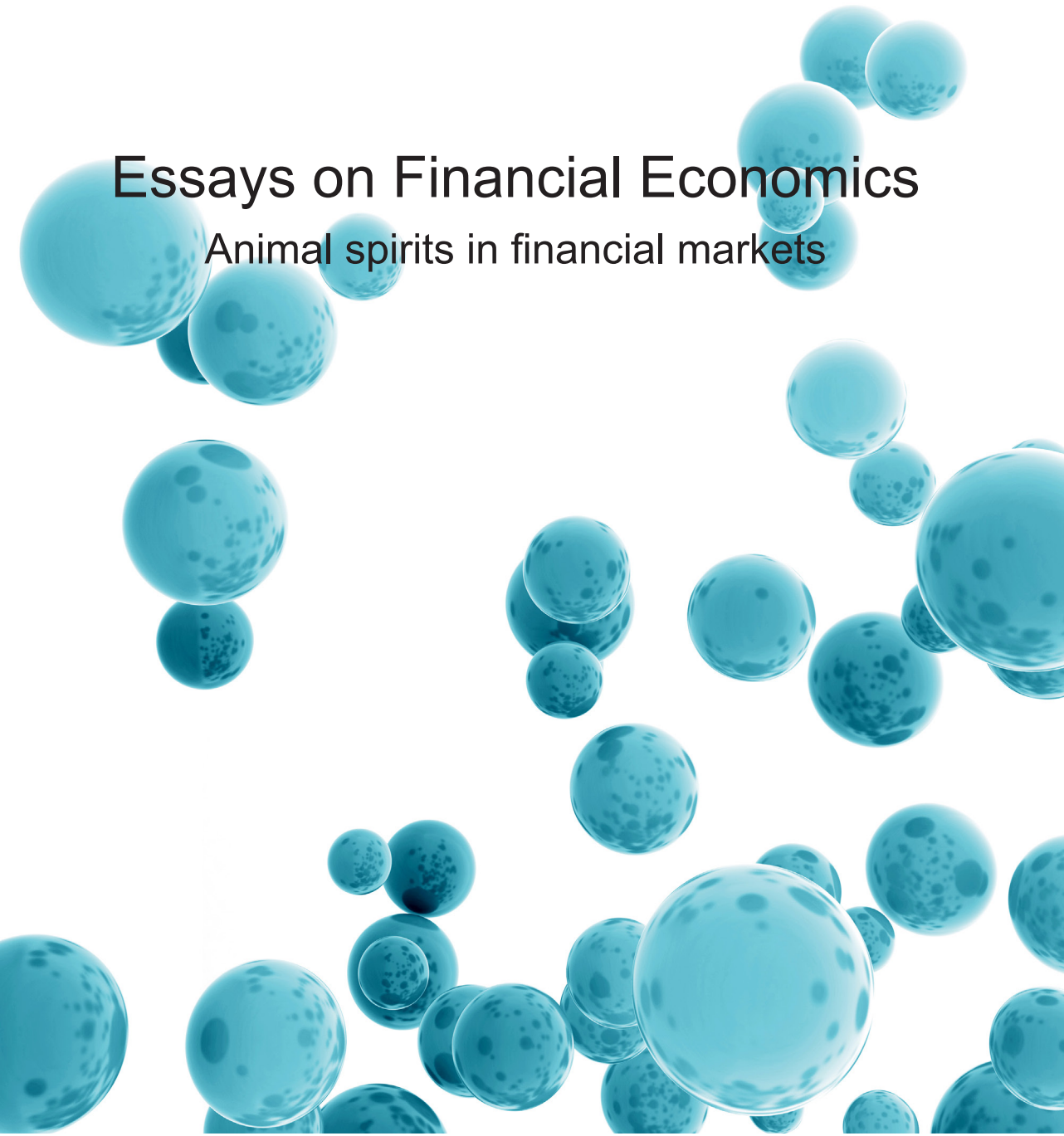JUKKA ILOMÄKI

Essays on Financial Economics
Animal spirits in financial markets

JUKKA ILOMÄKI

Essays on Financial Economics

Animal spirits in financial markets

■

UNIVERSITY OF TAMPERE

JUKKA ILOMÄKI

Essays on Financial Economics

Animal spirits in financial markets

The originality of this thesis has been checked using the Turnitin OriginalityCheck service
in accordance with the quality management system of the University of Tampere.

Cover design by
Mikko Reinikka

ACKNOWLEDGEMENTS

Finally, I would like to express my deepest gratitude to my wife, Päivikki, who has never lost her faith in this project.

Tampere, February 2017

Jukka Ilomäki

COPYRIGHT NOTICE

ABSTRACT

J.M. Keynes argues that an investor does not only care about her own beliefs regarding the future returns, but also other market participants' beliefs about these returns, and also their beliefs about other market participants' beliefs, and so on. Keynes calls this "beauty contest in financial markets", and defines it as a combination of rational higher-order beliefs and market psychology. The key point is that behavioral factors affect the equilibrium price of a stock beyond rational estimation of the fundamental value of the stock. In his 2013 Nobel Prize lecture, Shiller uses the concept animal spirits for the psychological component.

The goal of the thesis is to investigate how the animal spirits of investors affects the outcomes in the financial markets. The thesis contains an introductory chapter and three published articles and a short note addressing animal spirits and investor behavior. The first article aims to answer to the following research question: what kind of effect has animal spirits to the expected returns of investors? This question is answered in the case where the Keynesian beauty contest is present in stock pricing. The second article studies if the level of the risk-free rate affects the expected returns of investors. Thus, it aims to answer to the question how the level of return from the risk-free asset affects to the expected returns of investors in risky assets when the animal spirits component is present. The third article aims to answer whether real stock markets professionals are affected by their animal spirits. The research question is tackled in an experiment with market professionals.

In the first article, I include rational higher-order beliefs and animal spirits into the rational choice framework. I show analytically that the animal spirits component reduces expected returns for rational informed and uninformed investors when the Keynesian beauty contest is present. In the second article, I find that the level of the risk-free rate is an important factor for expected returns when animal spirits is present in pricing. I conclude that if the risk-free rate rises then the animal spirits profits fall. The third article is an experiment that aims to examine how stock market professionals construct their decisions under restricted information in an environment of fast-moving situations. I find that, in this environment, they in fact utilize their animal spirits.

The combined contribution of the three articles is that the animal spirits component affects the expected returns of investors by reducing it, but these returns depend on the level of the risk-free rate in the market. In fact, if the level of the risk-free rate is low, the animal spirits component can produce higher returns for uninformed investors compared to the alternative where they only buy and hold the risky asset. When the level of the risk-free rate rises the animal spirits excess profits disappear. The empirical part of the second article suggests that the level of the break-even risk-free rate is as low as 3%. Moreover, the results suggest that, at this level, also the expected returns of investors, who recognize the real value of the stock, receive their fair expected returns. The diminishing effect due to the animal spirits of uninformed investors disappears. Finally, the last article supports the conclusion that the animal spirits can be present in real life stock markets, because stock markets professionals seem to utilize the animal spirits component it in the experiment. The short note (2017) clarifies the differences between the first and the second article.

TIIVISTELMÄ

J.M. Keynes argumentoi, että sijoittaja ei ainoastaan mieti omia ennusteita osakkeen tulevista tuotoista, vaan hän yrittää arvioida mitä muut sijoittajat ennustavat. Mutta ei sekään vielä riitä, vaan hän yrittää myös selvittää, mitä muut sijoittajat arvioivat siitä, mitä muut estimoivat. Keynes kutsuu tätä tapahtumaa rahoitusmarkkinoiden kauneuskilpailuksi ja hänen mukaansa se jakaantuu rationaalisiin korkeamman asteen odotuksiin ja markkinapsykologiaan. Shiller karakterisoi jälkimmäisen vuoden 2013 Nobel-palkintoluennossaan sanalla "animal spirits".

Tämän väitöskirjan tavoitteena on tutkia, miten animal spirits vaikuttaa sijoittajien käyttäytymisen. Väitöskirja koostuu johdantokappaleesta, kolmesta julkaistusta artikkelista ja lyhyestä nootista. Ensimmäinen artikkeli tutkii analyyttisesti, miten animal spirits vaikuttaa sijoittajien odotettuihin tuottoihin, kun Keynesin kauneuskilpailu on läsnä osakemarkkinoilla. Toinen artikkeli selvittää, miten riskittömän sijoituskohteen tuottotaso vaikuttaa sijoittajien osakemarkkinavoittoihin, kun animal spirits on mukana osakemarkkinoiden hinnoittelussa. Kolmas artikkeli tutkii kokeen avulla, vaikuttaako animal spirits osakemarkkina-ammattilaisten sijoituspäätöksiin.

