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The Fundamental Equity Premium and Ambiguity Aversion in an International Context

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Abstract: Stocks are riskier than bonds. This causes a risk premium for stocks. That the size of this premium, however, seems to be larger than risk aversion alone can explain the so-called "equity premium puzzle". One possible explanation is the inclusion of a degree of ambiguity in stock returns to account for an additional ambiguity premium, whose size depends on the degree of ambiguity aversion among investors. It is, however, difficult to test this empirically. In this paper, we compute the first firm-level estimation of equity premium based on the internal rate of return (IRR) approach for a total of N = 28,256 companies in 54 countries worldwide. Using a survey of international data on ambiguity aversion, we find a strong and robust relation between equity premia and ambiguity aversion.

Keywords: equity premium puzzle; ambiguity aversion; uncertainty aversion

1. Introduction

The equity risk premium puzzle is one of the classic puzzles in finance. Going back nearly three decades, Mehra and Prescott (1985) found that historical average returns on equity on the U.S. stock market from 1889 to 1978 (90 years) far exceeded the average returns of short-term debt, corresponding to basically riskless assets. While the difference would be a natural consequence of risk aversion, the authors argued that the sheer size of this difference could be explained only by a much higher level of risk aversion than what is usually measured in decision experiments.

In the meantime, many possible explanations for this puzzle have been proposed, for example consumption-based generalized expected utility (Epstein and Zin (1991); Constantinides (1990); Abel (1990); Campbell and Cochrane (1999)), rare and disastrous events (Rietz (1988); Mehra (1988); Barro (2005)), idiosyncratic income shocks, (Constantinides and Duffie (1996)), liquidity limitations (Bansal and Coleman (1996)), borrowing constraints (Constantinides et al. (2002)), tax reasons, (McGrattan and Prescott (2003 2005)), survivorship bias (Brown et al. (2012)), the relative volatility of stocks and bonds (Asness (2000)) and measurement errors and poor consumption growth proxies (Mankiw and Zeldes (1991); Ait-Sahalia et al. (2004)). Further discussion is found in some excellent surveys of this work, such as Kocherlakota (1996); Cochrane (1997); Mehra and Prescott (2003); Mehra (2006). All of these approaches, however, are capable of explaining only parts of the puzzle.

Therefore, recent research has concentrated on behavioral factors contributing to an explanation of the equity premium. The two most convincing theories are based on myopic loss aversion (Benartzi and Thaler (1995); Barberis and Huang (2006)) and ambiguity aversion (Chen and Epstein (2003); Barillas et al. (2009); Gollier (2011)).

The myopic loss aversion theory interprets the high amount of equity risk premium with loss aversion, as defined by prospect theory (Kahneman and Tversky (1979); Tversky and Kahneman (1992)), coupled with a myopic view of an investor who evaluates the returns of his/her portfolio on a short-term basis (e.g., annually), while in fact investing for a long-term goal (e.g., for retirement). Since in the short-term, the loss probability of stocks is relatively high, investors request a larger risk premium.

The explanation based on ambiguity aversion starts from the observation that return distributions of stocks are not well known by investors. Therefore, not only does risk aversion, but also ambiguity aversion make stocks unattractive. However, this should be distinguished from models on uncertainty, which can be observed from market data. Since the world is full of uncertainty, this additional ambiguous factor adds an extra premium over the premium for a risky asset. Uncertainty can refer to model uncertainty, probability uncertainty (Camerer and Weber (1992); Mukerji and Tallon (2001)) or political uncertainty (Pástor and Veronesi (2012 2013)). Additionally, information quality helps to understand the equity premium (Epstein and Schneider (2008)).

However, the investors' attitudes toward ambiguity, not the ambiguity itself, causes the ambiguity premium. Ambiguity aversion is therefore crucial for this effect. It has been modeled as an additional behavioral factor beyond risk aversion to contribute to the equity premium (Abel (1989); Abel (2002); Chen and Epstein (2003); Klibanoff et al. (2005); Barillas et al. (2009); Gollier (2011); Ju and Miao (2012)). However, it is hard to test this hypothesis empirically, since it is difficult to distinguish ambiguity from simple risk. An ambiguous situation for one investor might be a risky situation for another investor whose has better a priori knowledge. Even assuming its theoretical feasibility, measuring ambiguity from market data is a complicated task (Izhakian (2012)), and so is investigation of the interaction effect of ambiguity aversion associated with ambiguity on the ambiguity premium in asset pricing models.

Beyond that, one remaining critical problem is the fact that data on the equity risk premium is highly heterogeneous and often inconsistent: different methodologies and in particular very different time horizons are used for the analyses. While in the U.S. time series can go back more than 100 years, in countries that only recently have established financial markets (e.g., in South East Asia, South America or Eastern Europe), time series can be as short as 10 years. Additionally, it would be very helpful to have an estimate that can not only be established at the country level, but actually at the firm level, since this would allow researchers to include various firm level controls that are otherwise necessarily missing in a countrywide comparison.

In our paper, we follow the idea of Fama and French (1999) to consider every firm as an investment project. In other words, we treat an investment into the firm as buying the firm at the beginning of the investment period by acquiring all of its assets. We subsequently retrieve all the positive earnings from its operations and funding all its outflows during the time frame. Finally, we sell the firm at the end to realize our gains. The internal rates of return from the above investments are (on average) the implied returns that investors require when making their decisions to invest money in the companies. It remains to subtract the risk-free returns from the returns of the above investment to obtain an estimate for the equity risk premium. Applying this approach on the Osirisdatabase[1] results in the equity premia estimations for N = 28,256 companies in 54 countries over the world.

In order to test empirically the ambiguity aversion hypotheses, we also need data on ambiguity aversion and other potentially behavioral determinants in different countries. Such data have been collected by the INTRAsurvey (Rieger et al. (2015); Rieger et al. (2017)). Rieger et al. (2015) and Rieger et al. (2017) show that there is a substantial amount of between-country variation in variables measuring risk preferences and ambiguity aversion. If this relates to the dispersion of the equity

[1] "OSIRIS is a fully integrated public company database and analytical information solution. The database provides financial, ownership, news, ratings, earnings and stock data for the world's publicly listed companies. The industrial company financial data on OSIRIS is provided by World'Vest Base (WVB) and five regionally specialized providers; Korea Information Service (KIS), Teikoku Databank (Japan), Huaxia International Business Credit Consulting Company (China), Reuters (USA) and Edgar Online (USA)" (Osiris Data Guide).

premia worldwide beyond other risk factors, ambiguity aversion might play an additional role in accounting for the equity premium.

Cultural finance is a growing field of research that is currently attracting more and more attention. Like "law and finance", "cultural finance" plays the role of a complimentary part of "behavioral finance", which is based on the idea that cultural norms may explain some aspects of bounded rationality. Recent arguments yield a persuasive prediction that cultural characteristics indeed influence the decisions of individual investors. To our knowledge, there is not yet a solid model linking cultural factors to market anomalies, but only some empirical evidence from international research, such as overconfidence momentum returns (Chui et al. (2010)), risk attitudes and the value premium (Chui et al. (2012); Caliskan and Hens (2017))[2], as well as uncertainty avoidance and the equity premium (Rieger and Wang (2012)). However, how to precisely define cultural factors and how they influence investors' choices are still open problems. We study in this paper the impact of these cultural dimensions, together with ambiguity aversion on the equity premium with the aim to shed some new light on this potential connection.

This paper is structured as follows: In Section 2, we review some representatively related literature. Section 3 describes our methodology and reports our estimations of the fundamental equity premium. Section 4 discusses the possibility of applying regression methodology in our international context. Section 5 reports our tests on the ambiguity aversion hypothesis empirically and studies also the impact of cultural dimensions. Afterwards, we conclude and propose some further discussions in Section 6.

2. Related Literature

2.1. Measurements of Equity Premia

We first summarize briefly the three widely-accepted approaches of estimating the equity premium[3]: the historical equity premium, the required premium from surveys and the implied equity premium. All these methods have strengths and weaknesses, but they share the common limits of a survivor bias and the aggregation problem, as will be discussed below.

