pm$ standard errors), matching well the mean DA in a previous study (Abdellaoui and Bleichrodt, 2007). The mean risk aversion v, and logit sensitivity μ were 0.9466 ± 0.22 and 3.97 ± 2.53. A one–sample t–test was run to confirm the presence of DA ($A > 1$) with a statistically significant difference 0.23 from 1 (95% CI, 0.16 to 0.30), t(89) = 6.62, $p < 0.0005$. Specifically, as reported in Table 4.3, DA is captured among all three odours, and the mean $\pm$ standard errors of DA for clean air, jasmine and rotten egg are $1.082 \pm 0.035, 1.223 \pm 0.049$ and 1.391 ± 0.078, respectively.

[Insert TABLE 4.3 about here]

A one–way repeated measures ANOVA was conducted to determine whether there was a statistically significant difference in DA over three different odours. Since estimates of A tend to be positively skewed, the natural logarithm of A values are used to mitigate this defect. Although the assumption of sphericity was met (Mauchly's test of sphericity, $\chi^2(2) = 2.867$, $p = 0.238$. Epsilon (ε) was 0.911), due to a relatively small sample size, the assumption of sphericity is considered difficult not to violate (Weinfurt, 2000). Maxwell and Delaney (2004) recommend interpreting the result using a Greenhouse–Geisser correction (Greenhouse and Geisser, 1959) to report the one–way repeated measures ANOVA (see Table 4.4). Clearly, the variation in odours elicited statistically significant changes in the degree of DA, as demonstrated by $F(1.823, 52.856) = 14.389$, $p < 0.0005$.

Table 4.5 presents the results of the Bonferroni post hoc test, which allows us to discover which specific levels of DA differed with respect to different odours. We can see that there was a significant difference in every pair of odours. i.e., ($p = 0.010$) for clean air and jasmine; ($p = 0.000$) for clean air and rotten egg and ($p = 0.042$) for jasmine and rotten egg.

On the other hand, neither risk aversion nor logit sensitivity were significantly affected by the type of odour $(p > 0.1)$.

[Insert TABLES 4.4 and 4.5 about here]

To analyse whether the differences between jasmine and methylmercaptan in DA would be related to variations in odour pleasantness or odour intensity, Pearson's correlation coefficients were computed between the differences in DA and the difference in odour pleasantness or intensity between methylmercaptan and jasmine conditions. The scatter plots and linear regression lines for odour pleasantness and odour intensity are shown in Figures 4.2A and 4.2B, respectively. We found a statistically significant correlation between the difference values of A and odour pleasantness $(r(28) = -0.364, p = 0.048)$ pointing to a linear increase in A values with increased unpleasantness of methylmercaptan over jasmine.

[Insert FIGURES 4.2A and 4.2B about here]

The correlation computed between A and odour intensity was not statistically significant $(r(28) = -0.02, p = 0.91)$. The association between A values and odour pleasantness was further supported by a one–way ANCOVA for repeated measures using A values as the dependent variable and both odour pleasantness and intensity as covariates. The covariate effect of odour pleasantness was statistically significant $(F(1, 57) = 4.25, p = 0.044)$, and the main effect of odours changed to be statistically not significant after inclusion of odour pleasantness as a covariate $(F(2, 57) = 0.88, p = 0.42)$. This suggests that the odour pleasantness largely accounted for changes of A. The covariate effect of odour intensity was not statistically significant $(F(1, 57) = 0.35, p = 0.57)$, and the main effect of odours proved to be statistically significant even after inclusion of the odour intensity as a covariate $(F(2, 57) = 3.40, p = 0.040)$.

Taken together, the data suggest an increased DA in a monetary gamble task if prospects were displayed in the presence of an unpleasant odour, whose increase was related to variations in hedonic evaluation of odours.

4.4 Discussion and Conclusion

Our study shows for the first time that environmental stimuli could be another means of altering risk attitude. The variation in odours elicits statistically significant changes in the degree of DA, $F(1.597, 46.323) = 11.529$, $p < 0.0005$. Compared with clean air, the DA increased 0.141 ± 0.014 for the presence of pleasant odour (jasmine), whilst the difference jumped further at 0.309 ± 0.074 in response to an unpleasant odour (rotten egg). Moreover, odour–related individual variations in DA were associated with hedonic evaluations of odours but not with odour intensity.

To the best of our knowledge, the present study is the first to demonstrate increases in DA levels during an aversive odour, emphasising evolutionarily based, biological roots of decision–making. Furthermore, our finding highlights the role of unpleasant odours as behavioural signals of threat or danger. Thus, unpleasant odours alter hedonic evaluations of previously neutral stimuli toward less pleasant (Todrank et al., 1995; van Reekum et al., 1999). Unpleasant odours have also been shown to augment defensive reflexes (Miltner et al., 1994; Ehrlichman et al., 1997) and to increase motor–readiness (Bensafi et al., 2002; Jacob and Wang, 2006; Boesveldt et al., 2010), and autonomic arousal (Alaoui-Ismaili et al., 1997; Brauchli et al., 1995). In addition, increases in DA whilst smelling an unpleasant odour are in line with previous studies reporting that negative emotional states increase pessimistic outlooks (Lerner and Keltner, 2001), perceived likelihood for adverse life events (Johnson and Tversky, 1983), or perceived likelihood of occurrence of subsequent negative emotional states (DeSteno et al., 2000).

4.5 Tables & Figures of This Chapter

Table 4.1
List of Risky Gains and Assured Wins Used in the Experiment

The next tables lists all possible 20 risky gains (with a identical probability $p = 0.5$) and 20 assured wins. Trials were presented in random order for each participant. Due to the large number of trials, the experiment was split into three equal blocks of 100 trials lasting about 22 min each. Blocks were separated by resting periods of approximately 3 min.

Pair	£ Risky Gain $(p = 0.5)$	£ Assured win $(p = 1.0)$
1	0.5	1
2	1.5	0.5
3	2	1
4	2.5	1
5	3.5	1.5
6	4	1.5
7	6	3
8	6	2.5
9	6	2
10	7.5	2.5
11	7.5	3
12	9.5	4
13	11	5
14	11.5	5
15	12.5	4.5
16	12.5	5
17	13	5
18	13	6
19	14	7.5
20	15	6

Table 4.2
Estimations of Disappointment Aversion, Risk Aversion and Logit Sensitivity

The levels of DA (A), risk aversion v, and logit sensitivity μ from 32 subjects (numbered from OLA05–OLA036) are listed in Table 4.2. Due to erratic choices and unusually high/low values of DA ($A > 5$ and $A < 0.5$), two subjects (OLA012 and OLA018) were assessed statistically as outliers and removed from the sample. Thus, the final sample consisting of 30 participants (16 females, 14 males) is evaluated using one–way analysis of variance (ANOVA) for repeated measures with the three odour conditions as the within–subject factor.

