Disappointment Aversion and the Equity Premium Puzzle: New International Evidence

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Abstract

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JEL Classification: G11; G12

Keywords: Risk Aversion; Disappointment Aversion; Portfolio Choice; Equity Risk Premium; Downside Risk.

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1. Introduction

A number of studies have shown that stocks outperform bonds over long horizons by a surprisingly large margin. For example, Mehra (2008) reports 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 also observed in other international markets. Dimson *et al.* (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.[4] 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 *et al.*, 2006). On the theoretical side, various risk-related explanations that have been proposed to stress the inability 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 & Duffie, 1996); and habit formation (Constantinides, 1990; Abel, 1990; Campbell, 2001; Campbell and Cochrane, 1999).

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 & Thaler, 2003). Following a series of influential papers by Kahneman & Tversky (1974, 1979, and 1992), a growing body of literature focuses on behavioural explanations to the equity premium puzzle. Fundamental to the prospect theory of Kahneman & Tversky (1974) is the concept of loss aversion, which refers to the tendency to prefer avoiding losses over acquiring gains. A similar, though not identical, concept to loss aversion is that of disappointment aversion. Gul (1991) develops an axiomatic

[4] 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.

disappointment aversion framework where agents form an endogenous expected certainty equivalent. Outcomes below that equivalent are treated as "disappointments". 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)* 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 Kahneman & Tversky, 1979 and Tversky & Kahneman, 1992), which can be the risk-free rate (Barberis & Huang, 2001 and 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 prospect-dependent feature is known as the certainty equivalent.[5]

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 database from Morningstar,[6] which contains data spanning 112 years of history across 19 countries and is free of ex-post selection bias. This is important

[5] 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.

[6] 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, 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 into 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 is maintained. The use of the DMS database ensures that such problems do not apply in our empirical analysis.

because the magnitude of the equity premium differs significantly across markets (see Dimson *et al.*, 2006 and Mehra, 2007). 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 asset for each of the 19 markets considered. 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 the paper is organized as follows: Section 2 presents a simple asset allocation framework under disappointment aversion, which draws upon Ang *et al.* (2005). Section 3 provides details about the dataset utilized and Section 4 presents our results. Finally, Section 5 concludes.

2. The Disappointment Aversion (DA) Asset Allocation Framework

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

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

The DA utility is defined by

$$U\left(\mu_w\right)=\frac{\int_{-\infty}^{\mu_w} U\left(W\right)dF\left(W\right)+A\int_{\mu_w}^{\infty} U\left(W\right)dF\left(W\right)}{\Pr\left(W\le\mu_w\right)+A\Pr\left(W>\mu_w\right)}, \tag{2}$$

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 $U(W)=W^{1-\gamma}/(1-\gamma)$ [7]; "*A*" is the coefficient of disappointment aversion (where $0<A\leq 1$). $F(\cdot)$ is the cumulative distribution function for wealth *W*. The first order condition (FOC) for the DA investor is given by the following expression

$$\mathrm{E}\left[\frac{\partial U(W)}{\partial W}\left(\exp(y)-\exp(r)\right)\mathbf{1}_{\{W\leq\mu_w\}}\right]+A\mathrm{E}\left[\frac{\partial U(W)}{\partial W}\left(\exp(y)-\exp(r)\right)\mathbf{1}_{\{W>\mu_w\}}\right]=0, \tag{3}$$

where **1** is an indicator function and E refers to the expected value of certainty equivalent. According to Eq. (3) above, the DA utility function only concentrates on the differentiation between terminal wealth levels and μ_w, 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

$$W=\alpha W_0\left(\exp(y)-\exp(r)\right)+W_0\exp(r). \tag{4}$$

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, α^* can be calculated by solving Eq. (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 (Eq. (2) and (3)). In this study, we develop an algorithm of numerical quadrature which converts Eq. (2) and (3) into the following form:[8]

