



# Risk premia and ambiguity in an experimental market featuring a long-lived asset



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## ABSTRACT

This study reports consistent pricing below expected value in a laboratory market featuring a long-lived asset. I posit that this result reflects risk premia. The emergence of statistically significant risk premia appears to stem from the austerity and simplicity of the experimental design, the starkness and centrality of the risk/return relationship within the market environment, attempts to focus subjects' attention on the risk/reward relationship, and the experience level of the subjects. The proposition that the addition of ambiguity increases expected returns is tested, and no evidence of such a relationship is found.

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## 1. Introduction

In standard theoretical asset valuation models risk is a key determinant of expected returns, and by extension asset prices. Returns to risk are often observed in field studies, see for example Fama and French (1992), Jegadeesh and Titman (1993) and Kothari et al. (1995) and others. Laboratories are, potentially, ideal places to test theories regarding risk and expected return. In particular, ex-ante risk and expected return can be controlled and measured. And indeed, in individual choice laboratory experiments, behavior that appears to be broadly consistent with risk aversion is reported, see for example Binswanger (1980), Smith and Walker (1993), and Holt and Laury (2002). Furthermore, in laboratory markets with short-lived assets – assets that live for typically one or two periods – positive risk premia are reported (Plott and Bossaerts, 2004). However these results have not translated to laboratory markets with long-lived – typically ten to 15 period – assets. In laboratory markets with long-lived assets, pricing which persists below expected value (hereafter EV) and which implies risk aversion is rare. Notably, researchers including Robin et al. (2012) and Braeban and Noussair (2015) report that markets consisting

of subjects that are relatively risk averse exhibit lower prices, however those prices are not below the EV of the asset.

In this study I report stable equilibrium pricing below EV, consistent with risk aversion. To my knowledge, this is the first study to report positive and statistically significant risk premia in a laboratory market featuring a long-lived asset.

The result was a surprise to this researcher. The experiment is designed to answer a separate question, namely whether the introduction of ambiguity has an influence on price. However, design features implemented to aid in the study of the original topic likely brought to light the role of risk aversion in asset pricing. Perhaps most importantly, the design aims to encourage quick equilibration on fundamental value, which in the context of this study is the equilibrium price in a market comprised solely of informed, rational investors and devoid of speculative activity. I discourage bubbles through the use of a cocktail of 'best practices' developed by many researchers over the past two decades. Bubbles and crashes, which are prevalent in long-form laboratory markets, may obscure or diminish the influence of risk aversion on pricing.

If the containment of bubbles and crashes is a necessary condition for the emergence of risk premia, it may not be a sufficient condition. Indeed, recent research includes multiple instances of pricing in line with EV. See for example Huber et al. (2012), Kirchler et al. (2015) and Noussair et al. (2016), and perhaps treatment T2 of Huber et al. (2016). Fortunately, the design incorporates

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further elements which may promote the emergence of risk premia. Subjects are encouraged, through the instructions and the pre-market quiz, to focus on the risk/return trade-off as well as on EV. In addition, simplicity is a key attribute of the design, and may serve to maintain subjects' attention on risk. Interestingly, the design in this study is similar, in some key respects, to Porter et al. (1998), whose markets also exhibit consistent pricing below EV. The authors do not comment on potential explanations.

In this study risk aversion presents more clearly in markets with once-experienced subjects, where price generally remains below EV for the entire course of a market. In markets with inexperienced subjects, price is typically above EV in early periods and below EV in late periods.

In addition to the experience level of the subjects, markets are also segregated by the presence or absence of ambiguity with respect to EV. Knight (1921) and Keynes (1921) argue that ambiguity plays a role in economic decision making, and many studies in individual choice settings indicate ambiguity aversion, see for example Ellsberg (1961). With respect to short-form laboratory markets, ambiguity aversion has been addressed by many researchers, with varied results. It is possible that any influence of ambiguity on price may develop or evolve over time, thus extending the inquiry to long-form markets is warranted. The results of this study do not support a role for ambiguity in price formation.

## 2. Literature review

Risk aversion has long been a pillar of asset valuation. Theoretical underpinnings of risk aversion in investor decision making go back at least as far as (Markowitz, 1952) mean-variance optimization and the CAPM, see Sharpe (1964), Lintner (1965), and Black (1972). See also, for example, Merton (1973) and Merton (1980). Investment analyst equity valuations often rely on discounted cash flow models, which discount expected cash flows using a rate that is meant to correspond to the riskiness of those cash flows. Risk aversion is often, although not always, observed in individual choice experiments. For example, studies such as Binswanger (1980), Smith and Walker (1993), and Holt and Laury (2002) detect behavior consistent with risk aversion. Research on risk aversion in short-form laboratory markets is sparse but supportive of a role for risk aversion in pricing. In an early study, Ang and Schwarz (1985) report that markets which consist of conservative investors consistently exhibit higher risk premia than markets with speculative investors. Plott and Bossaerts (2004) report consistent risk aversion in single-period markets. Their markets utilize a large number of subjects and feature three simultaneously traded assets. Corgnat et al. (2012) report risk aversion in the first period of three-period markets, at least in some settings.