	Disappointment Aversion (A)		
No.	Clean Air	Jasmine	Rotten Egg
OLA05	1.18	1.12	1.95
OLA06	1.32	1.43	2.85
OLA07	0.92	1.04	1.16
OLA08	0.98	1.00	1.01
OLA09	0.99	1.16	1.65
OLA10	1.61	1.34	1.50
OLA11	1.15	1.15	1.08
OLA12	5.21	1.80	1.83
OLA13	1.10	1.09	1.16
OLA14	1.11	1.11	1.39
OLA15	1.00	1.47	1.94
OLA16	0.97	1.00	1.00
OLA17	1.16	1.00	1.03
OLA18	0.80	0.67	0.50
OLA19	1.45	1.07	1.66
OLA20	1.00	1.51	1.90
OLA21	1.01	1.02	1.17
OLA22	1.54	1.89	1.35
OLA23	0.86	0.95	1.09
OLA24	1.10	1.75	1.84
OLA25	1.02	1.00	1.00
OLA26	0.88	0.80	1.24
OLA27	0.87	1.13	1.00
OLA28	0.92	1.11	1.13
OLA29	1.09	1.05	1.39
OLA30	0.87	1.09	1.30
OLA31	1.28	1.78	1.22
OLA32	1.02	1.35	1.30
OLA33	1.16	1.23	1.11
OLA34	0.99	1.09	1.07
OLA35	1.00	1.66	2.05
OLA36	0.92	1.31	1.19

Table 4.2 (continued)
Estimations of Disappointment Aversion, Risk Aversion and Logit Sensitivity

Risk Aversion v			
No.	Clean Air	Jasmine	Rotten Egg
OLA05	0.80	0.68	0.79
OLA06	0.93	1.17	0.70
OLA07	0.65	0.67	0.67
OLA08	1.33	1.32	0.97
OLA09	0.84	1.02	0.84
OLA10	1.24	0.91	1.36
OLA11	0.85	0.90	0.82
OLA12	0.32	0.95	0.89
OLA13	1.04	0.95	0.96
OLA14	0.70	1.12	0.74
OLA15	0.95	1.01	1.22
OLA16	1.12	1.50	1.35
OLA17	1.32	1.15	1.50
OLA18	0.55	0.52	0.63
OLA19	1.17	1.26	1.18
OLA20	0.93	1.20	1.25
OLA21	0.79	0.73	0.75
OLA22	0.69	1.03	0.77
OLA23	0.93	1.26	0.61
OLA24	0.70	0.94	0.80
OLA25	1.03	1.31	1.13
OLA26	0.90	0.88	1.03
OLA27	0.67	0.82	0.69
OLA28	0.70	0.64	0.71
OLA29	1.20	0.84	1.42
OLA30	0.78	0.83	0.76
OLA31	0.93	0.94	0.81
OLA32	0.80	1.14	1.09
OLA33	0.86	0.85	0.87
OLA34	0.82	0.81	0.93
OLA35	0.77	0.89	0.77
OLA36	0.76	0.92	0.78

Table 4.2 (continued)
Estimations of Disappointment Aversion, Risk Aversion and Logit Sensitivity

Logit Sensitivity μ			
No.	Clean Air	Jasmine	Rotten Egg
OLA05	4.14	5.11	6.00
OLA06	1.24	1.86	2.75
OLA07	5.28	6.09	4.66
OLA08	1.10	1.63	3.27
OLA09	2.29	1.59	1.11
OLA10	6.29	2.46	2.15
OLA11	3.14	1.67	2.80
OLA12	0.92	1.01	0.36
OLA13	2.82	2.43	3.65
OLA14	4.17	1.87	3.77
OLA15	6.06	5.49	3.18
OLA16	5.50	1.92	3.07
OLA17	1.19	3.31	1.33
OLA18	4.61	4.19	1.99
OLA19	3.41	4.09	3.16
OLA20	5.03	1.76	5.15
OLA21	4.90	8.62	6.29
OLA22	2.91	1.72	4.66
OLA23	4.98	4.28	7.38
OLA24	4.62	2.05	2.58
OLA25	1.76	1.58	2.32
OLA26	3.57	4.64	2.92
OLA27	4.96	2.08	2.83
OLA28	4.49	5.40	4.45
OLA29	2.13	1.49	2.55
OLA30	6.49	4.21	3.57
OLA31	3.21	5.27	6.97
OLA32	4.38	6.54	4.36
OLA33	4.56	8.81	9.22
OLA34	4.27	4.48	3.00
OLA35	2.88	2.68	2.09
OLA36	5.58	3.40	2.85

Table 4.3
Means of Disappointment Aversion over Three Odours

Key Statistics of the Estimated Levels of DA for Clean Air, Jasmine and Rotten Egg.

			95% Confidence Interval	
Odours	Mean	Std Error	Lower Bound	Upper Bound
Clean Air	1.082	0.035	1.010	1.154
Jasmine	1.223	0.049	1.122	1.324
Rotten Egg	1.391	0.078	1.232	1.549

Table 4.4
One–Way Repeated Measures ANOVA between Disappointment Aversion and Different Odours

The final sample consisting of 30 participants (16 females, 14 males) are evaluated using one–way analysis of variance (ANOVA) for repeated measures with the three odour conditions as the within–subject factor. The degrees of freedom were corrected using the Greenhouse–Geisser correction to overcome any violation of the sphericity assumption.

Mauchly's Test of Sphericity

Within Subjects Effect	Mauchly's W	Approx. Chi–Square	df	Sig.	ε
Odours	0.748	8.132	2	0.017	0.799

Tests of Within–Subjects Effects

Source		df	Mean Square	F	Sig.
Odours	Sphericity Assumed	2.000	0.388	14.389	0.000
	Greenhouse–Geisser	1.823	0.426	14.389	0.000
	Huynh–Feldt	1.938	0.400	14.389	0.000
	Lower–bound	1.000	0.776	14.389	0.001

Table 4.5
Pairwise Comparisons over Three Odours

Table 4.5 reports the significance level for differences among three different odours: clean air, jasmine and rotten egg. It allows us to discover which specific levels of DA differ from other odour. (CA=Clean Air; JA=Jasmine; RE=Rotten Egg).

Pairwise Comparisons over three odours

Odours		Mean Difference	Std Error	Sig^b	95% Confidence Interval	
					Lower Bound	Upper Bound
CA	JA	-0.115^*	0.036	0.010	-0.206	-0.024
	RE	-0.227^*	0.048	0.000	-0.348	-0.107
JA	CA	0.115^*	0.036	0.010	0.024	0.206
	RE	-0.112^*	0.043	0.042	-0.222	-0.003
RE	CA	0.227^*	0.048	0.000	0.107	0.348
	JA	0.112^*	0.043	0.042	0.003	0.222

* The mean difference is significant at the 5% level.

b Adjustment for multiple comparisons: Bonferroni.

Figure 4.1
Flowchart of the Experiment

A. Declined gambles. Each trial started at around onset of inspiration. Two prospects have been displayed for 4 s. One half of the screen showed a gamble entailing 50% chance of winning or losing the displayed amount of money. The other half of the screen showed an assured win. In the case of choosing an assured win of 0, participants would neither lose nor win anything. In the next 2.5 s period, the prospects continued to be displayed, and two yellow rectangles appeared at the bottom part of the screen prompting the subject to reveal their decision by pressing the left or right button. If subjects declined to gamble and chose the assured win, a fixation cross appeared on the computer screen and the next trials started in few seconds depending on arrival time of the next inspiration.

B. Accepted gambles. If subjects accepted a gamble, a black screen was shown for 1 s after the 2.5 s response period elapsed, and the outcome of the last gamble was displayed ("You won" or "You lost") for 1 s. A resting period lasting 4 s was inserted to allow the skin conductance response to the outcome to evolve. The next trial started few seconds after the 4 s resting period as soon as inspiration has been detected.