The original and most natural approach is the historical equity premium. Proposed in the seminal paper of Mehra and Prescott (1985), the idea of comparing the actual returns on stocks over a long time period with the actual returns on a risk-free asset (usually long-term bonds or T-bills) to ascertain the difference on an annual basis as a proxy for the "historical" equity premium is straightforward and easy to replicate. Despite its wide application, the divergence in equity premia between different estimation periods and the general bounded robustness of this approach limits the applicability of this method.

Other concerns are the need for a precise definition of a risk-free proxy and the choice of a representative stock market index. Both treasury-bills and bonds cannot exclude systematic risks, while the return on a single market index clearly does not represent the stock market as a whole; also, whether using a geometric average or an arithmetic average predicts different equity premia, even on the same data and for the same investigation parameters.

All approaches for the estimation of the equity premium, including our approach, share two potential problems: the survivor bias and aggregation problems. First, only data at a country level have been studied, which leads to very few data points. The selection bias of using only data on listed companies (which show to some extent "the survival of the fittest" and tend to outperform other firms in the market) results in a positive return. There is also an "aggregation problem" that the index has to reflect the overall returns of the whole stock market, which requires the broadest coverage

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[2] A recent summary can be found in Table 3 in Breuer and Quinten (2009).

[3] We do not mention here the traditional definitions of equity premia derived from asset pricing models (CAPM, APTand others). An excellent review can be found in Damodaran (2013).

and has to be weighted according to stocks' market capitalization. Last but not least, the exogeneity of the equity premia leads to greater difficulties if one wishes to investigate the equity premia in an international comparison.

The second widely-accepted approach is the "required equity premium" from surveys. It seems natural to ask investors directly about the expected returns they demand when investing in stocks. The survey subjects may range from individual investors (Shiller (2000)), institutional investors, professionals, managers (Graham and Harvey (2015)), to academics (Welch (2000); Fernandez et al. (2017)). However, the participants in stock markets are very diverse. One of the challenges is to find a subset of investors that best represents the aggregate market. A sub-problem of that is to overcome the well-documented errors in the prediction of the survey subjects, such as narrow framing, the anchoring effect or overconfidence[4]. A specific investor/fund manager or other individuals in charge of investment decisions also have their own knowledge, experience and inside information. This means that their actions are driven by those behavioral errors and consequently lead to disagreement in the subjectively required equity premia. Since these components are often inaccurately predicted, the aggregation of those might not be particularly reliable.

The last method to be discussed is the implied equity premium. This method is most closely related to the "fundamental" approach that we apply in this paper. To prove that investing in stocks yields better payoffs than investing in other risk-free assets, the key components of the average equity premium, the rate of return from firm investments, need to be estimated. If we know a priori the duration in years of a firm's high growth rate as N, the expected free cash flows to equity (potential dividends) per year t as $\mathrm{E}(FDFE_t)$, the expected rate of return of equity investors as k_e and the stable growth rate (after year N) as g_N, we can estimate the implied rate of return with the following formula:

$$Value\,of\,equity = \sum \frac{E(FCFE_t)}{(1+k_e)^t} + \frac{E(FCFE_{N+1})}{(k_e - g_n)(1+k_e)^N} \tag{1}$$

The above equation is the basic NPV formula to solve k_e, given the potential dividends and the current price. The subtraction of a risk-free rate generates a more precise estimation. However, the assumption of a constant growth rate, a contrarian N and a forecasted g raises concerns about the accuracy of this methodology. Again, no guarantee on the representativeness of the country-wide aggregation rate of return is given.

All of these obstacles seem to suggest that it would be helpful to have an estimate that can not only be established at the country level, but actually at a firm level, since it would allow researchers to include various firm-level controls that are otherwise missing, especially in a country-wide comparison. Such an alternative approach is taken by the internal rate of return (IRR), which was initially used by Fama and French (1999) for a similar purpose[5]. Its advantages are, as pointed out above, that it is computable at a firm level and also computable on shorter time series. Its disadvantage is that it is rather difficult to compute, because, in order to obtain a worldwide sample, one needs accounting data of good quality for a sufficiently large number of companies worldwide. Fortunately, the Osiris database nowadays provides exactly such data. We describe our methodology and report the estimation results in Section 3.

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[4] In brief, investors usually overvalue themselves (overconfident), pay more attention to the recent fluctuations of some specific stocks in their portfolio (narrow framing) and use past information as reference points (anchoring effect). This explains the common positive magnitudes of the required equity premia and the tight bounds of those estimations.

[5] They used accounting and stock data in the U.S. for the period of 1950 to 1966. Their measurements were in the order of six to seven percent in real terms, which is close to the compound year returns of stocks for the same period.

2.2. Ambiguity Aversion to Explain the Equity Premium

Ambiguity as introduced in the seminal work by Knight (1921), in which Knightian uncertainty is defined as a situation in which some events do not have an obvious probability assignment. The experimental relevance of this distinction between risk and uncertainty was first introduced through the Ellsberg paradox (Ellsberg (1961)), whereby people would rather choose to bet on the outcome of an urn with 50 red balls and 50 blue balls than to bet on the one with 100 balls, but for which the distribution of blue or red balls is unknown. The behavior of preferring risky choices over ambiguous choices is, therefore, ambiguity aversion.

In later literature, attitudes toward ambiguity and the degree of ambiguity were mixed in some axiomatizations (Gilboa and Schmeidler (1989); Epstein and Miao (2003)), but they are two different concepts in other works (Ghirardato et al. (2004); Klibanoff et al. (2005)). While attitudes toward ambiguity (ambiguity aversion) can be measured with data from experiments in the setting of the above-mentioned Ellsberg paradox, other works argue that the degree of ambiguity can be observed directly from the market data (Izhakian (2012) and the references therein). However, behaviorists maintain a skeptical view on the direct measurement of ambiguity: the distinction between risk and ambiguity exists in the mind of the decision maker, rather than in the data. Thus, only attitudes toward ambiguity can be observed, rather than the ambiguity that influences the decisions of agents (Chen and Epstein (2003); Barillas et al. (2009); Gollier (2011)).

Intuition suggests that the effect of ambiguity aversion adds to those of risk aversion: the effect reduces the demand for ambiguous assets and acts as an extra risk aversion. Then, the equity premium is the sum of two positive terms, one for risk aversion and the other for ambiguity aversion (Chen and Epstein (2003)). However, definitions of ambiguity aversion differ among scholars, such as the aversion toward model misspecifications in robust control asset pricing (Hansen et al. (1999)) or the aversion towards the unknown probability distribution of contingent events (Mukerji and Tallon (2001)). In line with this, the most widely-known theory, the smooth ambiguity model (Klibanoff et al. (2005, 2009)), succeeds in separating ambiguity and ambiguity attitudes to form the preference foundations for introducing ambiguity as an additional (risk) factor. Investors require a premium for their compensation for risks, but also an ambiguity premium for additional ambiguity. In theoretical models, this is proven to hold under some specific conditions (Gollier (2011)). Ambiguity aversion implies an increased implicit risk, not necessarily an increase in risk aversion. The increasing implicit risk reduces the risk-free return, thereby leading to a larger equity premium.

3. The "Fundamental" Equity Premium

To estimate the equity premium with the fundamental approach, we treat every firm as a project. In other words, we consider the investment as buying a firm at the beginning by acquiring all its assets, subsequently retrieving earnings and funding outflows. At the end, we sell the firm to realize returns. The IRR from this investment is the objective return, given the condition that investors had enough initial money to buy the whole company at the beginning and to sponsor all the outcomes (e.g., investments and operational costs). The equity premia aggregated at the country level can then be used as a proxy for the required equity premia under the assumptions of the law of large numbers.

More precisely, we use the following accounting items to estimate the IRRs: the book capital of a firm in year t is defined as the sum of long-term debt plus short-term debt and book equity, where book equity is the sum of total assets, minus total liabilities, plus deferred tax. The cash earnings in year t are computed by adding earnings before extraordinary items and depreciation.

Investment in year t is measured as the change in book capital of the firm between year $t-1$ and t. To increase the number of observations, we set the value of long-term debt, short-term debt

and the value of net cash flow to zero when there are missing values[6]. This modification is suggested by Fama and French (1999) and has been proven to work well for real-life data.