Ensimmäisessä artikkelissa yhdistän rationaaliset korkeamman asteen uskomukset ja animal spiritsin samaan teoreettiseen kehikkoon. Artikkelissa havaitaan, että animal spirits vaikuttaa negatiivisesti informoitujen ja ei-informoitujen sijoittajien odotettuihin tuottoihin. Toisessa artikkelissa havaitaan, että riskittömällä tuottotasolla on ratkaiseva merkitys osaketuottojen muodostumiseen, kun animal spirits on läsnä. Siinä korostetaan, että kun riskittömän tuoton taso nousee rahoitusmarkkinoilla, se vähentää mahdollisia ei-informoitujen animal spirits -voittoja osakemarkkinoilla. Lyhyt nootti selventää ensimmäisen ja toisen artikkelin eroavaisuuksia. Viimeinen artikkeli paljastaa, että osakemarkkina-ammattilaisilla animal spirits vaikuttaa nopealiikkeisissä sijoituspäätöksissä.

Väitöskirjan kontribuutiona voidaan todeta, että animal spirits vähentää sijoittajien odotettuja tuottoja osakemarkkinoilla, mutta riskittömän sijoituskohteen tuoton taso ohjaa voimakkaasti prosessia. Kun taso on matala, animal spirits voi parantaa ei-informoitujen sijoittajien tuottoja, mutta tason noustessa ylimääräiset

voitot nopeasti katoavat. On huomioitava, että näissä teoreettisissa malleissa oletetaan, että markkinoilla toimii myös sijoittajaryhmä likviditeetin luojina, jotka aina tekevät tappiota osakekaupoilla. Näiden tappioiden suuruuteen vaikuttaa välillisesti animal spirits. Toisen artikkelin empiirisen testin mukaan, niin alhaisen kuin kolmen prosentin riskittömän sijoituskohteen tuottotason ylittäminen kääntää ei-informoitujen sijoittajien animal spirits -voitot tappioiksi. Tässä vertailukohtana ovat osta ja pidä -strategian realisoituneet tuotot viimeisen kolmenkymmenen vuoden ajalta.

CONTENTS

1 INTRODUCTION

John Maynard Keynes (1936) writes: "professional investment may be likened to those newspaper competitions in which competitors have to pick out the six prettiest faces from hundreds of photographs, the prize being awarded to the competitor whose choice most nearly corresponds to the average preferences of the competitors as a whole". Keynes calls this setting a "beauty contest in the financial markets". He argues that, in this beauty contest, there are two effects in action: the effect of rational higher-order beliefs, and the effect of market psychology. Shiller (2014) calls the latter component "animal spirits", and he follows Keynes (1921) in defining animal spirits as a "gut feeling that rises from the ambiguity of directly unobservable probabilities of future returns." The goal of the thesis is to investigate how the animal spirits of investors affects the outcomes in the financial markets.

Samuelson (1965) shows that, in efficient financial markets with risk-neutral investors, the equilibrium price follows the martingale process:

$$E(P_{t+1} \mid \theta_t) = P_t,$$ (1)

where E is the expectations operator and θ_t is the information set. The martingale property implies that, with today's information, the best forecast for the price of tomorrow is the price of today. Samuelson notes that Equation (1) can include a constant expected price change π, so that $E(P_{t+1} \mid \theta_t) = P_t + \pi$. Furthermore, Samuelson (1973) argues that, in efficient markets with risk-neutral investors, the following must hold:

$$P_t = V_t = E_t \sum_{s=1}^{\infty} \frac{D_{t+s}}{(1+r^f)^s},$$ (2)

where D_t displays the dividends, and r^f is the constant risk-free rate of return. In other words, the fundamental value V_t of stock F is equal to the expected present value of the cash flow for a shareholder from now to eternity. In efficient markets with risk-neutral investors this is equal to the equilibrium price P_t. Hence, as P_t is the expected discounted dividends to eternity for risk-neutral investors, the Keynesian beauty contest, including both rational higher-order beliefs and animal spirits, is absent.

However, Equations (1) and (2) are based on the assumption that investors risk-neutral. In real life, a rational investor not only cares about the reward, but also about the risk of the investment. The risk in financial markets can be interpreted as the variation of an investment's returns, which leads to the well-known mean-variance paradigm (Markowitz 1952, Sharpe 1964). Adding the risk premium ω results in $(1 + r^f + \omega)$ in the denominator on the right-hand side of Equation (2). For simplicity, I follow Shiller (2014) and ignore variation of both the risk-free rate and the risk premium.

Shiller (1984, 2014) argues that the animal spirits component affects the equilibrium price, because informed investors are risk averse. In psychological terms, animal spirits can be called affect heuristic (Finucane et al. 2000), which appears when people utilize it to make decisions in complex and fast-moving situations. However, it is well known (see for example LeRoy, 1973; Cochrane, 2008; and Fama, 2014) that investors' risk aversion incorporates return predictability into the stock market thus creating an environment, where the return predictability and the psychological effect (that is the animal spirits component) can be undistinguishable from each other. Indeed, the literature on stock return forecastability is vast. A common feature for all these studies is that they take the buy-and-hold returns as a benchmark, and they compare the returns statistics that can be achieved by some additional component in the market to the buy-and-hold returns statistics. Recent studies include Campbell and Yogo (2006), Ang and Bekaert (2007), Campbell and Thompson (2008), Hjalmarsson (2010) and Maio (2014), among others. A common conclusion is that the short-term interest rate forecasts buy-and-hold returns, but only over a short horizon. In addition, Cochrane (2008) argues that, because dividend growth is not forecastable, market returns must be forecastable in order to produce the observed variation in dividend/price ratios. The author concludes that the variation can be accounted to time-varying risk premia. However, in the articles of this thesis I ignore the possibility of time-varying risk premia.

Naturally, the animal spirits component can be interpreted as a product of other known psychological factors, but I follow the common practice of the behavioral finance literature and, for simplicity, I choose to ignore them in this thesis. See, for example Hirshleifer (2015) for a recent survey of the literature on behavioral finance.

1.1   Summaries of the Essays

1.1.1   Animal spirits, beauty contests and expected returns

In the first article, I incorporate rational higher-order beliefs and animal spirits into the rational choice framework. Starting from Friedman (1953), financial theory has assumed that uninformed investors act independently, and if their actions happen to correlate, the informed investors take an infinite arbitrage position against mispricing. For example, Brown and Jennings (1989), DeLong et al. (1990), Froot et al. (1992), Campbell and Kyle (1993), and Shiller (2014) explicitly assume that the actions of uninformed investors correlate in the equilibrium. Therefore, risk averse rational investors are needed, because the coordinated actions of uninformed investors create a risk of mispricing.

Furthermore, we need short-lived investors who cannot take long lasting positions in the markets. This can be motivated by performance based arbitrage, where the capability to invest is measured in short intervals (Shleifer and Vishny 1997). Thus, the presence of market psychology can be modelled by assuming that a large group of uninformed investors coordinate their actions, and that the rational investors are short-lived and risk averse. Finally, I follow Shiller (2014) by assuming that the animal spirits component of the uninformed investors is unpredictable to the informed investors.

I assume a risky asset (share of the firm F) and a constant risk-free rate of return r^f in the economy, where there is an infinite set of short-lived atomistic rational investors with asymmetric information. One half of the investors is assumed informed, and the other half is uninformed over all periods. A rational risk-averse CARA (constant absolute risk aversion) investor lives for two periods, investing in period one, and consuming in period two. The setting, known as the overlapping generations (OLG) model, is in common use in the literature of asymmetric

information. Tirole (1985) argues that, in an OLG model with short-lived investors and infinitely lived assets, bubbles are possible so that $P_t \neq V_t$ may occasionally happen. In addition, I assume that there are unobservable dumb traders, who act as liquidity providers. In this economy, the natural logarithm of the dividend D_t follows random walk,

$$\ln D_t = \ln D_{t-1} + e_t^d , \qquad\qquad (3)$$

where $e_t^d \sim WN(0, \sigma_d^2)$. I assume that the firm F pays D_t to old investors at time t. The information advantage of a young informed investor comes from observing D_{t-1}, D_t, D_{t+1}. Thus, when old, she recalls D_{t-2}, D_{t-1}, D_t. Common information for all rational investors is the history of the equilibrium prices $P_{t-1}, P_{t-1}, P_{t-3}, ...$ and the risk-free rate r^f.