$$\mu_W^{1-\gamma}=\frac{\sum_{s:\,W_s\leq\mu_W} p_s W_s^{1-\gamma}+A\sum_{s:\,W_s>\mu_W} p_s W_s^{1-\gamma}}{\Pr(W\leq\mu_w)+A\Pr(W>\mu_w)}, \tag{5}$$

$$\sum_{s:\,W_s\leq\mu_w} p_s W_s^{-\gamma}\left(\exp(y_s)-\exp(r)\right)+A\sum_{s:\,W_s<\mu_w} p_s W_s^{-\gamma}\left(\exp(y_s)-\exp(r)\right)=0. \tag{6}$$

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

[8] See Appendix for details.

Using (5) and (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 determines the optimal weights.[9]

Solving the system above provides optimal weights that usually lie between the interval [0, 1]. A value of α^* that equals to 0 implies that the optimal portfolio choice includes no exposure to the equity market (i.e., risky asset). A value of α^* that equals to 1 implies that all wealth is invested in equities. Our model is not restricted to produce weights only within the [0, 1] interval. A negative weight implies that investors anticipate underperformance of the equity market, leading them to take short (optimal) positions on equities. To 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 the ones obtained by Ang *et al*. (2005) in the case of the US market. The aim of this paper is to extend Ang's *et al*. (2005) study in an international context and examine the role of disappointment aversion in explaining the equity premium puzzle around the world.

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 on the equity premium puzzle. Our final sample is obtained by the 2012 Global Investment Returns Yearbook[10] 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, Netherlands, New Zealand, Norway, South Africa, Spain, Sweden, Switzerland, United Kingdom and United States. 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*

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[9] Further details about the bisection search procedure can be found in Ang *et al.* (2005).

[10] 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.

(CRSP) in order to replicate the findings of Ang *et al*. (2005) for the US market (see Section 4.1 for details). The main stock market index in each case represents investment in the risky asset. For the risk-free benchmark, we focus on T-bills issued in each country.[11]

Table 1 presents some descriptive statistics of our data. The equity premium lies between 2.60% 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 5.20% (4.20%) premium over the US (UK) bills returns. At a global and European level,[12] the outperformance of stocks over T-bills is 4.40% and 3.60%, respectively.

An interesting finding that emerges from Table 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., Bollerslev *et al.*, 1988; Harvey, 1989 and Ghysels *et al.*, 2005), another strand in the literature reports results that reject this view (see e.g., Campbell, 1987; Breen *et al.*, 1989 and Brandt & Kang, 2004). A third group of studies further suggests that the relation between risk and return is time varying (e.g., French *et al.*, 1987 and Campbell & 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

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[11] Short-term T-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.

[12] To construct the world and the European indexes, a weighted average is used based on each country’s GDP (see Global Investment Returns Yearbook, 2012).

holdings (i.e., investments in the risky asset). In this way, our findings provide useful insights into the ambiguous risk-return relationship.

[*Insert TABLE 1 about here*]

4. Empirical Results

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 and Ang *et al*., 2005), the impact of the rebalancing period becomes less of an issue (see also Benartzi & Thaler, 1995; Fielding & Stracca, 2007). We therefore focus on overall sample means to calculate the optimal weights. Table 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 about here*]

Table 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 (i.e. γ =2 and γ =5) and disappointment aversion (i.e., between 0.65, which represents a high DA aversion, and 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 effects). The differences in the estimated optimal weights tend to decrease as disappointment aversion declines, and they 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 (γ =2 and γ =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 3 about here*]

4.2 Optimal Portfolio Weights

Table 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 the relative risk aversion γ is somewhere between 1 and 4. We let the initial coefficient equal to 2 and report how the optimal weights change for different levels of disappointment aversion. Panel A reports the results for euro-zone countries (Belgium, Finland, France, Germany, Ireland, Italy, the Netherlands, and Spain). Panels B reports the optimal weights for European countries from outside the euro-zone area (Denmark, Norway, Sweden, Switzerland, and the UK) while Panel C the optimal weights for non-European countries (Australia, Canada, Japan, New Zealand, South Africa and USA) as well as out two composite European and Global indexes.