A natural concern is the accounting regulation in different countries investigated, but this has been addressed by the global detailed format in Osiris. Raw data are presented in the company's country-specific and regional accounting standards. The accounts are further condensed, and the format presentations are synchronized across the different templates in the global detailed and global formats. These standardized formats enable users to follow the account logic while maintaining a high level of data transparency and accuracy[7].

Technically, the IRR[8] is the discount rate r_c solving from the following formula:

$$0 = -IC_0 + \sum_{t=1}^{T-1} \frac{X_t - I_t}{(1+r_c)^t} + \frac{FC_T + (X_T - I_T)}{(1+r_c)^T}, \tag{2}$$

where IC_0 is the book value of a firm's assets at the beginning of the investment period, X_t is the cash earnings of a firm in year t, I_t is the gross investment of a firm in year t, FC_T is the book value of a firm's assets at the end of the investment period, T is the number of years of the investment period, c denotes book values and t is the summation index.

Formula (2) is the standard expression of the IRR of an investment project. The ideal cases in which we have all the accounting variables for the whole period of 10 years from OSIRIS are infrequent, whereas the cases in which firms entering and exiting the data in durations of less than 10 years are more frequent. Thus, the time indexes of the IRR formula have to be adjusted to match these time spans.

We have to apply the following method to utilize the best information available from OSIRIS: firstly, the IRR formula requires firm values at time zero, firm values at time T (the end of an investment period) and yearly information about incomes and investments. Secondly, firms with at least two consecutive years of data availability are then selected. Thirdly, an investment subperiod is named as a run from year t to year $t+i$, in which i is the number of consecutive years. Lastly, the firm value at the beginning of a run IC_t equals the book capital of this firm in that year, while the firm value at the end of the run FC_{t+i} has to be adjusted by the net cash flow (i.e., earnings minus investments). The largest number of years in a run is nine, and the smallest number is two. Numerical examples of the IRR methodology are illustrated in Table 1.

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[6] We have to replace 2438 observations of deferred tax, 5196 observations of extraordinary items, 1921 observations of short-time debt and 1162 observations with long-term debt with zero. This constitutes in total less than 7% of the overall observations. This trade-off makes sense, since we can include more firms, but our methodology still maintains the consistency of the estimated IRRs.

[7] "The industrial financials on Osiris from World'Vest Base, Multex, KIS, Teikoku and Huxia are collected through direct company contact and directly from the original annual reports issued by the companies. The regional accounting practices are retained with the use of the *Anglo* (mostly used for American, English and Nordic companies), *Hybrid* (mostly used for European companies) and *Continental* (mostly used for Asian and Australian companies) templates, which present differing *Spreadsheet* formats. Accuracy is retained in the *Global detailed* and *Global* formats as the accounts are further condensed and the format presentations are synchronized across the three industrial templates" (Osiris data guide) (http://www.otago.ac.nz/library/pdf/OSIRISDataGuide.pdf).

[8] Fama and French (1999) propose two concepts: IRRs on costs and IRRs on values. In the first term, the initial investment is to acquire the firm at its market value, while booked costs are used in the second. The same argument is applied to the values at the end of the investment period. In this section, we apply only nominal values following the "money illusion" assumption in which investors usually deal with nominal values in practice (Benartzi and Thaler (1995)). Consequently, the use of book values better captures the "fundamental" corporate returns by excluding all trading risks in stock markets. Thus, such data perfectly fit our international comparison.

Table 1. Numerical examples of the internal rate of return (IRR) methodology.

	Company A	**Company B**	**Company C**	**Company D**
31 December 2001	−1.104.830			−183.174
31 December 2002	203.821			−5.310
31 December 2003	−197.944		−3.022.000	142.967
31 December 2004	−490.045		−252.000	
31 December 2005	−662.773		628.000	
31 December 2006	435.908	−73.653	252.000	
31 December 2007	−38.688	1.975	4.627.000	
31 December 2008	−511.806	2.218		
31 December 2009	462.479	−8.246		
31 December 2010	4.591.151	107.112		
IRR	12%	9%	15%	−13%

The cash flows to estimate IRRs are formed as follows: the initial value of each run equals the book capital of the firm and starts with a negative value; the middle terms are net cash flows (i.e., earnings minus investments); and the end-run value equals the book capital of the firm plus the net cash flow of the end-run year. The currency unit is U.S. dollars. These values are extracted from real data, but company names are hidden.

The next step is to create a 10-year investment period from 2001 to 2010 to apply the IRR formula to estimate the equity premia[9]. After computing the IRR for a large number of companies, we then remove outliers[10] and check the consistency of our results by comparing the country-aggregated IRRs with the equity premia approximated by other methodologies.

Applying this method yields reasonably-sized estimates for the equity premium (Table 2). The median equity premia range from 0.94% (Denmark) to 7.75% (The Netherlands) in Europe; 4.46% (Argentina) to 13.82% (Cayman Islands) in the Americas; 4.14% (Jordan) to 11.86% (United Arab Emirates) in the Middle East; 3.04% (Indonesia) to 15.05% (Vietnam) in Asia; and 9.55% (Morocco) to 16.33% (South Africa) in Africa. Interestingly, the equity premium in the U.S. is 9.93%, which is very close to some recent estimations of the equity premia (reviews can be found in Damodaran (2013); Rieger and Wang (2013) and the references therein). Intuitively, the equity premium that we measure for a single country is, strictly speaking, not an equity premium, but just one instance of a required return by investors. On average, however, this corresponds to the equity premium.

To the best of our knowledge, this is the first international estimation of firm-level equity premia. The results confirm that the equity premium exists and is not merely an artifact of previously applied country-level methods. There is a certain payoff applying this approach, since the values do not necessarily reflect long-term data; however, the (necessary) short-term series expand our world sample and keep the consistency of our international comparison.

[9] We attempt to increase the IRR estimates by assuming that a firm with data that have missing values during the investigation period can be disparted into a maximum of three runs (consecutive years). The IRRs from these runs are then aggregated to estimate an IRR for a specific firm. However, this does not work since the IRRs cannot yield estimated results due to a lack of data points.

[10] We drop the top and bottom 1% percent of observations, as is standard in this field (Ramsey and Ramsey (2007)). In addition, we remove countries that have less than 30 companies in order to improve the representativeness of sampling, thereby excluding 64 countries and 491 companies out of the sample.

Table 2. Fundamental equity premia across countries.

No.	Country	Firms	Obs.	ERPs	SD	No.	Country	Firms	Obs.	ERPs	SD
	Western Europe						*Middle East*				
1	Austria	58	468	5.57%	120.1%	29	United Arab Emirates	35	217	11.86%	17.3%
2	Belgium	96	705	5.88%	16.9%	30	Israel	364	1896	5.68%	11.1%
3	Switzerland	119	847	6.04%	12.5%	31	Jordan	121	892	4.14%	8.3%
4	Cyprus	78	360	7.23%	215.8%	32	Kuwait	90	556	11.21%	50.4%
5	Germany	489	3465	3.26%	13.3%	33	Oman	92	719	8.19%	96.5%
6	Denmark	58	391	0.94%	9.6%	34	Saudi Arabia	70	442	8.98%	11.6%
7	Spain	98	603	4.75%	11.1%						
8	Finland	101	866	5.83%	8.8%		*Far East and Central Asia*				
9	France	564	3976	6.63%	25.5%	35	Bangladesh	99	294	10.20%	23.2%
10	U.K.	1075	6449	6.30%	49.6%	36	China	2236	14,548	6.36%	12.4%
11	Greece	200	1303	1.66%	8.7%	37	Hong Kong	123	856	7.34%	8.6%
12	Ireland	50	336	6.98%	12.3%	38	Indonesia	72	278	3.04%	6.9%
13	Italy	197	1319	3.29%	9.5%	39	India	2756	14,583	5.01%	11.4%
14	Netherlands	98	747	7.75%	9.8%	40	Japan	2435	17,769	3.02%	6.1%
15	Norway	98	564	5.65%	9.9%	41	Korea (South)	1288	8143	7.48%	19.4%
16	Portugal	38	274	1.46%	8.3%	42	Sri Lanka	158	835	7.14%	12.3%
17	Sweden	265	1604	7.29%	20.1%	43	Malaysia	672	4865	5.48%	9.2%
18	Turkey	228	1108	5.16%	15.1%	44	Philippines	126	713	6.79%	12.7%
						45	Pakistan	347	1697	6.16%	136.6%
	South and Central America					46	Singapore	527	3256	9.02%	11.1%
19	Argentina	81	549	4.66%	15.1%	47	Thailand	409	2771	7.78%	9.1%
20	Bermuda	543	4057	7.12%	17.1%	48	Taiwan	1413	9104	6.86%	11.7%
21	Brazil	303	1848	6.35%	58.6%	49	Vietnam	155	417	15.06%	18.2%
22	Chile	69	366	4.73%	136.3%						
23	Cayman Islands	657	3793	13.82%	47.5%		*Africa*				
24	Mexico	83	518	5.43%	13.6%	50	Egypt	154	1065	13.77%	12.0%
25	Peru	123	737	5.54%	33.5%	51	Kenya	34	181	12.23%	20.4%
26	Virgin Islands (British)	58	194	8.80%	18.4%	52	Morocco	34	233	9.55%	9.2%
						53	Nigeria	84	399	11.25%	115.6%
	North America					54	South Africa	212	1366	16.33%	13.4%
27	Canada	2596	13,596	1.50%	383.5%						
28	U.S.	5727	36,089	9.93%	249.1%						