To calculate the common risk premium for investors, consider the following. A risk-averse (CARA) young investor y_t, who lives for two periods, maximizes her utility under rational choice, allocating her wealth between risky and risk-free assets. The expected excess return on a share is $E_t(R_{t+1}) = \left[(P_{t+1} + D_{t+1}) + (1 + r^f)P_t \right] / P_t$. A young investor solves the maximization problem

$$Max[E(-e^{-vc_{t+1}} \mid \theta_t^y, w_t^y)],$$

where θ_t^y is the information set, v is the coefficient of risk aversion, c is consumption, and w_t^y is initial wealth. The maximization leads to the stock demand equation, and to the constant risk premium $\omega = \dfrac{v\sigma_r^2}{(1 + r^f)}$, where σ_r^2 is the variation of excess returns. In this article, I assume that ω is the same for informed and uninformed investors, implying that the required rate of return is $r_i^n = r_u^n = r^n$. Since the informed investors have more information than the uninformed ones, and σ_r^2 is

the risk of investment by the mean-variance paradigm, then $\sigma_u^2 > \sigma_i^2$. The constant risk premium suggests that

$$\omega = \frac{v_i \sigma_i^2}{(1+r^f)} = \frac{v_u \sigma_u^2}{(1+r^f)} \Rightarrow \frac{v_i}{v_u} = \frac{\sigma_u^2}{\sigma_i^2}. \tag{4}$$

According to the properties of random walk series, the change of a dividend at time t is permanent (Equation 3). Note that old and young informed investors observe D_t and the old ones have to close their positions. Thus, they agree that

$$V_t = \frac{D_t}{r^n}. \tag{5}$$

In fact, the young informed investors observe D_{t+1}, and they buy or sell as they open their positions according to that information. The market clearing condition reads

$$\int_y x_y - \int_o s_o + e_t^{du} = 0, \tag{6}$$

where x is total demand of the stock, s is total supply of the stock, and e_t^{du} is the noisy net supply by the liquidity providers.

Recall that one half of rational young and old investors are informed, so that they recognize V_t. The other half can observe only the past prices and the risk-free

rate in order to calculate their required return. The rational choice equilibrium price in this economy is simply

$$P_t = \frac{1}{2}V_t + \frac{1}{2}(1 + r^n)P_{t-1} \qquad (7)$$

with the restriction of Equation (4). Equations (3) and (7) imply that $P_t \neq V_t$ in every step. Following Shiller (2014), the inclusion of Keynesian beauty contest component C_t in Equation (7) yields

$$P_t = \frac{1}{2}(V_t + C_t^i) + \frac{1}{2}[(1 + r^n)P_{t-1} + C_t^u],$$

which results in

$$P_t = \frac{1}{2}(V_t + P_{t-1} - V_{t-1}) + \frac{1}{2}[(1 + r^n)P_{t-1} + \Delta P_{t-1} - r^n P_{t-2}]. \qquad (8)$$

Equation (8) describes an equilibrium where the returns predictability exists but the animal spirits component is absent. Supposing that *uninformed* investors start to include the animal spirits component (A_t) into the pricing equation,

$$(1 + r^n + A_t)P_{t-1}. \tag{9}$$

Recall that the uninformed investors can coordinate their actions perfectly, and assume that P_t and V_t cannot drift apart forever. The informed investors do not observe Equation (9), but they do recognize that Equation (8) does not hold at time $t-1$. Being rational, the informed investors utilize the cointegration results of Engle and Granger (1987) so that

$$C_t^i = P_{t-1} - V_{t-1}. \tag{10}$$

Thus, the equilibrium price series is

$$P_t = \frac{1}{2}(V_t + P_{t-1} - V_{t-1}) + \frac{1}{2}[(1 + r^n + A_t)P_{t-1}] \tag{11}$$

with the restriction of Equation (4).

By analyzing expected returns for the informed and uninformed investors in the equilibriums (Equations 8 and 11), the main finding is that the animal spirits component reduces expected returns for rational informed and uninformed investors. Thus, the market clearing condition states that, when the animal spirits component exists in the equilibrium, the dumb traders (that is liquidity provers) lose less money compared to the case where the component is absent.

1.1.2   Risk-free rates and animal spirits in financial markets

In the second article, I study theoretically and empirically what happens to the possible animal spirits profits, when the level of the constant risk-free rate is changed. That is, what is the difference in expected excess returns in the long run, when the constant risk-free rate changes.

The theoretical model is based on that at the first article, but here I allow $\Delta r^f > 0$ ceteris paribus. I have included detailed short note (Ilomäki 2017) about the differences between these two articles as the fourth paper in the thesis.

I show that if $\Delta r^f > 0$, the expected animal spirits profits for an uninformed investor decrease, but expected profits for an informed investor increase by the same amount. Note that I have a constant risk-free rate implying the result holds in the long run. Thus, the analysis implies that a low (high) level of risk-free rate creates positive (negative) animal spirits profits, when transaction costs are ignored.

In the empirical section, I test the theoretical results with respect to data from developed countries. The data consist of MSCI-indices from 1 March 1986 to 29 February 2016. In the testing, the animal spirits component is assumed to capture by the trend-chasing rule of technical analysis (Gartley, 1935), where the average of the fixed side window of stock prices moves with time. When the moving average is smaller (larger) the current closing stock price, the trading rule suggests to buy (sell). The dependent variable for the empirical analysis is

$$ r_t^{\alpha ei} = (r_t^{mi} - r_t^{fe}) - (r_t^{bhi} - r_t^{fe}) \qquad (12) $$

where r_t^{mi} denotes the animal spirits (trend-chasing) returns for the MSCI index i with reasonable transactions costs, r_t^{fe} is the one-month Euribor return, r_t^{bhi} is the buy and hold return and $r_t^{\alpha ei}$ is the animal spirit excess profits after transaction costs. Furthermore, I calculate the annualized three years' animal spirit excess profits $\tilde{r}_j^{\alpha ei}$, and annualized three years' local risk-free returns $\tilde{r}_j^{if}$ (local three-months' interest rate) for every non-overlapping period j so that they match every MSCI index i.

Animal spirits can cause excess volatility of returns. For example, Ang et al (2009) find that high volatility in returns suggest low buy-and-hold returns, which is an anomaly to the mean-variance paradigm. Thus, I create an additional explanatory

variable, $\tilde{\sigma}_j^{bhi}$, which is three years' annualized average volatility of buy and hold returns. The main regression reads

$$\tilde{r}_j^{aei} = \beta_1 + \beta_2 \tilde{r}_j^{if} + \beta_3 \tilde{\sigma}_j^{bhi} + e_j \quad .$$

The estimation results suggest that the volatility of daily returns is positively and the level of risk-free rate is negatively linked to three years annualized animal spirits excess profits. This supports my theoretical results that low (high) risk-free rate increases (decreases) animal spirits profits in the long run.

1.1.3 Connecting theory and empirics for animal spirits, returns and interest rates: A clarification of "Risk-free rates and animal spirits in financial markets"

The note is meant to correct the ethical err of the missing citation in the second essay to the first one. Since the second essay utilizes the basic model described in the first essay, it should have been mentioned. The err is due to the "wrong" order of the permissions for publication.

In the model of the first article (2016a), I determine two equilibria, the rational higher-order beliefs equilibrium, and the equilibrium where the animal spirits component exists, too. I assume that the fundamental value of the risky asset and the equilibrium price cannot drift apart forever, and that uninformed investors correlate in their trading decisions. This is a rational and common assumption used for example by Santos and Woodford (1997). In this framework, I show theoretically that if uninformed investors include the animal spirits component in their trading rule, their expected returns are smaller compared to the case where only the rational higher-order beliefs prevail.

More importantly, also the expected returns of informed investors reduce, if uninformed investors include their animal spirits component in their trading behavior compared to the case with only rational higher-order beliefs. Note that there are liquidity providers in the model who always lose money. Thus, the relative

amount of money that the liquidity providers lose depends on whether the animal spirits component exists or not in the equilibrium.