Only a handful of long-form laboratory markets, where assets survive for typically ten to 15 periods, exhibit clear and consistent pricing below EV. One of these, as noted earlier, is Porter et al. (1998). Noussair and Haruvy (2006) find that allowing short sales (which are not permitted in my study) reduces prices, often pushing them below EV—“short selling merely influences the supply of and demand for the asset, which is in part determined by forces other than the relationship between current prices and fundamental values” (page 1154). Lin and Rassenti (2012) report consistent underpricing in bullish environments, but consistent overpricing in bearish environments and pricing in line with EV in neutral environments. The authors ascribe the results to “underreacting drifts” (page 59). Huber et al. (2012) employ a treatment (T4) where prices remain either on top of EV or just below EV. The average pricing for the treatment is a 2.7% discount to EV. The authors do not investigate the potential role of risk aversion in pricing. Kirchler et al. (2015) find undervaluation in markets with an increasing EV regime (not present in my study). The authors

note that their results are consistent with literature finding underreaction to changes in EV, and propose an anchoring heuristic and confusion as potential explanations. Braeban and Noussair (2015) also report underpricing in markets with increasing fundamental value trajectories. The authors note that the result may be due to relatively low cash to asset ratios near the end of those sessions. Finally, also note that in many studies with declining EVs prices are below EV in early periods but evolve to or above EV in relatively short order, with bubbles often developing.

A small number of long-form studies examine risk aversion. Guth et al. (1997) find no link between the elicited risk aversion of individual subjects and those same subjects' chosen portfolio allocations. Fellner and Maciejovsky (2007) report that risk averse subjects trade less frequently. Robin et al. (2012) find some evidence that mispricing is less severe and trade activity is less intense in markets with a higher share of risk averse traders. Lin and Rassenti (2012) report results consistent with the notion that, in some circumstances at least, expected variance influences prices, but risk aversion does not appear to be the driver. Braeban and Noussair (2015) report that greater levels of risk aversion on the part of traders in a market predicts lower market prices.

Discussion of the role of ambiguity in economic decision making goes back at least as far as Knight (1921), who reasons that risk, which can be represented by precise probabilities, is distinct from ambiguity, which occurs when the probability distribution of future states is not known. Keynes (1921) also highlights the significance of ambiguity, noting that when making decisions, people take into account not only their best judgment, but also the amount and quality of the evidence they have available. Arrow (1951) and Savage (1954) take the other side of the debate. Arrow argues that “In brief, Knight's uncertainties seem to have surprisingly many of the properties of ordinary probabilities, and it is not clear how much is gained from the distinction” (page 417), and also that “...his uncertainties produce about the same reactions in individuals as other writers ascribe to risks” (page 426). Ellsberg (1961) showed that, at least within some settings, people do in fact treat risk and ambiguity differently. A plethora of individual choice research corroborates Ellsberg's finding, see for example a good summary by Camerer and Weber (1992).

If individuals are averse to ambiguity, asset prices may be influenced by its presence or magnitude. Field research is relatively sparse, perhaps due to the difficulty in measuring and controlling for ambiguity in the field. One study with relevance for this paper, however, is Ang and Boyer (2010), who present evidence of an ambiguity return premium using IPO returns. Within the realm of short-form laboratory markets, results have not been uniform, and it appears that the relationship between price and ambiguity is an intricate one. For example, Huber et al. (2014) find ambiguity aversion in assets with negatively skewed dividend distributions, but not in assets with dividend distributions of zero or positive skew, and Fullbrun et al. (2014) report that ambiguity effects are dependent upon market structure (call market vs. double auction). Regarding long-form laboratory markets, this author is unaware of any prior reported results pertaining to the influence of ambiguity with respect to EV on price.

## 3. Experimental design

In this study, the containment of bubbles and crashes is a key aim of the experimental design. Toward that end, the market is stripped down to its essentials, the salient features of which are as follows: Subjects trade “tickets” that are redeemed for cash at the end of a market. The redemption amount is either \$0.50 (low) or \$1.50 (high), based upon a simulated random draw of one ball from a container of a hundred. In each market there is only one draw,

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