4. Data on Ambiguity Aversion and the Empirical Approach

4.1. Data on Ambiguity Aversion and Risk Preferences

In order to find empirical evidence for the ambiguity aversion hypothesis, we need data on ambiguity aversion and risk preferences in different countries. The INTRA survey (Rieger et al. (2015); Rieger et al. (2017)) shows that there is a substantial amount of between-country variation in variables measuring risk preferences and ambiguity aversion. If this relates to the dispersion of the equity premia worldwide beyond other risk factors, ambiguity aversion might play an additional role in accounting for the equity premium.

The first experimental design to capture the ambiguity-averse attitude is the well-known Ellsberg paradox (Ellsberg (1961)). By recording choices of decision makers between alternative lotteries with precise and imprecise probabilities, Ellsberg (1961) determines a preference for known risks over unknown risks. The degree of ambiguity aversion can be measured experimentally with minor modifications in the settings of the original lottery selection game. In the INTRA survey, ambiguity aversion is measured by the percentage of participants who chose the unambiguous lottery in each country, using an Ellsberg paradox-type question as follows. These data are then aggregated at a country level to determine a proxy for the average ambiguity aversion of individual investors in a country. Therefore, a higher value means more ambiguity aversion.

Please imagine the following offers and mark your choice.

In an urn, there are 100 balls with three colors (red, yellow and blue); 30 balls are red, whereas the remaining 70 consist of yellow and blue balls.

30 balls	**70 balls**	
Red	Yellow	Blue

Imagine a ball is drawn randomly from the urn. You are offered the following two lotteries. Which lottery would you prefer?

A. If the color of this ball is red, you win \$100; otherwise, you win nothing

B. If the color of this ball is yellow, you win \$100; otherwise, you win nothing.

(A preference for Option A points to a significant amount of ambiguity aversion).

Similarly, we use the relative risk premium (RRP) parameters from the INTRA as proxies for risk preferences. The RRP[11] is measured in the two domains: gains and losses. According to the prospect theory, losses have more emotional impact than an equivalent amount of gains. The RRP is positive when a person is risk averse and negative when a person is risk-seeking. A large RRP means more risk aversion (or less risk-seeking).

Connecting investors' preferences to the equity premium requires us to overcome the critique of the representativeness of our countrywide aggregation. Thanks to home bias (Coval and Moskowitz (1999)), investors tend to hold local stocks in the majority. For instance, French and Poterba (1991) empirically report the domestic ownership share in 1990 of the world's five largest stock markets to be 92.2% (U.S.), 95.7% (Japan), 92% (U.K.), 79% (Germany) and 89.4% (France). This tendency to prefer local stocks is due to institutional barriers to foreign investments, transaction costs (Black (1974); Stulz (1981)) and tax reasons (French and Poterba (1991))

While we do not assume that ambiguity aversion of average investors corresponds exactly to that measured in the INTRA study, the relative differences between countries should be reflected by the relative differences between investors of companies from the respective countries[12]. For instance,

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[11] For a more detailed description of the survey, please refer to Rieger et al. (2015).

[12] Cross listing and foreign ownership could be issues if the aim is to estimate precisely the equity premia acquired by local investors. However, firm-level data on ownership structures are difficult to find. Moreover, the relative differences of equity

it might be the case that participants of the INTRA study in Vietnam and Germany have higher ambiguity aversion than average investors in their respective countries, but given that the participants in Vietnam have a higher ambiguity aversion than those in Germany, the result nevertheless suggests that investors in Vietnam are likely to have a higher ambiguity aversion than investors in Germany. That this relative difference is consistent with the INTRA study data is relevant for our empirical result. A precise value of ambiguity aversion of investors would be nice to know, but the elicitation method in the INTRA survey in any event does not allow us to obtain precise quantitative data on the amount of ambiguity aversion.

Since preference variables from INTRA are the results of the aggregation among individual investors, a possible criticism is that institutional investors might outperform individual investors. However, the majority of investors, especially in emerging markets, are individuals (DeBondt (1998)). Even when that is not the case, in a world of institutional investors such as pension, mutual and hedge funds, managers investing others' money often exhibit interests aligned with those of their clients (Haigh and List (2005)). In fact, our estimation of investors' preferences in INTRA proves a good proxy to model a representative investor in every country in the sample. Matching INTRA data with our estimations of equity premia results in N = 25,748 companies in 35 countries for our final investigation (Table 3).

Table 3. Equity premia, ambiguity aversion and risk preferences.

Country	Number of Companies	ERPs	RRP		Ambiguity Aversion
			Gains	Losses	
Argentina	81	4.66%	0.74	−0.34	0.59
Austria	58	5.57%	0.65	−0.63	0.39
Australia	1344	3.61%	0.65	−0.44	0.48
Belgium	96	5.88%	0.66	−0.35	0.72
Canada	2596	1.50%	0.77	−0.33	0.63
Switzerland	119	6.04%	0.78	−0.45	0.57
Chile	69	4.73%	0.67	−0.17	0.68
China	2236	6.36%	0.56	−0.35	0.67
Germany	489	3.26%	0.84	−0.54	0.47
Denmark	58	0.94%	0.64	−0.17	0.59
Spain	98	4.75%	0.72	−0.23	0.60
Finland	101	5.83%	0.73	−0.32	0.46
France	564	6.63%	0.54	−0.43	0.54
U.K.	1075	6.30%	0.72	−0.49	0.61
Greece	200	1.66%	0.66	−0.77	0.59
Hong Kong	123	7.34%	0.93	−0.72	0.64
Ireland	50	6.98%	0.86	−0.53	0.48
Israel	364	5.68%	0.83	−0.63	0.58
India	2756	5.01%	0.68	−0.54	0.82
Italy	197	3.29%	0.80	−0.35	0.53
Japan	2435	3.02%	0.76	−0.54	0.62
South Korea	1288	7.48%	0.55	−0.39	0.58
Mexico	83	5.43%	0.93	−0.72	0.62
Malaysia	672	5.48%	0.64	−0.81	0.59
Nigeria	84	11.25%	0.69	−0.60	0.65
Netherlands	98	7.75%	0.44	−0.17	0.57
Norway	98	5.65%	0.74	−0.46	0.46
New Zealand	81	7.95%	0.67	−0.64	0.53
Portugal	38	1.46%	0.61	−0.29	0.60
Sweden	265	7.29%	0.65	−0.21	0.50
Thailand	409	7.78%	0.60	−0.52	0.80
Turkey	228	5.16%	0.63	−0.18	0.62
Taiwan	1413	6.86%	0.66	−0.54	0.67
USA	5727	9.93%	0.78	−0.43	0.42
Vietnam	155	15.06%	0.67	−0.33	0.70

premia across countries, not their absolute values, are the main subjects of our investigation in accordance with the variation in investors' preferences. This could be improved in further research, provided that more data are available.