In the second article (Ilomäki 2016b), I study both theoretically and empirically what happens to the possible animal spirits profits, when the level of the constant risk-free rate is discretely changed. That is, the focus is on uninformed investors, and I define the concept of animal spirits profits, and test it empirically. The theoretical model is based on Ilomäki (2016a) with the amendment that $\Delta r^f > 0$ is now allowed. Moreover, I include also the expected returns of the buy-and-hold strategy into the theoretical analysis. Hence, I show that if $\Delta r^f > 0$, the expected animal spirits profits for an uninformed investor decrease. Ignoring transaction costs, the analysis indicates that a low (high) level of the risk-free rate creates positive (negative) animal spirits profits for uninformed investors.

More importantly, in the paper of Ilomäki (2016b), the theoretical results of the paper are empirically tested by using the global MSCI-index data from 1st March 1986 to 29th February 2016. I find that the local risk-free rate explains negatively, and the volatility of daily returns explains positively the animal spirits excess profits. The findings support the theoretical results of the paper.

Moreover, the theoretical and empirical results of Ilomäki (2016b) suggest that there must be a breaking point in the level of the risk-free rate for informed investors. In the breaking point, the expected returns are equal whether the animal spirits component of uninformed investors exists or not in the equilibrium price. To see this, consider the results in Ilomäki (2016b) about expected returns of informed investors over the expected buy and hold returns when $\Delta r^f > 0$. Write
$E_t(r_{t+1}^i) = \dfrac{1}{2} r^m + \dfrac{1}{4} \alpha + \dfrac{1}{4}(r_{t+1}^f - r_t^f)$, where r^m is the product of correct positions produced above buy-and-hold returns, α is the animal spirits component, r_t^f is the level of risk-free rate before the discrete change of the rate, and r_{t+1}^f is the new level of the risk-free rate. Substitute $E_t(r_{t+1}^i) = r^m$ and manipulate to get

$$2r^m - \alpha + r_t^f = r_{t+1}^f. \tag{13}$$

The result indicates that the reduced expected returns of informed investors disappears when Equation (13) holds, because then the restriction in (2016b) paper $\left(\alpha < 2r^m \to \alpha = 2r^m \right)$ is violated taken that $r_t^f = r_{t+1}^f$.

To prove this, consider $E_t(r_{t+1}^u) = \dfrac{1}{2}r^m - \dfrac{1}{4}\alpha + \dfrac{1}{4}(r_{t+1}^f - r_t^f)$ and substitute $E_t(r_{t+1}^u) = 0$ so that the expected returns of uninformed investors with animal spirits is equal to the expected returns of the buy-and-hold strategy. Then manipulate to get

$$\alpha - 2r^m + r_t^f = r_{t+1}^f \tag{14}$$

Combine Equations (13) and (14) to get

$\alpha = 2r^m$. **Q.E.D.**

The empirical results of the paper suggest that this happens when the level of the risk-free rate is $r_{t+1}^f > 3\%$. This is because then the buy-and-hold returns exceeds the returns of uninformed investors with the animal spirits component in the trading rule.

Thus, the combination of the results of Ilomäki (2016a) and Ilomäki (2016b) indicates several interesting conclusions. First, the effect of the animal spirits component to the expected returns of investors depends on the risk-free rate. Second, there must be an upper limit for the risk-free rate, where the component that reduces the expected returns of informed investors in Ilomäki (2016a) disappears. Third, the empirical results of Ilomäki (2016b) indicates that the break-even level is as low as 3%.

1.1.4   Framed field experiment with stock market professionals

The third article aims to detect the behavioral patterns of stock market professionals in an experimental setting. The task of the professionals is to forecast the return in the next period with given information, and they are rewarded according to their accuracy in forecasts. The key aspect of a speculative asset price equilibrium is the formation of investors' expectations, because investors make their trading decisions by predicting the future return on the asset. Thus, the forecasting task with payments according to forecasting accuracy can be interpreted as taking a sell or buy position for a short-term speculative investment sequentially with one period holding time of the position. In this experiment, decisions have to be made in minutes with available information.

Epstein (1994) notes that people face a dual-decision processing problem with two modes of information processing; an emotionally driven experiential system, and a rational analytical system. The experiential system can be characterized as rapid processing, oriented toward immediate action, whereas the rational system includes slower processing with delayed action. In addition, the experiential system is more sluggish to change than the rational one.

Moreover, Finucane et al. (2000) and Slovic et al. (2007) argue that affect heuristic has a huge influence in the experiential system. By Shiller (2014), affect heuristic is a psychological term for animal spirits, and as it creates some behavioral biases, then market psychology and rational higher-order expectations can be demerged from each other.

In the experiment, there are 19 subjects randomly splitted into two groups: informed and uninformed market professionals. The information set consists of real private and public information. Public information, common to all subjects, is actual past returns data from financial markets, and private information is the change of term spread for the forecasted period. The information within the groups is identical, and the experienced stock market professionals in each group are assumed homogenous. Thus, the aggregated forecasts of the groups can be interpreted as average professional behavior.

In the experiment, the actual equilibrium price P_t follows a martingale process, saying that the subjects should act in a risk-neutral way. The efficient markets theory suggests that the subjects with only public information should forecast martingale returns, and the subjects with private information should ignore past returns, and utilize private information consistently. Hence, this is the null hypothesis. An alternative hypothesis is that the subjects utilize past returns in their forecasts.

According to the regression results, the uninformed market professionals use the U.S. returns to forecast next returns of the target country. The informed market professionals utilize both the U.S. returns and their private information, giving more weight to the U.S. returns. However, since the target returns are normally distributed with a zero mean, the informed subjects obey a behavioral bias. Thus, the null hypothesis is rejected.

2   CONCLUSIONS

The thesis concentrates on a special psychological factor that affects the behavior of investors in financial markets. Namely, the focus is on investors' *animal spirits* first introduced by Keynes (1936), and rehabilitated by Shiller (2014). The corresponding term in human psychology is *affect heuristic* (Slovic et al. 2007). The thesis yields several interesting conclusions and suggestions that can lead to fruitful extensions in further research.

According to Shiller (2014), animal spirits, the gut feeling, or intuition, is present in the stock markets simply because investors are human beings. Investors are uncertain and even confused about ambiguities of the future returns of risky assets, which makes them to rely on their instinct, or subconscious aspirations about the outcomes. In other words, they utilize their animal spirits.

A noteworthy result of the field experiment included in the thesis is that also stock market professionals seem to be exposed to animal spirits. The finding is quite robust, because the identification and operationalization of the animal spirits component is reasonably accurate in the experimental setting, in which also time series analysis is utilized. Further elaboration of the experimental design might reveal evidence on other kinds of psychological factors that affect in the behavior of professionals and other investors in financial markets.

Second, if we assume that the equilibrium stock price and the fundamental value of that share cannot drift apart forever, then the animal spirits component of uninformed investors tends to reduce expected returns of all rational investors. Irrational liquidity providers lose less compared to the case where the animal spirits component is absent, at least in the long run. Note that informed investors never utilize their animal spirits in pricing behavior, because they observe the real value of the stock, but that they are indirectly affected by animal spirits, because the uninformed investors utilize it. Furthermore, even though the uninformed investors coordinate perfectly in their animal spirits component to obtain an identical product of A_t, their expected returns tend to reduce. The explanation of this result is that the equilibrium price and the fundamental value have to converge in the long run.

Third, possible animal spirits profits for uninformed investors depend crucially on the level of the risk-free rate of return. Moreover, the thesis shows the break-

even level for the risk-free rate, under which the gut feeling may produce profits over the buy-and-hold strategy for uninformed investors. Above the break-even level, the outcome is the other way round. The thesis also suggests that the break-even level produces expected returns for informed investors, when the reduction of returns due to the animal spirits component disappear.