[*Insert TABLE 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., $A \leqslant 0.65$). Also, the results show significantly different A^* values across countries. For example, the present 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. Inventors in European countries from outside the euro-zone 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 into 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 indexes. It is also worthy 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 of 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, United States 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 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 two countries have an identical equity premium at 5.5%, the lower volatility 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 effect helps to further reduce the value of *A**.

[*Insert FIGURE 1 about here*]

Figure 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 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 disappointed-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 about here*]

5. Conclusion

Stocks have outperformed bonds over the last century by a surprisingly large margin (Benartzi & 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, the findings of this paper enhance our understanding of the sources of the equity premium puzzle around the world.

We identify three promising avenues for future research: First, Routledge & Zin (2010) propose a generalized disappointment aversion (GDA) framework in which outcomes are disappointing only if they lie sufficiently far below the certainty equivalent. This is a realistic addition to current decision-making theories that needs to be tested in future empirical work. Second, in disappointment aversion-based models such as the one of Ang *et al.* (2005), investors are assumed to receive their utility from elations and disappointments only. However, as argued by Barberis (2010), such modelling choice mainly reflects a need for tractability, not a view that consumption levels do not matter. Therefore, it would be very interesting to see an extended DA function that would consider utility from not only elation/disappointment but also from consumption. Third, following *cumulative prospect theory* (CPT) of Tversky & Kahneman (1992), the use of a subjective probability weighting is widespread. In the context of the disappointment aversion, an appealing exercise would be to test whether a subjective probability weighting could enhance our understanding of investors' portfolio choices.

Appendix

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

$$\max_{\alpha \in [0,1]} \mathrm{E} U\left(W\right). \tag{7}$$

The ending period wealth level W is the same as DA problem, see eq. (4). Also, we denote risk aversion by γ, $U\left(\cdot\right)$ is the power utility of the form $U\left(W\right) = \frac{W^{1-\gamma}}{1-\gamma}$. The FOC of Eq. (7) can be solved by computing the α such that

$$\int_{-\infty}^{\infty} W^{-\gamma}\left(\exp(y) - \exp(r)\right) f(y)dy = 0. \tag{8}$$

Where $f\left(y\right)$ is the density function of the equity returns, the Gauss-Hermite Rule is used to get a numerical approximation under the assumption that Eq. (8) converges to a certain value and $f\left(y\right)$ follows a normal distribution. The Gauss–Hermite quadrature is an extension of Gaussian-Quadrature method for approximating the value of the integrals of the following kind:

$$\int_{-\infty}^{\infty} e^{-x^2} f(x)dx \approx \sum_{i=1}^{n} w_i f(x_i), \tag{9}$$

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 $w_i = \frac{2^{n-1} N! \sqrt{\pi}}{N^2 [H_{N-1}(x_i)]^2}$. It is discretionary in choosing quadrature products and weighting functions, we refer to this rule because it can be directly used in dealing with indefinite integral without further modification. According to Abramowitz and Stegun (1972), for variables that follow normal distributions, Eq. (9) is converted into the formula

$$\int_{-\infty}^{\infty} \varphi(y)\, f(y)\, dy \approx \sum_{i=1}^{n} p_s \varphi(y_s). \tag{10}$$

In our case, $\varphi(y) = U(W)$ for Eq. (2) while $\varphi(y) = W^{-\gamma}\left(\exp(y) - \exp(r)\right)$ for Eq. (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. (10) is connected to Eq. (9) by

$$p_s = \frac{1}{\sqrt{\pi}} w_i,\ y_s = \mu + \sqrt{2}\sigma x_i. \tag{11}$$

In the DA problem, the Eq. (3) can be rewritten to the following integral when the μ_W is known