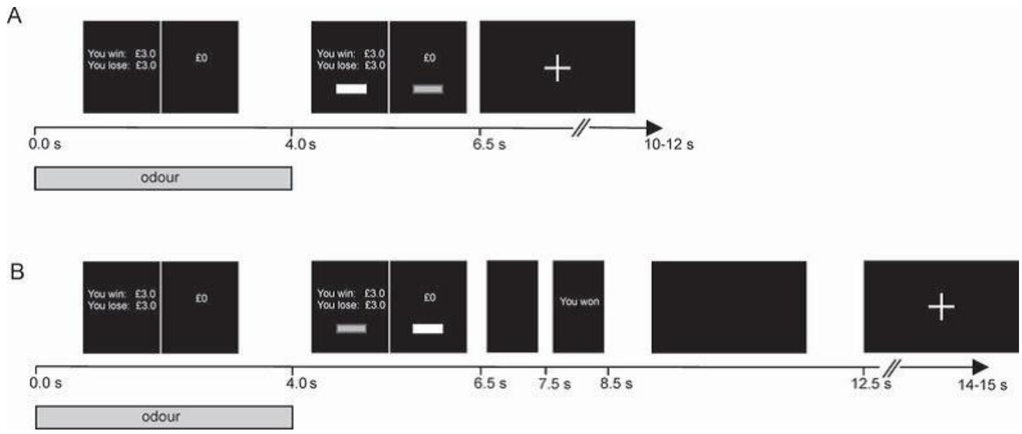
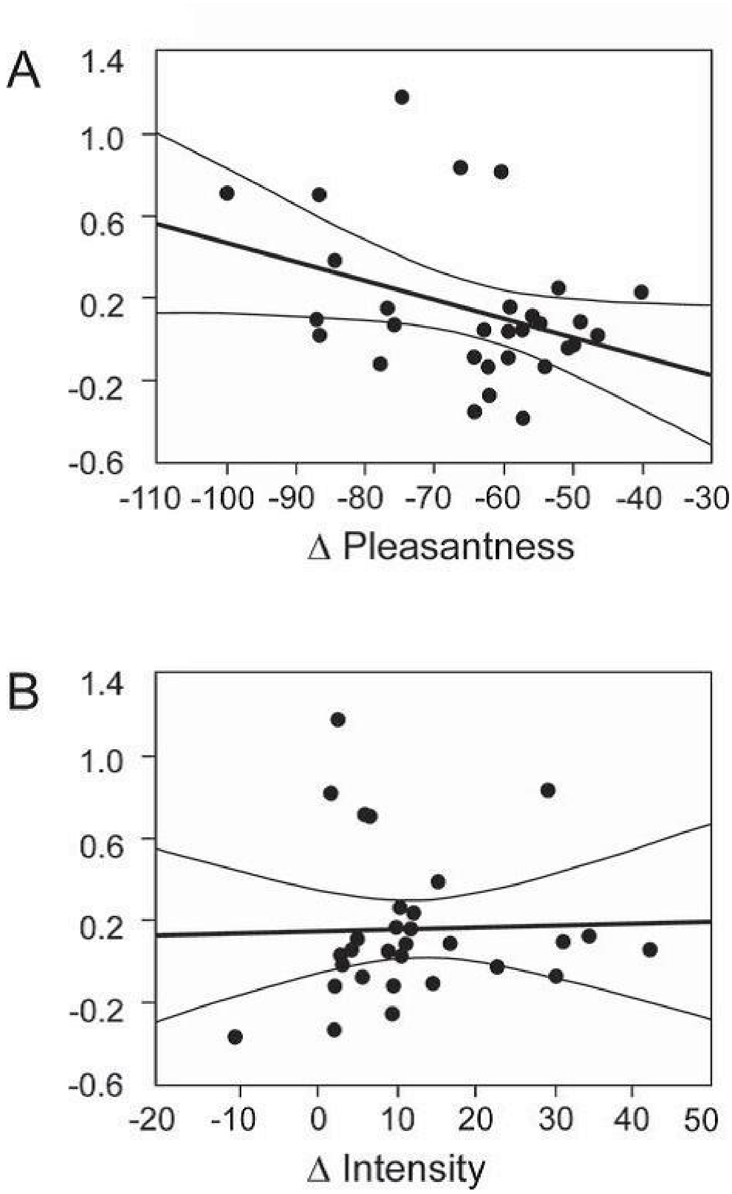


Figure 4.2
Disappointment Aversion vs. Odour Pleasantness and Intensity

The scatter plots, linear regression lines, and 95% confidence lines representing correlations between methylmercaptan–jasmine differences in disappointment aversion A and odour pleasantness (A) and intensity (B).



Chapter 5

Conclusion and Further Directions

5.1 General Conclusion

This thesis takes a close look at the implication of disappointment aversion (DA) in the asset allocation context. Striving to provide partial solutions to the equity premium puzzle, we have demonstrated that how the risk exposures reduce to account not only for risk aversion, but also for disappointment aversion. We argue that investors are subject to this joint effect so that their risk aversion does not have to be overstated to reconcile the observed huge equity premiums.

In Chapter 2, drawing upon the portfolio choice model of Ang et al. (2005), we examine whether this behaviour approach could still be valid outside the US markets. A novel algorithm of numerical approximation is developed to solve the portfolio allocation problem that allows quantitative identification of how the optimal weights relate to different levels of DA. For the empirical analysis, we consider the Dimson–Marsh–Staunton (DMS) database from *Morningstar*, which covers 19 countries over the period 1900–2011 and is also free of ex–post selection bias. Our findings strongly support the view that, in addition to the risk aversion, disappointment aversion further leads investors to reduce their exposure to the stock market (i.e., DA significantly depresses the weights of equities in all cases considered). We further show that optimal equity proportions are jointly determined by the levels of risk and disappointment aversion. Taken together, the findings of this paper enhance our understanding of the sources of the equity premium puzzle around the world.

Despite its appealing features, being a descriptive model in nature, DA is still restricted to applications for several reasons. Most importantly, as existing literature gives little guidance about how to choose an appropriate level of DA, a quantitative measurement is in demand not only for descriptive purposes, but also for theoretical development. In an attempt to cover this area, Chapter 3 develops a formal framework to estimate the aggregate level of DA across 35 countries around the world. We propose (i) principal analytic results derived from the optimization required by DA utility; (ii) the aggregate levels of DA based on the international asset allocations; and (iii) derived results applied to investigate the extent to which the levels of DA are affected by a set of economic and cultural factors. In particular, our focus is on whether the DA will be influenced by an individualism index developed by Hofstede (2001).

Our main results stand as follows: first, DA changes depending on different market conditions. More specifically, for a given period of time, our theoretical results illustrate that one market (country) offering larger equity premiums is often surrounded by stronger DA. This is in agreement with the experimental findings of Abdellaoui and Bleichrodt (2007) in whose study people are particularly frustrated at suffering losses when they have a very good chance of winning. Second, DA also changes depending on different asset types. We obtain a global average DA (standard errors) of stock, bond, and other investments at 2.28 (0.31), 1.64 (0.17) and 1.93 (0.24) respectively. Investors appear to be more disappointment–averse to a risky asset than a less risky one and this might be regarded as a potential source of the equity premium puzzle. Third, our model generates a negative relationship between DA and risk aversion. Implicitly, it implies that wealthier people are prone to have stronger DA because of their higher tolerance to risk. Finally, DA is also clearly affected by cultural impacts. We find robust evidence to conclude that DA is positively associated with individualism. This may be interpreted as meaning that a more individualistic character encourages investors to overstate their ability and prior expectations and therefore leads to a higher probability of being disappointed.