Fourth, the literature on time-varying risk premium gives an alternative explanation on returns predictability, and to the relation between the equilibrium price level and the fundamental value level. For simplicity, the thesis follows Shiller (2014) and ignores the time-varying risk premium. The assumption of investors' rationality means that when buy-and-hold returns are high (low), volatility is high (low). Cochrane (2008) argues that the excess buy-and-hold returns ratio to volatility stays reasonably constant over time, but the risk-premium adjusts continuously. However, the empirical results of the second article report that the animal spirits excess profits are positively correlated with the volatility of the buy-and-hold returns. This can be explained by the time-varying risk premium only if it is highly sensitive. When the risk-free rate is low, the risk-premium must be extremely low if the volatility of returns is high. The basic theoretical model of the thesis could be easily enlarged to include time-varying discount rate, which might yield interesting results.

REFERENCES

Ang, A., Bekaert, G. (2007) Stock return predictability: Is it there? *Review of Financial Studies* **20,** 651-707.

Ang, A., Hodrick, R., Xing, Y., Zhang, X. (2009) High idiosyncratic volatility and low returns: International and further U.S. evidence, *Journal of Financial Economics* **61,** 1-23.

Brown, D., Jennings, R. (1989) On technical analysis, *Review of Financial Studies* **2,** 527-551.

Campbell, J. and Kyle, A. (1993) Smart money, noise trading and stock price behavior, *Review of Economic Studies* **60**, 1-34.

Campbell, J., Yogo, M. (2006) Efficient test of stock returns predictability, *Journal of Financial Economics* **81,** 27-60.

Campbell, J., Thompson, S. (2008) Predicting excess returns out of sample: Can anything beat the historical average? *Review of Financial Studies* **21,** 1509-1532.

Cochrane, J. (2008) The dog that did not bark: A defense of return predictability, *Review of Financial Studies* **21,** 1533-1573.

DeLong, B., Shleifer, A., Summers, L. and Waldmann, R. (1990) Positive feedback investment strategies and destabilizing rational speculation, *Journal of Finance* **45**, 379-395.

Engle, R. and Granger, C. (1987) Co-integration and error correction: Representation, estimation, and testing, *Econometrica* **55**, 251-275.

Epstein, S. (1994) Integration of the cognitive and the psychodynamic unconscious, *American Psychologist* **49**, 709-724.

Fama, E. (2014) Two pillars of asset pricing, *American Economic Review* **104**, 1467-1485.

Finucane, M., Alhakami, A., Slovic, P. and Johnson, S. (2000) The affect heuristic in judgments of risk and benefits, *Journal of Behavioral Decision Making* **13,** 1-17.

Friedman, M. (1953) *Essays in positive economics,* University of Chicago Press, Chicago.

Froot, K., Scharfstein, D. and Stein, J. (1992) Herd on the street: informational inefficiencies in a market with short-term speculation, *Journal of Finance* **47**, 1461-1484.

Gartley, H. (1935) *Profits in stock markets,* Lambert-Gann Publishing, Washington.

Hirshleifer, D. (2015) Behavioral Finance, *Annual Review of Financial Economics* **7,** 133-159.

Hjalmarsson, E. (2010) Predicting global stock returns, *Journal of Financial and Quantitative Analysis* **45,** 49-80.

Ilomäki, J. (2012) Framed field experiment with stock market professionals, *Journal of Behavioral Finance* **13,** 251-258.

Ilomäki, J. (2016a) Animal spirits, beauty contests and expected returns, *Journal of Economics and Finance,* DOI 10.1007/s12197-016-9364-8.

Ilomäki, J. (2016b) Risk-free rates and animal spirits in financial markets, *Annals of Financial Economics* **11,** No. 3, 1-18.

Ilomäki, J. (2017) Connecting theory and empirics for animal spirits, returns and interest rates: A clarification of "Risk-free rates and animal spirits in financial markets, *Annals of Financial Economics,* **accepted.**

Keynes, J. (1921) *A Treatise of probability*, McMillan, London.

Keynes, J. (1936) *General theory of interest, employment and money*, McMillan, London.

LeRoy, S. (1973) Risk aversion and the martingale property of stock prices, *International Economic Review* **14,** 436-446.

Maio, P. (2014) Don't fight the Fed!, *Review of Finance* **18**, 623-679.

Markowitz, H. (1952) Portfolio selection, *Journal of Finance* **7**, 77-91.

Samuelson, P. (1965) Proof that properly anticipated prices fluctuate randomly, *Industrial Management Review* **6**, 4-12.

Samuelson, P. (1973) Proof that properly discounted present values of assets vibrate randomly, *Bell Journal of Economics and Management* **4**, 369-374.

Santos, M. and Woodford, M. (1997). Rational asset pricing bubbles, *Econometrica,* **65**, 19-57.

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

Shiller, R. (1984) Stock prices and social dynamics, *Brookings Papers on Economic Activity* **2,** 457-510.

Shiller, R. (2014) Speculative asset prices, *American Economic Review* **104**, 1486-1517.

Shleifer, A., Vishny, R. (1997) The limits of arbitrage, *Journal of Finance* **52**, 35-55.

Slovic, P., Finucane, M., Peters, E. and MacGregor D. (2007) The affect heuristic, *European Journal of Operational Research* **177**, 1333-1352.

Tirole, J. (1985) Asset bubbles and overlapping generations, *Econometrica*, 53, 1499-1528.

ORIGINAL PUBLICATIONS

World Scientific
www.worldscientific.com

RISK-FREE RATES AND ANIMAL SPIRITS
IN FINANCIAL MARKETS

JUKKA ILOMÄKI

University of Tampere, Finland
jukka.ilomaki@uta.fi

We show analytically that animal spirit excess profits for uninformed investors fall (increase) when the risk-free rate rises (falls). In the theoretical analysis, we examine the expected returns of risk-averse, short-lived investors. In addition, we find empirically that the local risk-free rates explain 14% of the changes in the animal spirit excess profits in the global stock markets for the last 29 years when the animal spirits is characterized as a product of the trend-chasing rule.

Keywords: Interest rates; Portfolio choice; stock returns.

JEL Classification: G11, G12

1. Introduction

Shiller (2014) argues that the equilibrium price of a stock (P_t) is equal to the fundamental value (V_t) plus an additional component (C_t), describing all the errors when $P_t \neq V_t$ with $P_t \sim I(1)$ (i.e. non-stationary), $V_t \sim I(1)$ and C_t can include animal spirits (A_t), and A_t tends to be sluggish to change. Shiller follows Keynes's (1921) definition of animal spirits as the gut feeling that arises from the ambiguity of the directly unobservable probabilities of a stock's future returns. In decision-making situations (Epstein, 1994), people face the dual-decision processing problem in which they have two modes of thinking and information processing: a fast, emotionally driven, experiential system and a slow, rational, analytical system. In psychological terms, this gut feeling is called the affect heuristic (Finucane *et al.*, 2000; Slovic *et al.*, 2007) in the experiential system, suggesting that people automatically consult the affect pools in their minds in the process of making decisions.

We have risk-averse constant absolute risk aversion (CARA) short-lived rational investors with asymmetric information assuming that half of them receive information about the dividend process. In addition, we assume that uninformed

investors can coordinate perfectly with their animal spirit heuristic. These conditions imply that the animal spirits have an influence on the equilibrium price.

We find that the animal spirit excess profits for uninformed investors fall when the risk-free rate rises, defining the difference between the animal spirit excess returns and the buy and hold excess returns as animal spirit profits. Our empirical test results are consistent with our theoretical results. We find that the local risk-free rates explain 14% of the changes in the animal spirit excess profits in the global stock markets. Furthermore, we control the effect of the volatility of returns, and find that the animal spirits profits increase when the daily volatility rises. However, the explanatory power for volatility is approximately 13%. The results are novel in concerning the interactions between the risk-free rates and the animal spirits profits for investors. The empirical findings suggest that rational investor should include trend-chasing position in her portfolio when the risk-free rate is lower than 3%.

The remainder of this paper is organized as follows. Section 2 outlines the theories of equilibrium price in stock markets, Sec. 3 presents the model and Sec. 4 presents the theoretical analysis of the model. Section 5 introduces the empirical evidence, and Sec. 6 concludes.