4.2. Regression Models and Controls

We apply the weighted regression as follows:

$$w_i EP_{i,j} = \alpha_i + w_i A_i \beta_{1i} + w_i C_i \beta_{2i} + \epsilon_i \quad (3)$$

where $EP_{i,j}$ is the equity premium of firm j in country i and A_i is the vector of ambiguity aversion and/or other risk factors. C_i is the vector of controls, and w_i is the weight, which equals the ratio of the number of companies in a country over the total number of companies in the sample, while ϵ_i is the error term. As robustness checks, we apply regressions using the down-weighting outlier methodology, as introduced in Street et al. (1988). This helps to create a smoother dataset by assigning case-by-case weights associated with every extreme case. However, for international data, an outlier in one country could be the normal case in the sample of another region. This approach increases the explanatory power (high R-squared), but reduces the effects of global-wide dispersion in our investigated variables.

Controls have been selected with care. For firm-specific risks, we use the beta of a stock (Ben-Zion and Shalit (1975)) (computed using the last one-year returns in reference to the market indexes), the volatility (Bekaert and Wu (2000)) (over the last 360 trading days[13]), the log of a firm's leverage ratio (Ben-Zion and Shalit (1975)), the number of analysts following a stock (Harris and Marston (2001)) and the past one-year's cumulative stock return (Graham and Harvey (2005)). Those variables are available from the OSIRIS database.

The effects of market-wide determinants and country-level factors (Ferson and Harvey (1994); Lombardo and Pagano (2006)) are controlled by proxies representing information quality, transparency, institutional environment and government policies. To overcome collinearity, we report only results in regressions with selected macroeconomics factors as controls. In particular, all our regressions are tested using the Collin tests (Belsley et al. (2005)).

We use the log of gross domestic product (GDP) per capita, log of the ratio of stock market capitalization to GDP, log of the GDP growth rate and the economic freedom index as macroeconomic controls. For robustness checks, the investor protection index, market efficiency index and the Gini index are investigated, as well as the *LLSV*[14]-type variables (details in Appendix A), which control for the relationship between law, institutional system and finance, and all may have some impact on the equity premium.

Since our data are unique, we integrate additional behavioral variables from other international surveys. One of these is the proportion of participants who describe themselves as risk-seeking or risk averse in the World Value Survey[15], and the uncertainty avoidance index (UAI) from Hofstede (2001), which is more closely related to ambiguity aversion. This index captures the extent to which a society can tolerate an uncertain or ambiguous situation. Last but not least, the cultural indexes of Hofstede are investigated to shed light on the relationship between the equity premium and cultural determinants. Intuitively, one may infer that the UAI is associated with risk attitude, but Hofstede (2001) has emphasized that "uncertainty avoidance does not equal to risk avoidance". Moreover, Rieger et al. (2015) also demonstrated that ambiguity aversion differs from Hofstede's UAI.

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[13] The 360-day volatility as of a specific date is the unbiased standard deviation of the 359 most recent logarithmic daily returns, multiplied by an 'annualization' factor (which is 260, since there are 260 working days in a calendar year) (OSIRIS definition).
[14] Rafael La Porta, Florencio Lopez-de-Silanes, Andrei Shleifer and Robert Vishny (LaPorta et al. (1998, 2000)); Djankov et al. (2008)).
[15] http://www.worldvaluessurvey.org/.

5. Empirical Tests on Ambiguity Aversion and the Equity Premium

5.1. Key Results

We begin our investigation by using equity premium as the dependent variable and other potential determinants as the independent components of the weighted least squares regressions. Starting with only firm-level controls, we investigate our ambiguity-aversion measure together with other macroeconomics factors in turn (Table 4). Our evidence supports the additional role of ambiguity aversion beyond other risk preferences to account for the equity premia (Table 5). The coefficients of ambiguity aversion are significantly negative in all of our models, that is the equity premia are lower in countries where investors are ambiguity averse, which is in line with Gollier (2011). Even though the intuition suggests that ambiguity aversion plays an additional role beyond risk aversion to explain the equity premium puzzle (Hansen et al. (1999); Chen and Epstein (2003)), this is not true (Rothschild and Stiglitz (1971); Fishburn and Porter (1976); Gollier (1995); Abel (2002); Athey (2002)) or holds only under some specific conditions[16]. Ambiguity aversion increases the implicit risk, not necessarily the risk aversion. Generally speaking, the ambiguity premium, i.e., the interaction term between ambiguity aversion and ambiguity, plays this additional role beyond risk premium in the modern asset pricing formula. The impossibility to measure ambiguity from our data prevents us from testing the effects of this interaction term between ambiguity aversion and ambiguity on the equity premium.

In the next step, we attempt to test cultural factors, in particular Hofstede (2001)'s individualism collectivism index (IDV) and UAI. All the four behavioral dimensions might have effects, but we focus more on the above-mentioned two factors, because they have been shown previously to affect financial markets (Kwok and Tadesse (2006); Beugelsdijk and Frijns (2010)). The feasible approaches have been applied on momentum returns (Chui et al. (2012)), value premium (Chui et al. (2012); Caliskan and Hens (2017)), foreign equity holdings of institutional investors (Anderson et al. (2011)) and, similarly, in the field of cultural behavioral finance (Lucey and Dowling (2013)).

According to Hofstede (2001), the individualism dimension reflects the degree to which individuals address themselves as unique and independent, or alternatively, as integrated into groups. However, because the individualism index is the result of an aggregation of cultural values, it is difficult to imply a direct link from cultural norms to investors' risk attitudes. On the one hand, individualism is positively related to overconfidence and self-attribution bias (Chui et al. (2010)): investors in more individualistic countries tend to see themselves as better than others, which leads to overweighting their own trading skills and private information, and consequently, more risk-seeking. This eventually causes excess noise-trading and, therefore, higher equity premia. On the other hand, the "cushion hypothesis" (Hsee and Weber (1999)) proposes the opposite: the strong social network in a collectivistic (i.e., low individualism) society provides a "cushion" against potential financial catastrophe and, therefore, induces less risk-averse behavior. Our empirical results slightly support the first of these ideas by finding positive significant coefficients of the IDV in all our models (Table 6).

The second cultural dimension that we investigate is the UAI, which is to some extent related to our ambiguity aversion. This dimension expresses the degree to which the members of a society feel

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[16] As indicated in Gollier (2011): if the distribution of the returns of the equity market is ambiguous and agents bias their beliefs towards the one with the smallest expected utility, i.e., ambiguity aversion, the sufficient conditions for an increase in ambiguity aversion to reduce the demand for the risky asset, i.e., an increase in the equity premium, are the following: (1) the marginals (priors) can be ranked by first-order stochastic dominance, and relative risk aversion is less than unity; (2) the marginals can be ranked by Rothschild and Stiglitz's increase in risk, and relative prudence is positive and less than two; and (3) the marginals can be ranked by second-order stochastic dominance and central dominance. In this case, a reduction in the return on an asset has a substitution effect and a wealth effect. The wealth effect may induce an increase in the ambiguous asset demand in the same way as the Giffen goods in consumption theory, consequently an increase in the equity premium. However, the existence of the Giffen goods is quite rare and not well documented in the literature. Ambiguity aversion increases the implicit risk of the uncertain assets, but does not necessarily affect the risk preference of investors. In the counter example of Gollier (2011), the more ambiguity averse, the less the equity premium.

comfortable with uncertainty or ambiguity. In the original definition by Hofstede (2001), uncertainty avoidance measures how a society deals with the fact that "*the future can never be known: should we try to control the future or just let it happen?*". Uncertainty avoidance is a much more general concept than ambiguity aversion itself. In our tests, the effects of uncertainty avoidance on the equity premium are weak and negative, suggesting a need for further investigation before any implication can be drawn (Table 7).

Two possible concerns are the possibility of collinearity between cultural variables with ambiguity aversion and the strong effect of ambiguity aversion in joint models with other macroeconomic and cultural characteristics. We check these issues by removing ambiguity aversion from the above-mentioned models after the collinearity tests. However, the results remain similar and, therefore, are not reported.