In addition to the dimension of economic concerns, Chapter 4 explores the dynamic variation of DA in a series of monetary gamble tasks. Our study shows for the first time that the environmental stimuli could be another means of altering risk attitude such as risk and disappointment aversion. The variation in odours elicits statistically significant changes in the degree of DA, $F(1.597, 46.323) = 11.529$, $p < 0.0005$. Compared with clean air, the DA increase 0.141 ± 0.014 for the presence of pleasant odour (jasmine), whilst the difference jumps further at 0.309 ± 0.074 in response to an unpleasant odour (rotten egg). Moreover, odour–related individual variations in DA were associated with hedonic evaluations of odours but not with odour intensity.

5.2 Further Directions

We identify a few promising avenues for further research. First, Routledge and Zin (2010) propose a generalized disappointment aversion (GDA) framework in which outcomes are disappointing only if they lie sufficiently below the certainty equivalent. This is a more realistic addition to current decision–making theories that calls for further investigation. Second, the traditional expected utility accommodates an independence axiom, which means past performance should be irrelevant to further decisions. One would wonder whether this contradicts our daily intuitions, as human nature suggests that we should place limits on the assumption of "no prior effect" and allow for the possibility that prior outcomes matter for future risky choices. After two famous survey papers that investigate the aversion to losses over inter–temporal conditions, Thaler and Johnson (1990) and Gertner (1993) document solid evidence to argue that most of the decisions under risk are influenced by prior outcomes. In some later studies, this pattern was even captured among institutional investors. As O'Connell and Teo (2009) and Froot et al. (2011) find that, after experiencing losses, professional investors have an increased propensity to cut risk.

Although the asymmetric utility between gains and losses has experienced rapid development for years, due to its complexity in dynamics, neither loss aversion nor disappointment aversion is addressed in response to prior effect. Therefore, it would be very demanding for subsequent studies to go further beyond such static settings.

Third, from the view of psychology, decades of studies have found human perception and evaluation to be inherently comparative (Festinger, 1954; Kahneman and Miller, 1986; Mussweiler, 2003). Represented by the well–known prospect theory (Tversky and Kahneman, 1979, 1992), behavioural decision–making theories have extensively relied on the *status quo* (SQ) to identify gain–loss utility. In the meantime, although the SQ appears to be the most popular evaluative benchmark, recent studies have shown that decision–makers are systematically sensitive to multiple reference points. The assumption related to a single, fixed reference point could potentially impair prediction power over choice behaviour. Specifically, besides the SQ, scholarly works (e.g., Heath et al., 1999; Lopes and Oden, 1999; March and Shapira, 1992) emphasise two additional reference points: the goal (G) and the minimum requirement (MR). The use of G and MR creates two extra domains on the basis of original gain–loss utility. Since G serves as a desire of aspirations, outcomes that exceed it are classified as elation (also called success/win in some studies). The reference point MR represents the requirement of survival, thereby outcomes below MR are deemed to be a disappointment. Contrary to those early beliefs on the multiple reference points that assume people combined SQ, G and MR endogenously (e.g., Olson et al., 1996), subsequent researchers have finalised a framework by allowing those three reference points to exist and interact simultaneously (i.e., Koop and Johnson, 2012). For instance, an investor feels positive towards an outcome that is greater than his SQ. However, he might also be a little disappointed for not having a better pay–off to meet his G.

Based on the DA utility proposed in Chapter 3, we provide a more detailed discussion below to show a possible form of multiple reference point. When investors utilize the multiple reference points, the utility is split into more regions. Thus, the definition in Eq. (3.1) is no longer suitable to depict how people code future outcomes. Suppose a situation where investors have two reference points, denoting the expected wealth level (μ_w) and the *status quo* as the proxy of their goal (G) and minimum requirement (MR), respectively. The DA utility in Eq. (3.1) can be rewritten as:

$$\begin{aligned}\mu(W,\mu_w) \equiv \mu_w - \varphi\Big[& AI_1^- |W-\mu_w|^v|_{W\leq 0} \\ & + A' I_2^- |W-\mu_w|^v|_{0<W<\mu_w} - I_3^- |W-\mu_w|^v|_{W\geq\mu_w}\Big],\end{aligned} \tag{5.1}$$

where μ_w is the expected wealth, and W represents the end–of–period wealth. The parameter, $\varphi > 0$ shows the relative importance of risk in the utility and represents the *trade–off* relationship between the wealth utility and disappointment–elation utility. I^- is an indicator variable: I_1^- equals 1 only if $W \leq 0$; I_2^- equals 1 only if $0 < W < \mu_w$ and I_3^- equals to 1 only if $W \geq \mu_w$; otherwise, the indicator variable stays zero. Now, two reference points MR and G divide the utility into three domains. Specifically, returns that exceed μ_r (i.e., $W \geq G = \mu_w$) are processed as elation. They occupy the same region as the original case of single–reference point. On the contrary, outcomes will be regarded as disappointment only when they bring absolute losses ($W <= MR = 0$). Finally, remaining situations where $0 < \mu_w < G$ should also generate bad, but milder feelings, which are controlled by A^- and require $1 < A' < A$ to hold for all cases. Suppose the curvature parameters v are equal across all regions: Eq.(5.1) can be rewritten as:

$$U_{DA} = 1 + r_f + \alpha(\mu_r - r_f) - \varphi\Big[A\alpha^v p_d u_d + A'\alpha^v p_m u_m - \alpha^v p_e u_s\Big], \tag{5.2}$$

where α is the proportion of risky assets, and the expected utility with respect to each region is given:

$$\begin{cases} u_d = \mathbb{E}[(W-\mu_w)^v|_{W\leq 0}], & p_d = Pr(W \leq 0) \\ u_m = \mathbb{E}[(W-\mu_w)^v|_{0<W<\mu_w}], & p_m = Pr(0 < W < \mu_w) \\ u_e = \mathbb{E}[(W-\mu_w)^v|_{W\geq\mu_w}], & p_e = Pr(W \geq \mu_w) \end{cases} . \tag{5.3}$$

With respect to the weight (α) on risky assets, taking first-order-condition and second-order-condition of Eq. (5.2), we have:

$$\frac{\partial U_{DA}}{\partial \alpha} = (\mu_r - r_f) + \alpha^{v-1}\varphi v(p_e u_e - A'p_m u_m - Ap_d u_d) = 0, \tag{5.4}$$

$$\frac{\partial^2 U_{DA}}{\partial \alpha^2} = \alpha^{v-2}\varphi v(v-1)(p_e u_e - A'p_m u_m - Ap_d u_d) < 0. \tag{5.5}$$

Solving Eq. (5.4) and (5.5) simultaneously shows $v > 1$ again. Hence, extending to two reference points does not affect **Proposition 1** of Chapter 3. In the meantime, the optimal A^* can be computed by rearranging Eq. (5.4):

$$A^* = \frac{\mu - r_f}{\varphi v p_d u_d} \alpha^{1-v} + \frac{p_e u_e - A' p_m u_m}{p_d u_d} \tag{5.6}$$