2. Theory

2.1. *Equilibrium price in stock markets*

By studying the time series properties of stock market prices, Shiller (2014) argues that aggregate stock markets seem to follow:

$$P_t = E_t \sum_{s=1}^{\infty} \frac{D_{t+s} + \omega A_{t+s}}{(1 + r^f + \omega)^s}, \tag{1}$$

where P_t is the stock price, E_t is the expectations operator, D_t is the dividend, r^f is the constant risk-free rate, ω is the constant risk premium and A_t is the animal spirits. If $\omega = 0$, then Eq. (1) becomes identical to the results obtained by Samuelson (1973).

$$P_t = V_t = E_t \sum_{s=1}^{\infty} \frac{D_{t+s}}{(1 + r^f)^s}. \tag{2}$$

That is, in efficient markets with risk-neutral investors, P_t must be equal to V_t. However, when investors are risk-averse with no A_t in markets, we include risk premium ω in the discount factor in Eq. (2). Naturally, r^f, ω or both can be

time-dependent, but for simplicity, we ignore these possibilities in the theoretical section of the study.

To include A_t in the equilibrium price, we must make three assumptions. First, rational investors must be risk-averse (Samuelson, 1973). Second, rational investors must have a short investment period to have the limits of arbitrage (Shleifer and Vishny, 1997). Thirdly, uninformed investors must herd (Hirshleifer and Teoh, 2003) such that they coordinate their A_t at time *t*. This can happen with the use of the same trend-chasing rule (Gartley, 1935), for example, and can be motivated by the fact that it is hard to infer future returns from past prices, suggesting that uninformed investors herd with a common heuristic.

In psychological terms, the animal spirits A_t are the affect heuristic (Finucane *et al.*, 2000). This has led to extensive literature on behavioral finance, which studies how, when and why anomalies, biases and heuristics affect markets. Notable surveys of behavioral finance include those by Barberis (2003); Shiller (2003); De Bondt *et al.* (2008); Shefrin (2008); Subrahmanyam (2008) and Hirshleifer (2015), among others.

Starting from Shiller (1981), the literature on excess volatility finds evidence that stock market prices seem to be too volatile to justify changes in the fundamental values. Thus, the excess volatility of returns can be caused by psychology. Ang *et al.* (2006, 2009) find that high (low) volatility in returns suggests low (high) buy and hold returns for individual stocks. This suggests an anomaly against the famous mean-variance paradigm (Markowitz, 1952; Sharpe, 1964). Baker *et al.* (2011) argue that this phenomenon is caused by investors' irrational preference for high volatility, and by the limits of possibilities for arbitrage (Shleifer and Vishny, 1997).

On the other hand, the Fisherian hypothesis (Fisher, 1930) states that stock returns include compensation for inflation because the returns on real assets can be expressed as the sum of real returns and the inflation rate. Following Fama (2014) by assuming that the risk-free rate is a proxy for expected inflation, $E_t(i_{t+1}) = r_t^f$, the Fisherian hypothesis predicts that when the risk-free rate is low, the buy and hold returns are also low. However, when the risk-free rate is time-varying and rational investors are risk averse, the risk premium ω_t is also time-varying (LeRoy, 1973). Thus, the Fisherian hypothesis and time-varying risk premium together predict that if the risk-free rate is low (high), the buy and hold returns are low (high). Furthermore, when the volatility of the buy and hold returns are high (low), then investors' risk tolerance must be highly sensitive in time and extremely high (low). Note that this holds if investors are rational.

In addition, Campbell and Kyle (1993) introduce an asymmetric information model in which infinitely lived, risk-averse, rational investors and randomly trading noise traders create $P_t = V_t + C_t$ with $C_t \sim I(0)$. That is, C_t is a stationary

linear combination of P_t and V_t; thus, they are cointegrated (Engle and Granger, 1987). $P_t = V_t + C_t$ implying that the buy and hold returns vary more than the fundamental value returns.

3. The Model

3.1. *Basic assumptions*

All the assumptions are common knowledge among the rational investors in the model unless we mention otherwise. We assume one infinitely lived risky asset economy (stock of firm F) and a constant risk-free rate r^f.

We assume a market with an atomistic set of rational investors. We use the overlapping generations model of investors with standard rational preferences investing in only one period and consuming and dying in the next period. Thus, we assume no consumption among young investors in period one. That is, we have two kinds of rational investors in every trading period: young investors (Y) who open their positions (demand at time t) and old investors (O) who close their positions (supply at time t); we assume that $Q_t = Y_t + O_t$ and $Y_t = O_t$, where Q is the quantity of investors at time t. We assume that the continuum of young investors Y_t is unity. Thus, the continuum of old investors O_t is also unity. For simplicity, we assume constant $Q = Y + O$ in time in this economy.

We suppose that short selling is available to individual investor y and that there are no transaction costs or taxes. Assuming the possibility of short selling, a young investor y may produce a negative demand by selling short at time t, so then she has to produce a negative supply by closing her short position as an old investor o at time $t + 1$.

We assume that firm F pays cash dividends (D) for investors at time t and that the natural logarithm of dividend D_t follows an unobservable random walk with the drift process:

$$\log D_t = g + \log D_{t-1} + e_t^d, \tag{3}$$

where $g = \beta r^f$ and $e_t^d \sim WN(0, \sigma_d^2)$. The coefficient β is constant with $0 < \beta < 1$. We assume that firm F pays nominal D_t to old investor o_t at time t *after* she has closed her position if she set a long position for the stock when she was young. Thus, D_t is then revealed to be an old investor and she does not pass that information onwards. We suppose that the past equilibrium prices ($P_{t-1}, P_{t-2}, \ldots$) of stock F are common information that is shared by the rational investors.

We assume CARA of rational investors such that their utility function is $U(c) = -\exp^{-\nu c_{t+1}}$, where c is the consumption and ν is the coefficient of the investor's risk aversion. However, we assume that the information about the future

dividends of the risky asset (Eq. (3)) is received by only a fraction μ of young investors at time t. Thus, we have risk-averse, CARA, young informed $i(\mu)$ and young uninformed $u(1 - \mu)$ rational investors in every period t, and μ_t describes the ratio of informed investors to young investors Y_t. For simplicity, we assume constant $\mu = \frac{1}{2}$ in this economy. We suppose that the young informed investor i observes the dividends D_t, D_{t+1} and D_{t+2} and the dividend growth g. In addition, we assume that an individual rational investor is constrained by wealth such that an individual rational young investor y at time t has the same initial wealth w_t^y.

In addition, we assume an unobservable noisy net supply of the stock by dumb traders (DU$_t$), distributed $e_t^{du} \sim WN(0, \sigma_{du}^2)$. The market clears:

$$\int_y x_y - \int_o s_o + e_t^{du} = 0, \tag{4}$$

where x is the demand for stock and s is the supply of stock.

In the summary of information among rational investors, we can define the following:

Summary 1: The information sets for young informed θ_t^{yi}, old informed θ_t^{oi}, young uninformed θ_t^{yu} and old uninformed θ_t^{ou} investors are the following:

$$\theta_t^{yi} = (r^f, g, D_{t+2}, D_{t+1}, D_t, P_{t-1}, P_{t-2}, \dots)$$
$$\theta_t^{oi} = (r^f, g, D_{t+1}, D_t, D_{t-1}, P_{t-1}, P_{t-2}, \dots)$$
$$\theta_t^{yu} = (r^f, P_{t-1}, P_{t-2}, \dots)$$
$$\theta_t^{ou} = (r^f, P_{t-1}, P_{t-2}, \dots).$$

3.2. *The benchmark model without animal spirits*

By assumption, the nominal return for the risky asset for an investor is

$$r_{t+1}^{\eta} = \frac{P_{t+1} + D_{t+1}}{P_t},$$

where P_t is the ex-dividend equilibrium price. A risk-averse CARA, informed investor y_t who lives for two periods simply maximizes her utility under rational choice by allocating her wealth between the risky asset and the risk-free asset. The expected excess return on a share is $E_t(R_{t+1}) = [E_t(P_{t+1} + D_{t+1}) - (1 + r^f)P_t]/P_t \Rightarrow E_t(R_{t+1}) = \psi - (1 + r^f)$, where

$$\psi = \frac{E_t(P_{t+1} + D_{t+1})}{P_t}.$$

The young investor y_t must solve the following problem:

$$\text{Max} E[U(-\exp^{-\nu c_{t+1}} | \theta_t^y, w_t^y)], \tag{5}$$

where c is consumption and ν is the coefficient of the investor's risk aversion. The budget constraints read $c_{t+1} = x^f(1 + r^f) + x^r E_t(R_{t+1})$ and $w_t^y = x^f + x^r$, where x^f is the amount of money allocated in risk-free asset and x^r in risky asset and w_t^y is initial wealth for young investor. Plugging the former constraint into the utility function and assuming normally distributed consumption, we obtain

$$U(c_{t+1}) = -\exp^{-\nu(x^f(1+r^f)+x^r E_t(R_{t+1})-\frac{\nu}{2}x^{r^2}\sigma_r^2)}$$

$$= -\exp^{-\nu x^f(1+r^f)-\nu x^r E_t(R_{t+1})+\frac{\nu^2}{2}x^{r^2}\sigma_r^2}. \tag{6}$$