Table 4. Regression results for the equity premium and ambiguity aversion.

	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 4	(5) Model 5
Ambiguity aversion	−1.88 ***	−2.53 ***	−1.88 ***	−2.08 ***	−0.77 ***
	(0.762)	(0.877)	(0.695)	(0.763)	(0.286)
GDP per capita	0.00 **				
	(0.000)				
GDP growth rate		−0.05 **			
		(0.022)			
Stock market capitalization			0.00 ***		
			(0.000)		
Economic freedom				0.03 ***	
				(0.009)	
Beta of stock	0.19 **	0.08 **	0.14 **	0.17 **	0.06
	(0.087)	(0.052)	(0.069)	(0.078)	(0.043)
Stock volatility	0.00	−0.00	0.02	0.02	0.03 *
	(0.019)	(0.04)	(0.019)	(0.018)	(0.020)
Leverage ratio	−0.03 **	−0.03 **	−0.03 **	−0.03 ***	−0.03 ***
	(0.012)	(0.014)	(0.013)	(0.012)	(0.009)
Analysts	−0.01	−0.00	−0.01	−0.01	−0.01
	(0.004)	(0.003)	(0.004)	(0.004)	(0.004)
Past stock return	−0.02	−0.001	−0.02	−0.02	−0.00
	(0.012)	(0.012)	(0.012)	(0.012)	(0.011)
Anti-director index	−0.24 ***	−0.24 ***	−0.27 ***	−0.33 ***	
	(0.078)	(0.081)	(0.090)	(0.109)	
Rule of law	−0.36 **	−0.07	−0.05	−0.16 **	
	(0.163)	(0.038)	(0.036)	(0.070)	
Anti-self-dealing index	1.53 ***	1.46 ***	1.42 ***	1.40 ***	
	(0.513)	(0.490)	(0.473)	(0.467)	
Creditor right index	−0.13 ***	−0.15 ***	−0.14 ***	−0.15 ***	
	(0.044)	(0.050)	(0.045)	(0.050)	
Judicial efficiency index	0.09 **	0.20 ***	0.17 ***	−0.01	
	(0.039)	(0.074)	(0.066)	(0.023)	
Constant	0.84 ***	0.94 **	0.97 ***	0.41 **	0.58 ***
	(0.294)	(0.332)	(0.341)	(0.175)	(0.186)
Observations	11,176	11,176	11,176	11,176	15,424
R-squared	1.19%	1.00%	0.98%	1.12%	0.18%

Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table 5. Regression results for the equity premium, ambiguity aversion and risk preferences. RRP, relative risk premium.

	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 4	(5) Model 5
Ambiguity aversion	−2.98 ***	−3.42 ***	−3.08 ***	−3.30 ***	−0.71 ***
	(1.104)	(1.206)	(1.130)	(1.201)	(0.261)
RRP gains	0.36 *	0.57 *	0.55 **	0.28	0.44 **
	(0.207)	(0.298)	(0.273)	(0.195)	(0.184)
RRP losses	1.11 ***	1.35 ***	1.20 ***	1.34 ***	0.23 ***
	(0.407)	(0.486)	(0.441)	(0.490)	(0.079)
GDP per capita	0.30 **				
	(0.149)				
GDP growth rate		−0.11 ***			
		(0.037)			
Stock market capitalization			0.00 **		
			(0.000)		
Economic freedom				0.03 ***	
				(0.012)	
Beta of stock	0.18 **	0.10	0.20 **	0.26 **	0.10 *
	(0.084)	(0.063)	(0.091)	(0.112)	(0.055)
Stock volatility	−0.02	−0.06 *	−0.02	−0.03	0.03
	(0.023)	(0.031)	(0.022)	(0.024)	(0.018)
Leverage ratio	−0.04 ***	−0.04 **	−0.04 ***	−0.04 ***	−0.03 ***
	(0.015)	(0.015)	(0.014)	(0.013)	(0.009)
Analysts	−0.01 *	−0.00	−0.01 *	−0.01 **	−0.01 *
	(0.005)	(0.003)	(0.005)	(0.007)	(0.004)
Past stock return	−0.01	−0.00	−0.01	−0.02	0.00
	(0.013)	(0.014)	(0.012)	(0.012)	(0.012)
Anti-director index	−0.29 ***	−0.28 ***	−0.32 ***	−0.41 ***	
	(0.097)	(0.102)	(0.113)	(0.146)	
Rule of law index	−0.39 **	−0.27 ***	−0.21 **	−0.13 **	
	(0.187)	(0.103)	(0.093)	(0.061)	
Anti-self-dealing index	1.91 ***	2.00 ***	1.87 ***	1.89 ***	
	(0.641)	(0.674)	(0.626)	(0.634)	
Creditor right index	−0.10 ***	−0.13 ***	−0.09 ***	−0.13 ***	
	(0.032)	(0.042)	(0.029)	(0.042)	
Judicial efficiency index	0.08 *	0.14 ***	0.09 **	−0.29 **	
	(0.047)	(0.055)	(0.042)	(0.119)	
Constant	−0.49	2.53 ***	2.30 ***	2.48 ***	0.35 ***
	(0.692)	(0.876)	(0.812)	(0.874)	(0.089)
Observations	11,176	11,176	11,176	11,176	15,424
R-squared	1.28%	1.36%	1.26%	1.50%	0.22%

Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table 6. The equity premia, ambiguity aversion and the individualism index.

	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 4	(5) Model 5
Ambiguity aversion	−2.31 ***	−2.34 ***	−2.19 ***	−2.30 ***	−0.35 **
	(0.874)	(0.845)	(0.824)	(0.860)	(0.158)
Individualism Index	0.01 ***	0.01 ***	0.01 ***	0.02 ***	0.00 ***
	(0.003)	(0.004)	(0.004)	(0.005)	(0.002)
GDP per capita	0.00 **				
	(0.000)				
GDP growth rate		−0.12 ***			
		(0.041)			
Stock market capitalization			0.00 **		
			(0.000)		
Economic freedom				0.04 ***	
				(0.015)	
Beta of stock	0.22 **	0.08	0.17 **	0.26 **	0.14 **
	(0.095)	(0.052)	(0.079)	(0.111)	(0.065)

Table 6. *Cont.*

	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 4	(5) Model 5
Stock volatility	−0.01	−0.04	−0.00	−0.03	0.04 *
	(0.020)	(0.026)	(0.019)	(0.023)	(0.021)
Leverage ratio	−0.03 **	−0.03 **	−0.03 ***	−0.03 ***	−0.03 ***
	(0.013)	(0.014)	(0.014)	(0.013)	(0.011)
Analysts	−0.01 *	−0.00	−0.01 *	−0.01 **	−0.01 **
	(0.005)	(0.002)	(0.005)	(0.006)	(0.005)
Past stock return	−0.02 *	−0.01	−0.02 **	−0.03 **	−0.00
	(0.012)	(0.012)	(0.012)	(0.013)	(0.011)
Anti-director index	−0.16 ***	−0.14 ***	−0.18 ***	−0.27 ***	
	(0.053)	(0.052)	(0.062)	(0.094)	
Rule of law	−0.61 **	−0.35 ***	−0.32 **	−0.32 **	
	(0.255)	(0.132)	(0.136)	(0.131)	
Anti-self-dealing index	1.50 ***	1.53 ***	1.37 ***	1.20 ***	
	(0.497)	(0.510)	(0.445)	(0.386)	
Creditor right index	−0.12 ***	−0.17 ***	−0.11 ***	−0.13 ***	
	(0.039)	(0.055)	(0.036)	(0.045)	
Judicial efficiency index	0.09 **	0.28 ***	0.20 **	−0.31 **	
	(0.041)	(0.101)	(0.076)	(0.126)	
Constant	0.41 **	0.33 **	0.43 **	0.23	0.04
	(0.181)	(0.159)	(0.183)	(0.145)	(0.045)
Observations	11,165	11,165	11,165	11,165	15,413
R-squared	1.47%	1.39%	1.26%	1.63%	0.33%

Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table 7. The equity premia, ambiguity aversion and the uncertainty avoidance index.