A Appendix

This section provides further details of the numerical approximation. The CRRA maximization problem is

$$\max_{\alpha \in [0,1]} \mathbb{E}U(\mu_w). \tag{A.1}$$

The ending period wealth level W is the same in Eq. (2.4). Also, we denote risk aversion by γ, and $U(\cdot)$ is the power utility of the form $U(W) = \frac{W^{1-\gamma}}{1-\gamma}$. The FOC of Eq. (A.1) can be solved by computing α such that

$$\int_{-\infty}^{\infty} W^{-\gamma}(exp(y) - exp(r))f(y)dy = 0 \tag{A.2}$$

Where $f(y)$ is the density function of the equity returns, the Gauss–Hermite Rule is used to get a numerical approximation under the assumption that Eq. (A.2) converges to a certain value and follows a normal distribution. The Gauss–Hermite quadrature is an extension of the Gaussian–Quadrature method for approximating the value of the integrals of the following kind:

$$\int_{-\infty}^{\infty} e^{-x^2} f(x)dx \approx \sum_{i=1}^{n} w_i f(x_i) \tag{A.3}$$

where x_i are the roots of the Hermite polynomial (also called the abscissa points of risky asset returns in our model), which are given by $He_n(x) = (-1)^n e^{x^2/2} \frac{d^n}{dx^n} e^{-x^2/2}$. We take N = 100 of abscissa points to approximate the integral. The associated weights w_i are given by $w_i = \frac{2^{n-1} N! \sqrt{\pi}}{N^2 [H_N - 1(x_i)]^2}$ Choosing quadrature products and weighting functions is discretionary; we refer to this rule because it can be directly used in dealing with indefinite integrals without further modification. According to Abramowitz and Stegun. (1972), for variables that follow normal distributions, Eq. (A.3) is converted into the formula

$$\int_{-\infty}^{\infty} \varphi(y)f(y)dy \approx \sum_{i=1}^{n} p_s \varphi(y_s) \tag{A.4}$$

In our case, $\varphi(y) = U(W)$ for Eq. (2.2) while $\varphi(y) = W^{-\gamma}(exp(y) - exp(r))$ for Eq. (2.3); $f(y) = \frac{1}{\sigma\sqrt{2\pi}}e^{-\frac{1}{2}(\frac{y-\mu}{\sigma})^2}$ represents the normal density function of the equity return with its mean μ and standard deviation σ. p_s and y_s in Eq. (A.4) are connected to Eq. (A.3) by

$$p_s = \frac{1}{\sqrt{\pi}}w_i, \; y_s = \mu + \sqrt{2}\sigma x_s \tag{A.5}$$

In the DA problem, Eq. (2.3) can be rewritten as the following integral when the μ_w is known:

$$\int_{-\infty}^{\mu_w} \left[W^{-\gamma}\left(exp(y) - exp(r)\right)\right] f(y)dy + A\int_{\mu_w}^{\infty} \left[W^{-\gamma}\left(exp(y) - exp(r)\right)\right] f(y)dy = 0 \tag{A.6}$$

Then the same Gauss–Hermite Rule converts Eqs. (2.2) and (2.3) to Eqs. (2.5) and (2.6), where, like Eq. (A.5), weights and abscissa points are given by $p_s = \frac{1}{\sqrt{\pi}}w_i, \; y_s = \mu + \sqrt{2}\sigma x_s$

B Appendix

This section briefly describes the bisection search procedure for finding the optimal interval of certainty equivalent.

Let $x_{e_i} = exp(y) - exp(r)$ denote the excess stock returns in any state i out of N possible outcomes for x_e, $\{x_{es}\}_{s=1}^{N}$, with probability weights $\{p_s\}_{s=1}^{N}$. We can sort x_e from low to high across all states. The utility equivalent μ_w^* corresponding to the optimal portfolio weight α^* could be in any of intervals:

$$\begin{gathered}
[exp(r) + \alpha^* x_{e,1}, exp(r) + \alpha^* x_{e,2}] \\
[exp(r) + \alpha^* x_{e,2}, exp(r) + \alpha^* x_{e,3}] \\
\vdots \\
[exp(r) + \alpha^* x_{e,N-1}, exp(r) + \alpha^* x_{e,N}]
\end{gathered}$$

Suppose μ_w^* lies in state i, namely, at a interval $[exp(r) + \alpha_{e,i}^*, exp(r) + \alpha_{e,i+1}^*]$. Then α^* solves:

$$\sum_{s:W_s \leq exp(r)+\alpha^* x_{e,i}} p_s (W_s^*)^{-\gamma} x_{es} + A \sum_{s:W_s > exp(r)+\alpha^* x_{e,i}} p_s (W_s^*)^{-\gamma} x_{es} = 0, \quad \text{(B.1)}$$

where $W_s^* = exp(r) + \alpha^* x_{es}$. According to Ang et al. (2005), Eq. (B.1) is a CRRA maximization problem with a modified probability distribution $\pi_i = \{\pi_{is}\}_{s=1}^{N}$, i.e., the probabilities π_{is} are transformed from the original quadrature probabilities p_s by the relation

$$\pi_i \equiv \frac{(p_1, ..., p_i, Ap_{i+1}, ...Ap_N)'}{(p_1 + ... + p_i) + A(p_{i+1} + ...p_N)}. \quad \text{(B.2)}$$

The certainty equivalent μ_w^* can be referred as

$$\mu_w^* = \left(\sum_{s=1}^{N} (W_s^*)^{1-\gamma} \pi_{is} \right)^{1/(1-\gamma)}. \quad \text{(B.3)}$$

The algorithm of the bisection search is as follows:

Step.1 Beginning with a guess state i, sloving α_i^*

Setp.2 Computing the $\mu_{w_i}^*$ by Eq.(B.3)

Setp.3 Checking if in this state the following is true:

$$\mu_{w_i} \subset [exp(r) + \alpha^* x_{e,i}, exp(r) + \alpha^* x_{e,i+1}]$$

if this is true for $i = i^*$, then $\alpha^* = \alpha_i^*$ and $\mu_w^* = \mu_{w_i}^*$. Since the states are ordered in increasing wealth across states for a given portfolio weight, if Step.3 is not satisfied and we find that μ_{wi} is greater (smaller) than $exp(r) + \alpha^* x_{e,i+1}$, then we go back to Step.1 by searching in the upper (lower) half of the state space.

References

Abdellaoui, M. (2000). Parameter-free elicitation of utility and probability weighting functions. *Management Science*, 46(11):1497–1512.

Abdellaoui, M. and Bleichrodt, H. (2007). Eliciting Gul's theory of disappointment aversion by the tradeoff method. *Journal of Economic Psychology*, 28(6):631–645.

Abel, A. B. (1990). Asset prices under habit formation and catching up with the joneses. *American Economic Review*, 80(2):38–42.

Abramowitz, M. and Stegun., I. (1972). *Handbook of Mathematical Functions*. Dover Publications, New York.

Alaoui-Ismaili, O., Vernet-Maury, E., Dittmar, A., Delhomme, G., and Chanel, J. (1997). Odor hedonics: Connection with emotional response estimated by autonomic parameters. *Chemical Senses*, 22(3):237–248.

Allais, M. (1953). Le comportement de l'homme rationnel devant le risque: critique des postulats et axiomes de l'cole amricaine. *Econometrica*, 21(4):503–546.