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

Then the same Gauss-Hermite Rule converts Eq. (2) and (3) to Eq. (5) and (6), where like Eq. (11), weights and abscissas points are given by

$$p_s = \frac{1}{\sqrt{\pi}} w_i, y_s = \mu + \sqrt{2}\sigma x_i.$$

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Table 1
Descriptive Statistics

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

Countries	Equity returns	Bills returns	Equity premium	Equity St. Dev.
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%	2.60%	20.90%
Finland	5.00%	-0.50%	5.50%	30.40%
France	2.90%	-2.80%	5.90%	23.50%
Germany	2.90%	-2.40%	5.70%	32.20%
Ireland	3.70%	0.70%	3.00%	23.10%
Italy	1.70%	-3.60%	5.50%	29.00%
Japan	3.60%	-1.90%	5.60%	29.80%
Netherlands	4.80%	0.70%	4.70%	21.80%
New Zealand	5.80%	1.70%	4.00%	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%	4.20%	22.90%
Switzerland	4.10%	0.80%	3.30%	19.70%
UK	5.20%	1.00%	4.20%	19.90%
United States	6.20%	0.90%	5.20%	20.20%
Europe	4.60%	0.90%	3.60%	21.50%
World	5.40%	0.90%	4.40%	17.70%

Table 2
S&P500 and Treasury Bill Returns from CRSP

This table presents descriptive statistics on equity returns (from S&P500) and Treasury bill returns (90-day T-bills) over the period 1926-1998. These data are obtained from CRSP and used to replicate the optimal weights of Ang *et al*. (2005) for the case of the US market

		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 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 (γ =2 and γ =5)

	Curvature Parameter γ ***= 2***			***Curvature Parameter*** γ ***= 5***		
A	*Ang's weights*	*Our weights*	*Diff (%)*	*Ang's weights*	*Our weights*	*Diff (%)*
1	0.927	0.932	0.51%	0.370	0.372	0.51%
0.95	0.833	0.839	0.73%	0.332	0.335	0.75%
0.90	0.734	0.741	1.05%	0.293	0.296	1.03%
0.85	0.628	0.638	1.50%	0.250	0.254	1.52%
0.80	0.517	0.528	2.17%	0.206	0.210	2.19%
0.75	0.398	0.411	3.29%	0.158	0.164	3.28%
0.70	0.271	0.286	5.54%	0.108	0.114	5.56%
0.65	0.136	0.153	12.60%	0.054	0.061	12.55%

Table 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 equal to 2 and report how the optimal weights change for different levels of disappointment aversion.

Panel A: Optimal Weights for countries from the Euro-zone

A	Belgium	Finland	France	Germany	Ireland	Italy	Nether-lands	Spain
0.6	-0.351	-0.118	-0.077	-0.103	-0.341	-0.120	-0.183	-0.343
0.65	-0.222	-0.016	0.056	-0.008	-0.208	-0.014	-0.041	-0.205
0.7	-0.101	0.079	0.180	0.082	-0.084	0.086	0.092	-0.076
0.75	0.014	0.168	0.296	0.166	0.033	0.180	0.218	0.047
0.8	0.122	0.253	0.406	0.246	0.144	0.268	0.336	0.162
0.85	0.225	0.333	0.509	0.322	0.249	0.352	0.447	0.271
0.9	0.322	0.408	0.606	0.393	0.348	0.431	0.552	0.374
0.95	0.414	0.480	0.698	0.461	0.442	0.506	0.651	0.472
1	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