	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 4	(5) Model 5
Ambiguity aversion	−1.69 ***	−1.82 ***	−1.62 **	−1.68 ***	−0.75 ***
	(0.650)	(0.679)	(0.639)	(0.645)	(0.281)
Uncertainty Avoidance Index	−0.00 ***	−0.00 ***	−0.00 ***	−0.00	−0.00 ***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
GDP per capita	0.52 **				
	(0.229)				
GDP growth rate		−0.08 ***			
		(0.030)			
Stock market capitalization			0.00		
			(0.000)		
Economic freedom				0.02 **	
				(0.009)	
Beta of stock	0.21 **	0.11 *	0.17 **	0.22 **	0.06
	(0.092)	(0.059)	(0.077)	(0.096)	(0.043)
Stock volatility	−0.00	−0.01	0.02	0.01	0.04 *
	(0.019)	(0.021)	(0.018)	(0.018)	(0.020)
Leverage ratio	−0.03 **	−0.03 **	−0.03 **	−0.03 ***	−0.03 ***
	(0.012)	(0.013)	(0.013)	(0.012)	(0.009)
Analysts	−0.01	−0.00	−0.01	−0.01 *	−0.01
	(0.004)	(0.002)	(0.004)	(0.005)	(0.004)
Past stock return	−0.02	−0.01	−0.02 *	−0.02 *	−0.00
	(0.012)	(0.012)	(0.012)	(0.012)	(0.011)
Anti-director index	−0.27 ***	−0.26 ***	−0.29 ***	−0.35 ***	
	(0.090)	(0.088)	(0.096)	(0.122)	
Rule of law	−0.36 **	−0.04	0.02	0.07 ***	
	(0.176)	(0.029)	(0.023)	(0.023)	
Anti-self-dealing index	1.60 ***	1.66 ***	1.62 ***	1.55 ***	
	(0.533)	(0.557)	(0.534)	(0.513)	
Creditor right index	−0.17 ***	−0.19 ***	−0.16 ***	−0.17 ***	
	(0.055)	(0.062)	(0.049)	(0.056)	
Judicial efficiency index	0.19 **	0.26 ***	0.18 **	−0.06	
	(0.073)	(0.094)	(0.072)	(0.049)	
Constant	−4.05 **	0.72 ***	0.75 ***	0.67 ***	0.62 ***
	(1.864)	(0.250)	(0.254)	(0.233)	(0.196)
Observations	11,165	11,165	11,165	11,165	15,413
R-squared	1.19%	1.13%	1.05%	1.19%	0.19%

Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

5.2. Robustness Checks

To test for robustness, we employ a new group of control variables that may have effects on the return distributions, which are well documented in the literature. We add the Investor Protection Index and Market Efficiency Index from the Global Competitiveness Report 2010 by the World Economic Forum and the Gini index as controls for the development of a country's stock market. Other firm-level factors remain unchanged. Further tests are implemented by collecting LSSV-type variables, such as the rule of law (LaPorta et al. (1998)), investor protection index (LaPorta et al. (2000)) and self-dealing regulations (Djankov et al. (2008)). In addition, ambiguity aversion remains a significant contributor in tests with or without controlling for risk-preference parameters (Tables 8 and 9).

Table 8. Regressions with different controls for the equity premia and ambiguity aversion.

	(1) Model 1	**(2) Model 2**	**(3) Model 3**	**(4) Model 4**
Ambiguity aversion	−0.95 **	−2.20 ***	−1.36 ***	−1.88 ***
	(0.404)	(0.852)	(0.518)	(0.695)
GDP per capita	0.21 ***			
	(0.073)			
GDP growth rate		−0.78 **		
		(0.307)		
Stock market capitalization			0.03 ***	
			(0.011)	
Economic freedom				0.04 ***
				(0.015)
Beta of stock	0.06	0.07	0.04	0.16 *
	(0.052)	(0.056)	(0.048)	(0.080)
Stock volatility	0.04	0.05	0.04 *	0.03
	(0.026)	(0.031)	(0.027)	(0.023)
Leverage ratio	−0.05 **	−0.06 **	−0.05 **	−0.05 **
	(0.023)	(0.028)	(0.023)	(0.022)
Analysts	−0.01	−0.01	−0.01	−0.01 *
	(0.005)	(0.005)	(0.004)	(0.006)
Past stock return	−0.00	0.00	−0.00	−0.01
	(0.014)	(0.016)	(0.014)	(0.014)
Investor protection index	0.05 ***	0.04 ***	0.05 ***	0.06 ***
	(0.018)	(0.014)	(0.017)	(0.022)
Market efficiency index	0.06	−0.02	0.18 ***	−0.31 **
	(0.041)	(0.029)	(0.063)	(0.124)
Gini index	0.02 ***	0.05 ***	0.02 ***	0.02 ***
	(0.007)	(0.018)	(0.006)	(0.008)
Constant	−1.33 ***	0.62 *	−0.90 ***	−1.34 ***
	(0.461)	(0.323)	(0.325)	(0.467)
Observations	12,324	12,324	12,324	12,324
R-squared	0.63%	1.07%	0.61%	0.87%

Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table 9. Regressions with different controls for the equity premia, ambiguity aversion and risk preferences.

	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 4	(5) Model 5
Ambiguity aversion	−2.85 ***	−2.17 ***	−1.21 ***	−2.17 ***	−2.01 ***
	(1.083)	(0.769)	(0.396)	(0.771)	(0.735)
RRP gains	1.69 **	1.63 **	0.88 **	0.44	0.77 **
	(0.771)	(0.634)	(0.447)	(0.394)	(0.393)
RRP losses	1.67 ***	1.49 ***	1.86 ***	1.16 ***	1.36 ***
	(0.601)	(0.510)	(0.691)	(0.448)	(0.473)
GDP per capita	−0.43 **				
	(0.181)				
GDP growth rate		−0.08 **			
		(0.035)			
Stock market capitalization			−0.00 **		
			(0.002)		
Economic freedom				0.02 *	
				(0.009)	
Beta of stock	0.15 *	0.13	0.28 **	0.17 **	0.15 *
	(0.083)	(0.083)	(0.136)	(0.088)	(0.084)
Stock volatility	0.01	0.01	−0.01	0.01	0.01
	(0.022)	(0.028)	(0.028)	(0.022)	(0.023)
Leverage ratio	−0.05 **	−0.06 **	−0.06 **	−0.05 **	−0.05 **
	(0.022)	(0.028)	(0.028)	(0.023)	(0.023)
Analysts	−0.01	−0.01	−0.01 *	−0.01 *	−0.01
	(0.006)	(0.006)	(0.008)	(0.006)	(0.006)
Past stock return	0.00	0.02	−0.01	−0.00	0.00
	(0.016)	(0.021)	(0.015)	(0.018)	(0.017)
Investor protection index	0.06 ***	0.10 ***	−0.00	0.07 ***	0.06 ***
	(0.019)	(0.031)	(0.010)	(0.023)	(0.022)
Market efficiency index	0.62 ***	0.21 ***	0.86 **	0.09	0.30 ***
	(0.233)	(0.070)	(0.340)	(0.126)	(0.098)
Gini index	0.03 ***	0.04 ***	0.07 **	0.04 ***	0.04 ***
	(0.012)	(0.016)	(0.029)	(0.014)	(0.014)
Constant	0.94 *	−1.99 ***	−5.45 **	-1.76 **	−1.85 ***
	(0.518)	(0.737)	(2.238)	(0.687)	(0.700)
Observations	12,324	12,242	11,440	12,324	12,324
R-squared	1.18%	1.34%	1.38%	1.13%	1.10%

Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

The second robustness test we employ is the robust regression for down-weighting outliers (Street et al. (1988)). An algorithm is applied in the first step to form the case-by-case weight for every extreme case, with the aim of minimizing the sum of a less rapidly increasing function of the residuals. The next step is to run a weighted least squares regression with these case-by-case weights, which yields robust results, since all the outliers are down-weighted to create smoother data. This approach helps to minimize the sum of residuals to the lowest extent, which results in a significantly high R-squared. However, this case-by-case weighting approach bypasses the country effect of those extreme values, which is captured successfully by the case-by-country weighting methodology.