Maximizing Eq. (6) with respect to x^r, x^f we obtain the optimal amount of money invested in the risky asset,

$$\nu E_t(R_{t+1}) - \nu^2 x_t^r \sigma_r^2 = 0 \ \Rightarrow x_t^r = \frac{E_t(R_{t+1})}{\nu \sigma_r^2}. \tag{7}$$

Plugging $E_t(R_{t+1}) = \psi - (1 + r^f)$ into Eq. (7) yields stock demand equation for y_t:

$$x_t^r = \frac{\psi - (1 + r^f)}{\nu \sigma_r^2}, \tag{8}$$

where σ_r^2 is the expected variance of excess returns. Recall that the aggregate demand in equilibrium is unity, $x_t^r = 1$. Then by manipulating Eq. (8)

$$\nu \sigma_r^2 = \psi - (1 + r^f) \quad \rightarrow \quad \frac{\nu \sigma_r^2}{(1 + r^f)} = \frac{\psi}{(1 + r^f)} - 1 = \omega, \tag{9}$$

where ω is the constant risk premium. However, informed investor i has more information than uninformed investor u suggesting $\sigma_i^2 < \sigma_u^2$. Then, in order to get identical risk premiums $\omega = \omega_i = \omega_u$ we must have

$$\frac{\nu_i \sigma_i^2}{(1 + r^f)} = \frac{\nu_u \sigma_u^2}{(1 + r^f)} \Rightarrow \frac{\nu_i}{\nu_u} = \frac{\sigma_u^2}{\sigma_i^2}. \tag{10}$$

Equation (10) suggests that a stable equilibrium is possible where informed and uninformed investors are present if uninformed investor tolerates more risk than informed investor. This suggests a trade-off between the quality of information and the tolerance of risk.

According to random walk's properties, change of dividend at time t is permanent (Eq. (3)) resulting Gordon growth model (please, see Gordon, 1959)

$$V_t = \frac{D_{t+1}}{r^n - g}, \tag{11}$$

where V_t is the ex-dividend (from period t) fundamental value per share of stock F, dividend growth $g = \beta r^f$ and $r^n = \omega + r^f$ is required cost of capital.

Therefore, following Summary 1, we can conclude that the young (old) informed investor $y_t^i(o_t^i)$ solves the fundamental values $V_{t+1}, V_t, V_{t-1}(V_t, V_{t-1}, V_{t-2})$. The rational choice pricing for y_t^i and o_t^i investors is simply $P_t = V_t$ because these atomistic investors have the same information and $o_t^i(y_t^i)$ recognizes that $y_t^i(o_t^i)$ observes this. However, uninformed investors do not observe dividends, but they do observe past equilibrium prices and the constant risk-free rate r^f, resulting an identical risk premium (Eq. (9)) and the required cost of capital $1 + r^n$ following rational pricing $P_t = (1 + r^n)P_{t-1}$. Thus, it must be that in equilibrium, there are only four kinds of rational investors: young (old) informed and uninformed investors who open (close) their positions. Consequently, the equilibrium price in this economy is simply:

$$P_t = \frac{1}{2}V_t + \frac{1}{2}(1 + r^n)P_{t-1}, \tag{12}$$

with the restriction (Eq. (10)) $\frac{\nu_i}{\nu_u} = \frac{\sigma_u^2}{\sigma_i^2}$ implying identical risk premium ω for informed and uninformed investor.

3.3. *Equilibrium with animal spirits when* $\mu = \frac{1}{2}$

Equations (3), (11) and (12) imply that $P_t \neq V_t$ in every step suggesting $P_t = V_t + C_t$ (Shiller, 2014), where C_t describes all errors when $P_t \neq V_t$. This suggests

$$P_t = \frac{1}{2}(V_t + C_t^i) + \frac{1}{2}[(1 + r^n)P_{t-1} + C_t^u]. \tag{13}$$

Now suppose that rational *uninformed* investor u starts to include animal spirit component $A_\tau = C_t^u$ (where $\tau = t - k$ is a rolling window size for the animal spirit rule) suggested in the pricing equation as $(1 + r^n + A_\tau)P_{t-1}$. Following DeLong *et al.* (1990) and Froot *et al.* (1992) we assume that uninformed investors can coordinate their actions perfectly.

Additional Assumption 1: Uninformed investors coordinate perfectly in their animal spirit component to obtain an identical product of A_τ, where A_τ is over-reacted demand for stocks per share.

However, informed investor i does not observe $A_\tau = C_t^u$ but she can recognize that Eq. (12) does not hold at time $t - 1$. In addition, we follow Santos and Woodford (1997) by assuming infinite bubble is impossible suggesting P_t and V_t cannot drift apart forever.

Additional Assumption 2: P_t and V_t cannot drift apart forever.

Then, being rational (assuming that P_t and V_t cannot drift apart forever), informed investor i utilizes the cointegration results of Engle and Granger (1987). That is, the difference $P_{t-1} - V_{t-1}$ gives the optimal forecast for A_τ when P_t and V_t

are cointegrated. Thus, we obtain

$$C_t^i = P_{t-1} - V_{t-1} \tag{14}$$

in Eq. (13). Then, following Eqs. (12)–(14) and $A_\tau = C_t^u$, the stable equilibrium price series follows:

$$P_t = \frac{1}{2}(V_t + P_{t-1} - V_{t-1}) + \frac{1}{2}[(1 + r^n + A_\tau)P_{t-1}] \tag{15}$$

with the restriction (Eq. (10)).

4. Theoretical Analysis of the Behavior of the Model

The equilibrium price series follows equilibrium (15). Rearranging it, we obtain

$$\Delta P_t = \frac{1}{2}\Delta V_t + \frac{1}{2}[P_{t-1}(r^n + A_\tau)]. \tag{16}$$

We transfer Eq. (16) one step ahead to obtain

$$\Delta P_{t+1} = \frac{1}{2}\Delta V_{t+1} + \frac{1}{2}[P_t(r^n + A_\tau)]. \tag{17}$$

Thus, Eq. (17) shows that ΔP_{t+1} is simply the sum of two equally weighted components. Now, young informed investor y_t^i does not observe the animal spirit component A_τ and uninformed investors u_t coordinate perfectly in A_τ. Hence, in equilibrium (Eq. (17)), we obtain four alternatives for young investors, yielding the following result.

Result 1: Four alternatives for young informed y_t^i and uninformed investor y_t^u when A_τ is included in the equilibrium price:

(1) $\Delta V_{t+1} > 0$ and $(r^n + A_\tau)P_{t-1} > 0$
(2) $\Delta V_{t+1} > 0$ and $(r^n + A_\tau)P_{t-1} < 0$
(3) $\Delta V_{t+1} < 0$ and $(r^n + A_\tau)P_{t-1} < 0$
(4) $\Delta V_{t+1} < 0$ and $(r^n + A_\tau)P_{t-1} > 0$

yielding expected returns $E_t(r_{t+1}^i) > E_t(r_{t+1}^u) > 0$, when $r^n > 0$.

4.1. *Proof of Result 1*

To prove Result 1, it is useful to analyze it in natural logarithm series to obtain log returns.

Calculating Eq. (15) in natural logs, we have as

$$\log P_t = \frac{1}{2}(\log V_t + \log P_{t-1} - \log V_{t-1}) + \frac{1}{2}(\log P_{t-1} + r^n + \log A_\tau), \tag{18}$$

where r^n is in the natural logarithm. Denoting $\log A_\tau = \alpha_\tau$ and rearranging Eq. (18), we obtain

$$\Delta \log P_t = \frac{1}{2} \Delta \log V_t + \frac{1}{2}(r^n + \alpha_\tau). \tag{19}$$

Then, moving Eq. (19) one step forward, we obtain

$$\Delta \log P_{t+1} = \frac{1}{2} \Delta \log V_{t+1} + \frac{1}{2}(r^n + \alpha_\tau). \tag{20}$$

This shows that the actual $\Delta \log P_{t+1}$ *is the sum of two equally weighted components,* $\Delta \log V_{t+1}$ *and* $r^n + \alpha_\tau$. Young informed investor y_t^i does not observe component α_τ and young and old uninformed investors u_t coordinate perfectly in α_τ.