Panel B: Optimal Weights for European countries outside the Euro-zone

A	Denmark	Norway	Sweden	Switzerland	UK
0.6	-0.416	-0.291	-0.232	-0.350	-0.236
0.65	-0.269	-0.180	-0.097	-0.193	-0.080
0.7	-0.132	-0.076	0.029	-0.046	0.066
0.75	-0.002	0.023	0.148	0.092	0.203
0.8	0.120	0.117	0.260	0.222	0.333
0.85	0.236	0.205	0.366	0.345	0.454
0.9	0.345	0.289	0.466	0.461	0.569
0.95	0.449	0.369	0.561	0.571	0.678
1	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 4 (Continued)
Optimal weights under different A values

Panel C: Optimal Weights for non-European countries

A	Australia	Canada	Japan	New Zealand	South Africa	USA	World	Europe
0.6	0.125	-0.233	-0.113	-0.261	-0.037	-0.114	-0.190	-0.300
0.65	0.297	-0.052	-0.010	-0.104	0.102	0.040	-0.014	-0.156
0.7	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	0.320	0.305	0.105
0.8	0.748	0.426	0.265	0.313	0.468	0.447	0.450	0.224
0.85	0.879	0.567	0.346	0.436	0.575	0.567	0.587	0.337
0.9	1.003	0.699	0.423	0.552	0.677	0.680	0.716	0.443
0.95	1.120	0.825	0.496	0.662	0.772	0.787	0.837	0.544
1	1.229	0.943	0.566	0.766	0.863	0.888	0.952	0.640
A*	0.566	0.665	0.656	0.685	0.613	0.637	0.654	0.708
ERP	0.065	0.041	0.056	0.040	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 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 equal to 2.