In all regressions, the effect of ambiguity aversion remains significant (with a high R-squared (Tables 10 and 11). As previously mentioned, the down-weighting methodology smooths out all the country effects, and therefore, it is not appropriate to interpret the regression coefficients in the usual way. However, the strong explanatory power of ambiguity aversion on the equity premia is robust, as can be observed by its statistical significance, which is at the 1% level in all models.

Table 10. Down-weighting outliers for the equity premium and ambiguity aversion.

	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 4
Ambiguity aversion	−0.10 ***	−0.06 ***	−0.09 ***	−0.04 ***
	(0.011)	(0.010)	(0.011)	(0.011)
GDP per capital	−0.00 ***			
	(0.000)			
GDP growth rate		0.01 ***		
		(0.000)		
Stock market capitalization			0.00 ***	
			(0.000)	
Economic freedom				0.00 ***
				(0.000)
Beta of stock	0.01 ***	0.01 ***	0.01 ***	0.01 ***
	(0.001)	(0.001)	(0.001)	(0.001)
Stock volatility	−0.17 ***	−0.17 ***	−0.17 ***	−0.17 ***
	(0.001)	(0.001)	(0.001)	(0.001)
Leverage ratio	−0.02 ***	−0.02 ***	−0.02 ***	−0.02 ***
	(0.001)	(0.001)	(0.001)	(0.001)
Analysts	0.00 ***	0.00 ***	0.00 ***	0.00 ***
	(0.000)	(0.000)	(0.000)	(0.000)
Past stock return	0.00 ***	0.00 ***	0.00 ***	0.00 ***
	(0.000)	(0.000)	(0.000)	(0.000)
Anti-director index	−0.03 ***	−0.03 ***	−0.02 ***	−0.03 ***
	(0.001)	(0.001)	(0.001)	(0.001)
Rule of law	0.02 ***	0.02 ***	−0.01 ***	0.01 ***
	(0.003)	(0.002)	(0.002)	(0.002)
Anti-self-dealing index	0.01 ***	0.02 ***	−0.01 ***	−0.01 ***
	(0.004)	(0.004)	(0.004)	(0.004)
Creditor right index	−0.00	0.00	−0.00	−0.00
	(0.001)	(0.001)	(0.001)	(0.001)
Judicial efficiency index	−0.02 ***	−0.03 ***	−0.02 ***	−0.06 ***
	(0.002)	(0.002)	(0.002)	(0.003)
Constant	0.41 ***	0.34 ***	0.38 ***	0.38 ***
	(0.008)	(0.009)	(0.008)	(0.009)
Observations	11,176	11,176	11,176	11,176
R-squared	68.75%	68.70%	67.94%	67.78%

Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table 11. Down-weighting outliers for the equity premia, ambiguity aversion and risk preferences.

	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 4
Ambiguity aversion	−0.14 ***	−0.14 ***	−0.17 ***	−0.15 ***
	(0.013)	(0.013)	(0.013)	(0.013)
RRP gains	0.02 **	−0.05 ***	−0.02 **	−0.01
	(0.011)	(0.010)	(0.010)	(0.011)
RRP losses	0.07 ***	0.05 ***	0.08 ***	0.07 ***
	(0.008)	(0.008)	(0.008)	(0.008)
GDP per capita	−0.00 ***			
	(0.000)			
GDP growth rate		0.01 ***		
		(0.000)		
Stock market capitalization			0.00 ***	
			(0.000)	
Economic freedom				0.00
				(0.000)

Table 11. *Cont.*

	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 4
Beta of stock	0.01 ***	0.01 ***	0.01 ***	0.01 ***
	(0.001)	(0.001)	(0.001)	(0.001)
Stock volatility	−0.17 ***	−0.17 ***	−0.17 ***	−0.17 ***
	(0.001)	(0.001)	(0.001)	(0.001)
Leverage ratio	−0.02 ***	−0.02 ***	−0.02 ***	−0.02 ***
	(0.001)	(0.001)	(0.001)	(0.001)
Analysts	0.00 ***	0.00 ***	0.00 ***	0.00 ***
	(0.000)	(0.000)	(0.000)	(0.000)
Past stock return	0.00 ***	0.00 ***	0.00 ***	0.00 ***
	(0.000)	(0.000)	(0.000)	(0.000)
Anti-director index	−0.02 ***	−0.02 ***	−0.01 ***	−0.02 ***
	(0.002)	(0.002)	(0.002)	(0.002)
Rule of law	0.00	0.00	−0.03 ***	−0.02 ***
	(0.004)	(0.003)	(0.003)	(0.003)
Anti-self-dealing index	0.01 **	0.01 ***	−0.01 ***	0.00
	(0.004)	(0.004)	(0.005)	(0.005)
Creditor right index	0.00	0.00	0.00 **	0.00 **
	(0.001)	(0.001)	(0.001)	(0.001)
Judicial efficiency index	−0.03 ***	−0.02 ***	−0.02 ***	−0.03 ***
	(0.003)	(0.003)	(0.003)	(0.003)
Constant	0.47 ***	0.39 ***	0.46 ***	0.46 ***
	(0.011)	(0.011)	(0.011)	(0.013)
Observations	11,176	11,176	11,176	11,176
R-squared	69.02%	69.05%	68.14%	68.40%

Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

6. Conclusions

The main contribution of this research is to provide rigorous empirical evidence supporting the approach of ambiguity aversion in explaining the equity premium puzzle. Intuitively, the interaction effect of ambiguity and ambiguity aversion causing an ambiguity premium beyond the risk premium must be the central object. Given the current data and results, we can conclude only that ambiguity aversion has an impact on the equity premium. Theoretical models suggest that ambiguity aversion can explain the equity premium puzzle, but our current data are insufficient to estimate the proportion of equity premium that can be explained by it.

A further interesting aspect of our research is the significant impact of cultural differences on the size of the equity premium. The cross-country differences in investors' preferences can be translated into a systematic distribution of the equity premia worldwide.

Our research, based on a large international database, is the first to understand the equity premium at a level beyond country aggregation. Since it is difficult to connect preferences and behavior at the individual level, our results suggest some initial causal effects, which could be investigated in more detail in future research in the field of cultural finance.

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Appendix A

Table A1. List of control variables.

Variables	Descriptions	Sources
(1) Firm level controls		
Beta of stock	The last 1-year beta of stock	OSIRIS
Stock volatility	The stock's volatility (the last 360 trading days)	OSIRIS
Leverage ratio	Log of (long-term debt/market capitalization)	OSIRIS
Analysts	The number of analysts following a stock	OSIRIS
Past stock return	Log of the last 1-year cumulative return	OSIRIS
(2) Country aggregate controls		
GDP per capita	Log of GDP per capita	World Development Indicators [1]
Stock market capitalization	Ratio of the stock market capitalization to GDP	World Development Indicators
GDP growth rate	Log of annual GDP growth rate	World Development Indicators
Economic freedom	A series of 10 economic measurements (World Heritage)	Economic Freedom Index [2]
Gini index	The index measures the equality of income distribution	World Bank [3]
Market efficiency index	Index of market efficiency by the World Economic Forum	The Global Competitiveness Report [4]
Investor protection index	Index of minority investor protection by the World Economic Forum	The Global Competitiveness Report [5]
(3) LLSV-type variables		
Rule of law (0–10)	Rule of law (0–10)	LaPorta et al. (1998)
Eff. of the jud. system	Efficiency of the judicial system (0–10)	LaPorta et al. (1998)
Corruption	Corruption index (0–10)	LaPorta et al. (1998)
Accounting standard	Accounting standard index	LaPorta et al. (1998)
Anti-director index (0–6)	Measure of shareholder protection	LaPorta et al. (2000)
Creditor right (0–4)	Creditor rights protection	LaPorta et al. (2000)
Anti-self-dealing index	Legal protection of minority shareholders	Djankov et al. (2008)

[1] http://data.worldbank.org/data-catalog/world-development-indicators; [2] http://www.heritage.org/index/about; [3] http://data.worldbank.org/indicator/SI.POV.Gini; [4] http://reports.weforum.org/global-competitiveness-2011-2012/; [5] http://reports.weforum.org/global-competitiveness-2011-2012/.

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