Ang, A., Bekaert, G., and Liu, J. (2005). Why stocks may disappoint. *Journal of Financial Economics*, 76(3):471–508.

Barberis, N. and Huang, M. (2001). Mental accounting, loss aversion, and individual stock returns. *Journal of Finance*, 56(4):1247–1292.

Barberis, N. and Huang, M. (2009). Preferences with frames: A new utility specification that allows for the framing of risks. *Journal of Economic Dynamics & Control*, 33(8):1555–1576.

Barberis, N., Huang, M., and Santos, T. (2001). Prospect theory and asset prices. *Quarterly Journal of Economics*, 116(1):1–53.

Barberis, N., Huang, M., and Thaler, R. H. (2006). Individual preferences, monetary gambles, and stock market participation: A case for narrow framing. *American Economic Review*, 96(4):1069–1090.

Barberis, N. and Thaler, R. (2003). *A survey of behavioral finance*. Elsevier, Amsterdam.

Barberis, N. C. (2013). Thirty years of prospect theory in economics: A review and assessment. *Journal of Economic Perspectives*, 27(1):173–195.

Barro, R. J. (2006). Rare disasters and asset markets in the twentieth century. *Quarterly Journal of Economics*, 121(3):823–866.

Beckmanna, D., Menkhoffa, L., and Suto, M. (2008). Does culture influence asset managers views and behavior? *Journal of Economic Behavior & Organization*, 67(3-4):624–643.

Bell, D. (1985). Disappointment in decision-making under uncertainty. *Operations Research*, 33(1):1–27.

Benartzi, S. and Thaler, R. H. (1995). Myopic loss aversion and the equity premium puzzle. *Quarterly Journal of Economics*, 110(1):73–92.

Bensafi, M., Rouby, C., Farget, V., Vigouroux, M., and Holley, A. (2002). Asymmetry of pleasant vs. unpleasant odor processing during affective judgment in humans. *Neuroscience Letters*, 328(3):309–313.

Bensafi, M., Sobel, N., and Khan, R. M. (2007). Hedonic-specific activity in piriform cortex during odor imagery mimics that during odor perception. *Journal of Neurophysiology*, 98(6):3254–3262.

Berkelaar, A. B., Kouwenberg, R., and Post, T. (2004). Optimal portfolio choice under loss aversion. *Review of Economics and Statistics*, 86(4):973–987.

Beugelsdijk, S. and Frijns, B. (2010). A cultural explanation of the foreign bias in international asset allocation. *Journal of Banking & Finance*, 34(9):2121–2131.

Boesveldt, S., Frasnelli, J., Gordon, A. R., and Lundstrom, J. N. (2010). The fish is bad: Negative food odors elicit faster and more accurate reactions than other odors. *Biological Psychology*, 84(2):313–317.

Bollerslev, T., Engle, R. F., and Wooldridge, J. M. (1988). A capital–asset pricing model with time–varying covariances. *Journal of Political Economy*, 96(1):116–131.

Bonomo, M., Garcia, R., Meddahi, N., and Tedongap, R. (2011). Generalized disappointment aversion, long-run volatility risk, and asset prices. *Review of Financial Studies*, 24(1):82–122.

Booij, A. S. and van de Kuilen, G. (2009). A parameter-free analysis of the utility of money for the general population under prospect theory. *Journal of Economic Psychology*, 30(4):651–666.

Brauchli, P., Ruegg, P. B., Etzweiler, F., and Zeier, H. (1995). Electrocortical and autonomic alteration by administration of a pleasant and an unpleasant odor. *Chemical Senses*, 20(5):505–515.

Breen, W., Glosten, L. R., and Jagannathan, R. (1989). Economic–significance of predictable variations in stock index returns. *Journal of Finance*, 44(5):1177–1189.

Breuer, W., Riesener, M., and Salzmann, A. J. (2014). Risk aversion vs. individualism: what drives risk taking in household finance? *European Journal of Finance*, 20(5):446–462.

Bruhin, A., Fehr-Duda, H., and Epper, T. (2010). Risk and rationality: Uncovering heterogeneity in probability distortion. *Econometrica*, 78(4):1375–1412.

Campbell, J. Y. (1987). Stock returns and the term structure. *Journal of Financial Economics*, 18(2):373–399.

Campbell, J. Y. (2001). Asset pricing at the millennium. *Journal of Finance*, 55(4):1515–1567.

Campbell, J. Y. and Cochrane, J. H. (1999). By force of habit: A consumption-based explanation of aggregate stock market behavior. *Journal of Political Economy*, 107(2):205–251.

Campbell, J. Y. and Hentschel, L. (1992). No news is good–news - an asymmetric model of changing volatility in stock returns. *Journal of Financial Economics*, 31(3):281–318.

Cerf-Ducastel, B. and Murphy, C. (2003). FMRI brain activation in response to odors is reduced in primary olfactory areas of elderly subjects. *Brain Research*, 986(1-2):39–53.

Chui, A. C. W. and Kwok, C. C. Y. (2008). National culture and life insurance consumption. *Journal of International Business Studies*, 39(1):88–101.

Chui, A. C. W., Titman, S., and Wei, K. C. J. (2010). Individualism and momentum around the world. *Journal of Finance*, 65(1):361–392.

Ciumas, C., Lindstroem, P., Aoun, B., and Savic, I. (2008). Imaging of odor perception delineates functional disintegration of the limbic circuits in mesial temporal lobe epilepsy. *Neuroimage*, 39(2):578–592.

Constantinides, G. and Duffie, D. (1996). Asset pricing with heterogeneous consumers. *The Journal of Portfolio Management*, 104(2):219–240.

Constantinides, G. M. (1990). Habit formation – a resolution of the equity premium puzzle. *Journal of Political Economy*, 98(3):519–543.

De Giorgi, E. and Legg, S. (2012). Dynamic portfolio choice and asset pricing with narrow framing and probability weighting. *Journal of Economic Dynamics & Control*, 36(7):951–972.

De Martino, B., Camerer, C., and Adolphs, R. (2010). Amygdala damage eliminates monetary loss aversion. *Proceedings of the National Academy of Sciences of the United States of America*, 107(8):3788–3792.

DeLong, J. and Magin, K. (2009). The U.S. equity return premium: Past, present, and future. *Journal of Economic Perspectives*, 23(1):193–208.

DeSteno, D., Petty, R. E., Wegener, D. T., and Rucker, D. D. (2000). Beyond valence in the perception of likelihood: The role of emotion specificity. *Journal of Personality and Social Psychology*, 78(3):397–416.

Dimson, E., Marsh, P., and Staunton, M. (2008). *The Worldwide Equity Premium: A Smaller Puzzle*, pages 467–514. Handbooks in Finance. Elsevier Science BV, Amsterdam.

Dimson, E., M. P. and Staunton, M. (2006). 'the worldwide equity premium: A smaller puzzle'. Zurich. European Finance Association Meeting.

Ehrlichman, H., Kuhl, S. B., Zhu, J., and Warrenburg, S. (1997). Startle reflex modulation by pleasant and unpleasant odors in a between–subjects design. *Psychophysiology*, 34(6):726–729.

Ellsberg, D. (1961). Risk, ambiguity, and the savage axioms. *Quarterly Journal of Economics*, 75(4):643–669.

Epstein, L. G. and Zin, S. E. (1990). First-order risk aversion and the equity premium puzzle. *Journal of Monetary Economics*, pages 387–407.