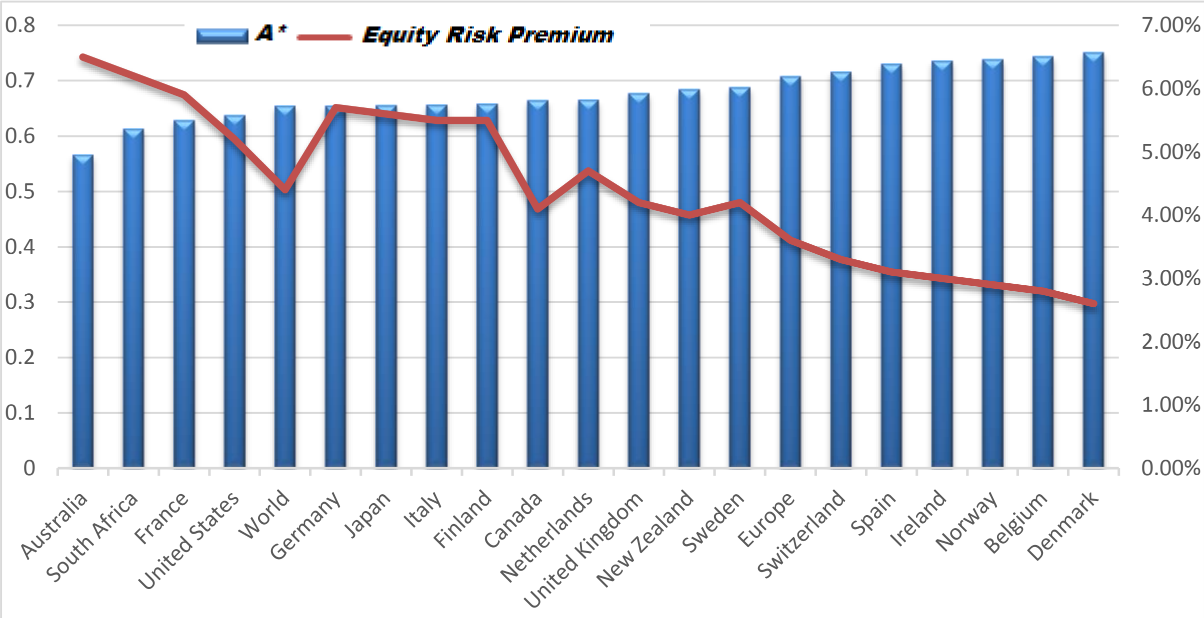


Figure 2

Optimal weights under different risk & disappointment aversion

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

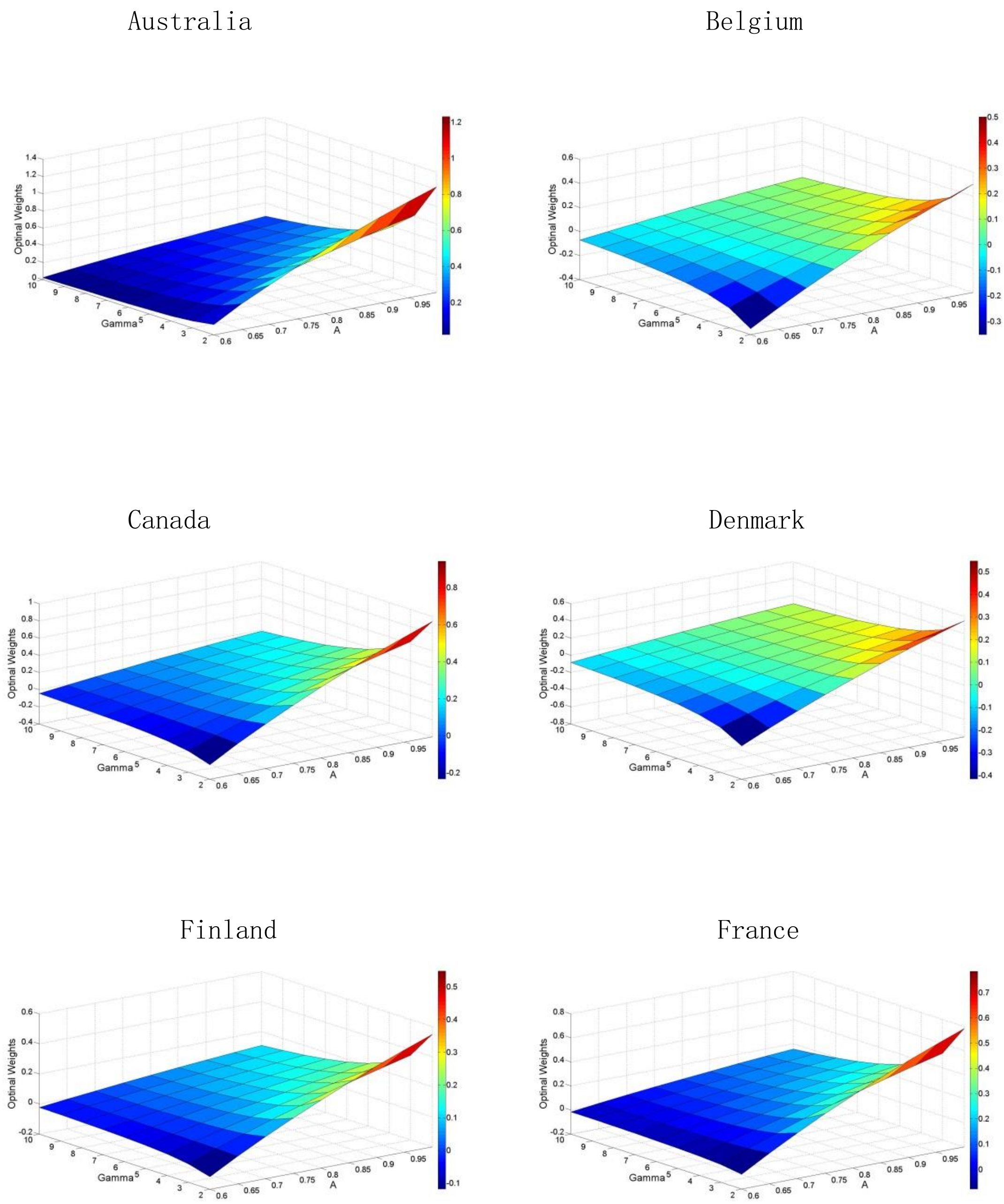


Figure 2 (continued)

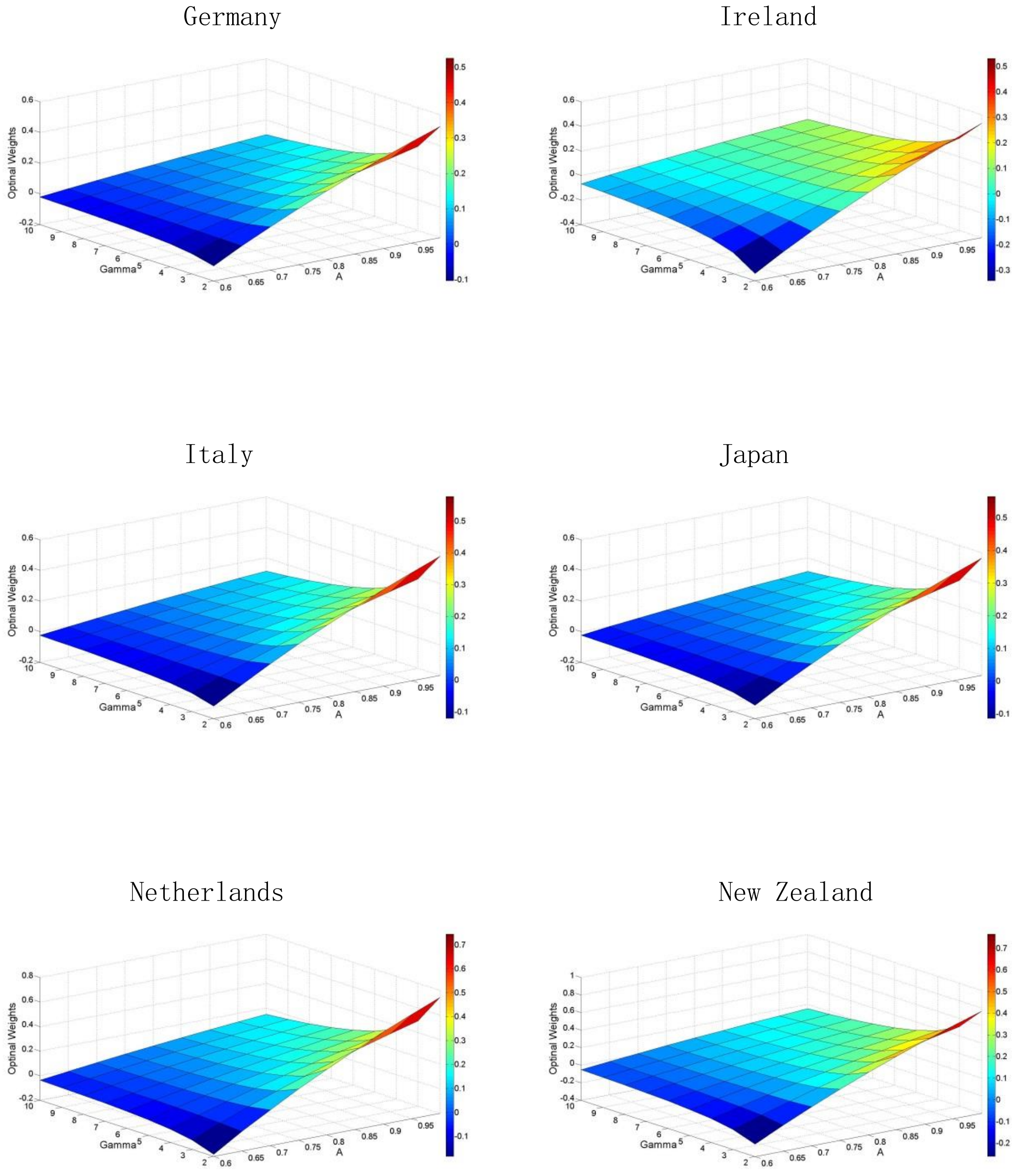
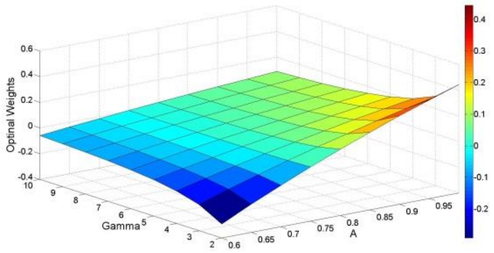
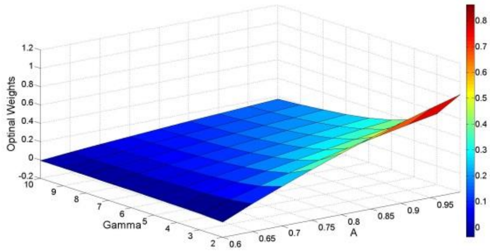