Epstein, L. G. and Zin, S. E. (1991). Substitution, risk–aversion, and the temporal behavior of consumption and asset returns – an empirical analysis. *Journal of Political Economy*, 99(2):263–286.

Epstein, L. G. and Zin, S. E. (2001). The independence axiom and asset returns. *Journal of Empirical Finance*, 8:537–572.

Fama, E. F. and French, K. R. (2002). The equity premium. *Journal of Finance*, 57(2):637–659.

Fennema, H. and Van Assen, M. (1998). Measuring the utility of losses by means of the tradeoff method. *Journal of Risk and Uncertainty*, 17(3):277–295.

Festinger, L. (1954). A theory of social comparison processes. *Human Relations*, 7(2):117–140.

Fielding, D. and Stracca, L. (2007). Myopic loss aversion, disappointment aversion, and the equity premium puzzle. *Journal of Economic Behavior & Organization*, 64(2):250–268.

French, K. R., Schwert, G. W., and Stambaugh, R. F. (1987). Expected stock returns and volatility. *Journal of Financial Economics*, 19(1):3–29.

Frijns, B., Gilbert, A., Lehnert, T., and Tourani-Rad, A. (2013). Uncertainty avoidance, risk tolerance and corporate takeover decisions. *Journal of Banking & Finance*, 37(7):2457–2471.

Froot, K., Arabadjis, J., Cates, S., and Lawrence, S. (2011). Evidence on dynamic loss aversion from currency portfolios. *The Journal of Portfolio Management*, 38(1):60–68.

Gemmill, G., Hwang, S., and Salmon, M. (2004). Performance measurement with loss aversion. *Working Paper*.

Gertner, R. (1993). Game shows and economic behavior: Risk–taking on ”card sharks”. *The Quarterly Journal of Economics*, 108(2):507–521.

Ghysels, E., Santa-Clara, P., and Valkanov, R. (2005). There is a risk-return trade–off after all. *Journal of Financial Economics*, 76(3):509–548.

Gill, D. and Prowse, V. (2012). A structural analysis of disappointment aversion in a real effort competition. *American Economic Review*, 102(1):469–503.

Gomes, F. J. (2005). Portfolio choice and trading volume with loss–averse investors. *Journal of Business*, 78(2):675–706.

Gonzalez, R. and Wu, G. (1999). On the shape of the probability weighting function. *Cognitive Psychology*, 38(1):129–166.

Gottfried, J. A. and Dolan, R. J. (2004). Human orbitofrontal cortex mediates extinction learning while accessing conditioned representations of value. *Nature Neuroscience*, 7(10):1144–1152.

Gottfried, J. A. and Zald, D. H. (2005). On the scent of human olfactory orbitofrontal cortex: Meta–analysis and comparison to non-human primates. *Brain Research Reviews*, 50(2):287–304.

Greenhouse, S. W. and Geisser, S. (1959). On methods in the analysis of profile data. *Psychometrika*, 24:95–112.

Gul, F. (1991). A theory of disappointment aversion. *Econometrica*, 59(3):667–686.

Harvey, C. R. (1989). Time-varying conditional covariances in tests of asset pricing-models. *Journal of Financial Economics*, 24(2):289–317.

Heath, C., Larrick, R., and Wu, G. (1999). Goals as reference points. *Cognitive Psychology*, 38(1):79–109.

Heining, M., Young, A. W., Ioannou, G., Andrew, C. M., Brammer, M. J., Gray, J. A., and Phillips, M. L. (2003). Disgusting smells activate human anterior insula and ventral striatum. In *Annals of the New York Academy of Sciences*, volume 1000, pages 380–384, New York.

Hofstede, G. H. (2001). Culture's consequences: Comparing values, behaviors, institutions and organizations across nations. *SAGE Publications*.

Hummel, T., Sekinger, B., Wolf, S. R., Pauli, E., and Kobal, G. (1997). "Sniffin Sticks": Olfactory performance assessed by the combined testing of odor identification, odor discrimination and olfactory threshold. *Chemical Senses*, 22(1):39–52.

Hwang, S. and Satchell, S. E. (2010). How loss averse are investors in financial markets? *Journal of Banking & Finance*, 34(10):2425–2438.

Jacob, T. J. C. and Wang, L. W. (2006). A new method for measuring reaction times for odour detection at iso-intensity: Comparison between an unpleasant and pleasent odour. *Physiology & Behavior*, 87(3):500–505.

Jehl, C., Royet, J. P., and Holley, A. (1994). Very short–term recognition memory for odors. *Perception & Psychophysics*, 56(6):658–668.

Jia, J. M. and Dyer, J. S. (1996). A standard measure of risk and risk–value models. *Management Science*, 42(12):1691–1705.

Johnson, E. J. and Tversky, A. (1983). Affect, generalization, and the perception of risk. *Journal of Personality and Social Psychology*, 45(1):20–31.

Kahneman, D. and Miller, D. (1986). Norm theory: Comparing reality to its alternatives. *Psychological Review*, 93(2):136–153.

Koop, G. and Johnson, J. (2012). The use of multiple reference points in risky decision making. *Journal of Behavioral Decision Making*, 25(1):49–62.

Koszegi, B. and Rabin, M. (2007). Reference–dependent risk attitudes. *American Economic Review*, 97(4):1047–1073.

Kwok, C. C. Y. and Tadesse, S. (2006). National culture and financial systems. *Journal of International Business Studies*, 37(2):227–247.

Lecq, F. V. D., Rivera-Rozo, J., and Steenbeek, O. (2013). Cultural determinants of regulation and supervision of pension funds. *Working Paper*.

Lerner, J. and Keltner, D. (2001). Fear, anger, and risk. *Journal of Personality and Social Psychology*, 81(1):146–159.

Lien, D. and Wang, Y. Q. (2002). Risk aversion, disappointment aversion, and futures hedging. *Journal of Futures Markets*, 22(2):123–141.

Lien, D. and Wang, Y. Q. (2003). Disappointment aversion equilibrium in a futures market. *Journal of Futures Markets*, 23(2):135–150.

Lintner, J. (1965). Security prices, risk, and maximal gains from diversification. *Journal of Finance*, 20(4):587–616.

Loomes, G. and Sugden, R. (1982). Regret theory: an alternative theory of rational choice under uncertainty. *The Economic Journal*, 92(368):805–824.

Lopes, L. and Oden, G. (1999). The role of aspiration level in risky choice: A comparison of cumulative prospect theory and SP/A theory. *Journal of Mathematical Psychology*, 43(2):286–313.

Luce, M. F., Payne, J. W., and Bettman, J. R. (2000). Coping with unfavorable attribute values in choice. *Organizational Behavior and Human Decision Processes*, 81(2):274–299.

March, J. and Shapira, Z. (1992). Variable risk preferences and the focus of attention. *Psychological Review*, 99(1):172–183.

Markus, H. R. and Kitayama, S. (1991). Culture and the self – implications for cognition, emotion, and motivation. *Psychological Review*, 98(2):224–253.

Maxwell, S. E. and Delaney, H. D. (2004). *Designing experiments and analyzing data: a model comparison perspective.* Erlbaum Associates, Mahwah, N.J., 2nd edition.

Mehra, R. (2007). The equity premium in India. In Basu, K., editor, *Oxford Companion to Economics in India*. Oxford University Press.