Figure 2 (continued)

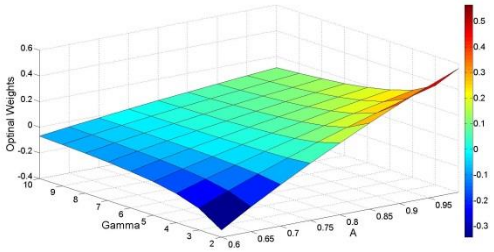
Norway



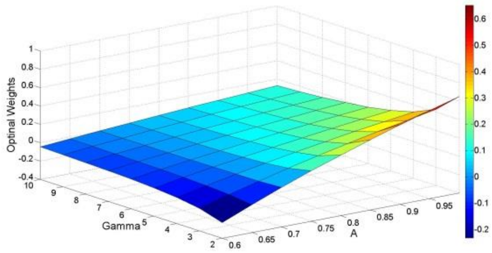
South Africa



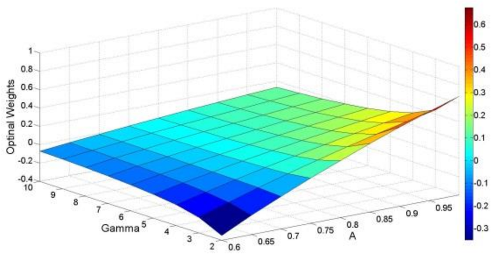
Spain



Sweden



Switzerland



United Kingdom

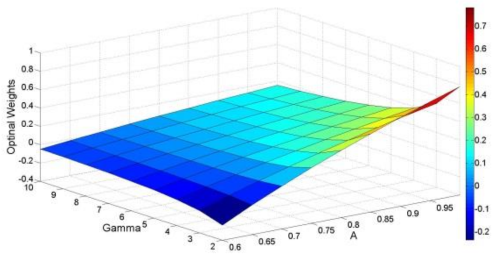
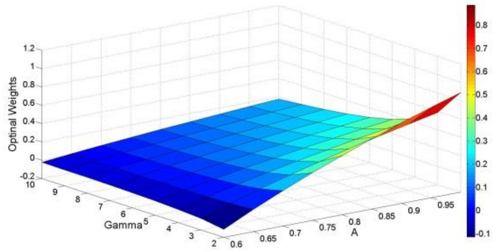
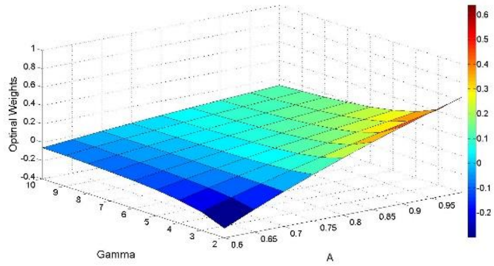


Figure 2 (continued)

United States



Europe



World