Mehra, R. (2008). Handbook of the equity risk premium. *Handbook of the Equity Risk Premium*, pages 1–609.

Mehra, R. and Prescott, E. C. (1985). The equity premium – a puzzle. *Journal of Monetary Economics*, 15(2):145–161.

Miltner, W., Matjak, M., Braun, C., Diekmann, H., and Brody, S. (1994). Emotional qualities of odors and their influence on the startle reflex in humans. *Psychophysiology*, 31(1):107–110.

Mussweiler, T. (2003). Comparison processes in social judgment: Mechanisms and consequences. *Psychological Review*, 110(3):472–489.

Nocedal, J. and Wright, S. J. (2006). *Numerical Optimization Berlin*. Springer-Verlag, New York.

O'Connell, P. and Teo, M. (2009). Institutional investors, past performance, and dynamic loss aversion. *Journal of Financial and Quantitative Analysis*, 44(1):155–188.

OECD Pensions Statistics (2013). Pensions at a glance 2013. *Doi: http://dx.doi.org/10.1787/data-00625-en*.

Olson, J., Roese, J., and Zanna, M. (1996). *Social Psychology: Handbook of Basic principles*. Guilford Press, New York.

Plailly, J., Radnovich, A. J., Sabri, M., Royet, J.-P., and Kareken, D. A. (2007). Involvement of the left anterior insula and frontopolar gyrus in odor discrimination. *Human Brain Mapping*, 28(5):363–372.

Prelec, D. (1998). The probability weighting function. *Econometrica*, 66(3):497–527.

Quiggin, J. (1982). A theory of anticipated utility. *Journal of Economic Behavior & Organization*, 3(4):323–343.

Quiggin, J. (1995). Economic choice in generalized expected utility-theory. *Theory and Decision*, 38(2):153–171.

Rolls, E. T. (2005). Taste, olfactory, and food texture processing in the brain, and the control of food intake. *Physiology & Behavior*, 85(1):45–56.

Rolls, E. T., Critchley, H. D., and Treves, A. (1996). Representation of olfactory information in the primate orbitofrontal cortex. *Journal of Neurophysiology*, 75(5):1982–1996.

Rolls, E. T., Grabenhorst, F., and Parris, B. A. (2010). Neural systems underlying decisions about affective odors. *Journal of Cognitive Neuroscience*, 22(5):1069–1082.

Rottenstreich, Y. and Hsee, C. K. (2001). Money, kisses, and electric shocks: On the affective psychology of risk. *Psychological Science*, 12(3):185–190.

Routledge, B. R. and Zin, S. E. (2010). Generalized disappointment aversion and asset prices. *Journal of Finance*, 65(4):1303–1332.

Royet, J. P., Zald, D., Versace, M., Costes, N., Lavenne, F., Koenig, O., and Gervais, R. (2000). Emotional responses to pleasant and unpleasant olfactory, visual, and auditory stimuli: a positron emission tomography study. *Journal of Neuroscience*, 20(20):7752–7759.

Savic, I. and Gulyas, B. (2000). Pet shows that odors are processed both ipsilaterally and contralaterally to the stimulated nostril. *Neuroreport*, 11(13):2861–2866.

Savic, I., Gulyas, B., Larsson, M., and Roland, P. (2000). Olfactory functions are mediated by parallel and hierarchical processing. *Neuron*, 26(3):735–745.

Segal, U. (1987). Some remarks on Quiggin's anticipated utility. *Journal of Economic Behavior & Organization*, 8(1):145–154.

Segal, U. (1989). Anticipated utility: a measure representation approach. *Annals of Operations Research*, 19(1):359–373.

Sharpe, W. F. (1964). Capital–asset prices – a theory of market equilibrium under conditions of risk. *Journal of Finance*, 19(3):425–442.

Sokol-Hessner, P., Camerer, C., and Phelps E., A. (2013). Emotion regulation reduces loss aversion and decreases amygdala responses to losses. *Social Cognitive and Affective Neuroscience*, 8(3):341–350.

Sokol-Hessner, P., Hsu, M., Curley, N. G., Delgado, M. R., Camerer, C. F., and Phelps, E. A. (2009). Thinking like a trader selectively reduces individuals' loss aversion. *Proceedings of the National Academy of Sciences of the United States of America*, 106(13):5035–5040.

Takahashi, H., Fujie, S., Camerer, C., Arakawa, R., Takano, H., Kodaka, F., Matsui, H., Ideno, T., Okubo, S., Takemura, K., Yamada, M., Eguchi, Y., Murai, T., Okubo, Y., Kato, M., Ito, H., and Suhara, T. (2013). Norepinephrine in the brain is associated with aversion to financial loss. *Molecular Psychiatry*, 18(1):3–4.

Thaler, R. and Johnson, E. J. (1990). Gambling with the house money and trying to break even: The effects of prior outcomes on risky choice. *Management Science*, 36(6):643–660.

Todrank, J., Byrnes, D., Wrzesniewski, A., and Rozin, P. (1995). Odors can change preferences for people in photographs – a cross–modal evaluative conditioning study with olfactory USs and visual CSs. *Learning and Motivation*, 26(2):116–140.

Tom, S. M., Fox, C. R., and Poldrack, R. A. (2008). The neural basis of loss aversion in decision–making under risk. *Advances in Consumer Research*, 35:129–130.

Tversky, A. and Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science*, 185(4157):1124–1131.

Tversky, A. and Kahneman, D. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, 47(2):263–292.

Tversky, A. and Kahneman, D. (1992). Advances in prospect–theory – cumulative representation of uncertainty. *Journal of Risk and Uncertainty*, 5(4):297–323.

Van Den Steen, E. (2004). Rational overoptimism (and other biases). *American Economic Review*, 94(4):1141–1151.

van Reekum, C. M., van den Berg, H., and Frijda, N. H. (1999). Cross–modal preference acquisition: Evaluative conditioning of pictures by affective olfactory and auditory cues. *Cognition & Emotion*, 13(6):831–836.

Von Neumann, J. and Morgenstern, O. (1944). *The Theory of Games and Economic Behavior*. Princeton University Press, Princeton.

Voronkova, S. and Bohl, M. T. (2005). Institutional traders' behavior in an emerging stock market: Empirical evidence on polish pension fund investors. *Journal of Business Finance & Accounting*, 32(7-8):1537–1560.

Weil, P. (1989). The equity premium puzzle and the risk-free rate puzzle. *Journal of Monetary Economics*, 24(3):401–421.

Weinfurt, K. P. (2000). *Repeated measures analyses: ANOVA, MANOVA, and HLM. In L. G. Grimm & P. R. Yarnold (Eds.), Reading and understanding more multivariate statistics :317-361*. American Psychological Association, Washington, DC.

Wicker, B., Keysers, C., Plailly, J., Royet, J. P., Gallese, V., and Rizzolatti, G. (2003). Both of us disgusted in my insula: The common neural basis of seeing and feeling disgust. *Neuron*, 40(3):655–664.

Xie, Y., Pantelous, A. A., and Florackis, C. (2014). Disappointment aversion and the equity premium puzzle: New international evidence. *The European Journal of Finance*, page forthcoming.

Zald, D. H. and Pardo, J. V. (1997). Emotion, olfaction, and the human amygdala: Amygdala activation during aversive olfactory stimulation. *Proceedings of the National Academy of Sciences of the United States of America*, 94(8):4119–4124.