However, please note that $\Delta \log V_t = r^n + e_t^v$, where $e_t^v \sim N(0, \sigma_v^2)$, resulting in $E(r_{t+1}^v) = r^n$ in the long run and for uninformed investor $E(\Delta \log P_{t+1}) = r^n + \alpha_\tau$, where E is the expectations operator, suggesting

$$E(\Delta \log P_{t+1}) = \frac{1}{2} r^n + \frac{1}{2}(r^n + \alpha_\tau). \tag{21}$$

However, recall Additional Assumption 2: to prevent P_t and V_t drifting apart forever, there has to be a long-run equilibrium in which

$$E(\alpha) = 0 \rightarrow E(\Delta \log P) = r^n, \tag{22}$$

suggesting that short-run coordination and uninformed investors (α_τ) cancel each other out in the long run:

$$r^n + \alpha \rightarrow E(r_{t+1}^m) = \frac{1}{2}(r^n + \alpha_\tau) + \frac{1}{2}(r^n - \alpha_\tau). \tag{23}$$

4.1.1. *All the alternative expected returns for the informed and uninformed investors and for the buy and hold investor*

To analyze performance for different information sets in trading sessions, we denote absolute (the product of correct positions) returns in the short run as r^m with constant variance σ_m^2. We have one alternative expected return for the young informed investor i and uninformed investor u and for the buy and hold investor bh in alternative (1) $\Delta V_{t+1} > 0$ and $(r^n + A_\tau)P_{t-1} > 0$.

$$\Delta \log V_{t+1} > 0 \wedge r^n + \alpha_\tau > 0 \rightarrow E(r_{t+1}^i) = \frac{1}{2} r^m + \frac{1}{2} r^m = r^m,$$

$$(1) \quad \Delta \log V_{t+1} > 0 \wedge r^n + \alpha_\tau > 0 \rightarrow E(r_{t+1}^u) = \frac{1}{2} r^m + \frac{1}{2} r^m = r^m,$$

$$\Delta \log V_{t+1} > 0 \wedge r^n + \alpha_\tau > 0 \rightarrow E(r_{t+1}^{bh}) = \frac{1}{2} r^m + \frac{1}{2} r^m = r^m.$$

We have one alternative expected return for the young informed and uninformed investors and for the buy and hold investor in alternative (2) $\Delta V_{t+1} > 0$ and $(r^n + A_\tau)P_{t-1} < 0$.

$$\Delta \log V_{t+1} > 0 \wedge r^n + \alpha_\tau < 0 \rightarrow E(r^i_{t+1}) = \frac{1}{2}r^m - \frac{1}{2}(r^m - \alpha_\tau) = \frac{1}{2}\alpha_\tau,$$

$$(2) \quad \Delta \log V_{t+1} > 0 \wedge r^n + \alpha_\tau < 0 \rightarrow E(r^u_{t+1}) = -\frac{1}{2}r^m + \frac{1}{2}(r^m - \alpha_\tau) = -\frac{1}{2}\alpha_\tau,$$

$$\Delta \log V_{t+1} > 0 \wedge r^n + \alpha_\tau < 0 \rightarrow E(r^{bh}_{t+1}) = \frac{1}{2}r^m - \frac{1}{2}(r^m - \alpha_\tau) = \frac{1}{2}\alpha_\tau.$$

We have one alternative expected return for the young informed and uninformed investors and for the buy and hold investor in alternative (3) $\Delta V_{t+1} < 0$ and $(r^n + A_\tau)P_{t-1} < 0$.

$$\Delta \log V_{t+1} < 0 \wedge r^n + \alpha_\tau < 0 \rightarrow E(r^i_{t+1}) = \frac{1}{2}r^m + \frac{1}{2}r^m = r^m,$$

$$(3) \quad \Delta \log V_{t+1} < 0 \wedge r^n + \alpha_\tau < 0 \rightarrow E(r^u_{t+1}) = \frac{1}{2}r^m + \frac{1}{2}r^m = r^m,$$

$$\Delta \log V_{t+1} < 0 \wedge r^n + \alpha_\tau < 0 \rightarrow E(r^{bh}_{t+1}) = -\frac{1}{2}r^m - \frac{1}{2}r^m = -r^m.$$

One alternative expected return exists for the young informed and uninformed investors and for the buy and hold investor in alternative (4) $\Delta V_{t+1}0$ and $(r^n + A_\tau)P_{t-1} > 0$.

$$\Delta \log V_{t+1} < 0 \wedge r^n + \alpha_\tau > 0 \rightarrow E(r^i_{t+1}) = \frac{1}{2}r^m - \frac{1}{2}(r^m - \alpha_\tau) = \frac{1}{2}\alpha_t,$$

$$(4) \quad \Delta \log V_{t+1} < 0 \wedge r^n + \alpha_\tau > 0 \rightarrow E(r^u_{t+1}) = -\frac{1}{2}r^m + \frac{1}{2}(r^m - \alpha_\tau) = -\frac{1}{2}\alpha_\tau,$$

$$\Delta \log V_{t+1} < 0 \wedge r^n + \alpha_\tau > 0 \rightarrow E(r^{bh}_{t+1}) = -\frac{1}{2}r^m + \frac{1}{2}(r^m - \alpha_\tau) = -\frac{1}{2}\alpha_t.$$

Hence, assuming equal probabilities between alternatives (1–4), we obtain

$$E_t(r^i_{t+1}) = \left(\frac{1}{4}r^m + \frac{1}{8}\alpha_\tau + \frac{1}{4}r^m + \frac{1}{8}\alpha_\tau\right) = \frac{1}{2}r^m + \frac{1}{4}\alpha_\tau$$

and

$$E_t(r^u_{t+1}) = \left(\frac{1}{4}r^m - \frac{1}{8}\alpha_\tau + \frac{1}{4}r^m - \frac{1}{8}\alpha_\tau\right) = \frac{1}{2}r^m - \frac{1}{4}\alpha_\tau$$

and

$$E_t(r_{t+1}^{bh}) = \left(\frac{1}{4} r^m + \frac{1}{8} \alpha_\tau - \frac{1}{4} r^m - \frac{1}{8} \alpha_\tau \right) = 0$$

when α_τ prevails. Then, with restriction $\frac{\alpha_\tau}{2} < r^m$ and $\alpha_\tau > 0$, Result 1 Q.E.D.

4.2. *Theoretical analysis when the risk-free rate rises*

Suppose that $\Delta r^f > 0$ *ceteris paribus*. Then, Eqs. (3) and (11) and $r^n = \omega + r^f$ imply that $\frac{\Delta r^f}{\Delta V_{t+1}} > 0$, suggesting the probability that the positive fundamental value change increases *ceteris paribus*. This directly implies that $\frac{\Delta r^f}{\Delta P_{t+1}} > 0$. Then, because r^f is free of risk, when $\Delta r^f > 0$, it has to be that

$$(A_\tau + \Delta r^f) = \mathrm{new} A_\tau, \tag{24}$$

suggesting in log returns $r^n + (\alpha_\tau + \Delta r^f)$ in alternatives (1–4).

We have one alternative expected return for the young informed i and unin-formed investor u and for the buy and hold investor bh in alternative (1) $\Delta V_{t+1} > 0$ and $(r^n + A_\tau)P_{t-1} > 0$.

$$\Delta \log V_{t+1} > 0 \wedge r^n + \alpha_\tau > 0 \rightarrow E(r_{t+1}^i) = \frac{1}{2} r^m + \frac{1}{2} r^m = r^m,$$

(1) $\quad \Delta \log V_{t+1} > 0 \wedge r^n + \alpha_\tau > 0 \rightarrow E(r_{t+1}^u) = \frac{1}{2} r^m + \frac{1}{2} r^m = r^m,$

$$\Delta \log V_{t+1} > 0 \wedge r^n + \alpha_\tau > 0 \rightarrow E(r_{t+1}^{bh}) = \frac{1}{2} r^m + \frac{1}{2} r^m = r^m.$$

We have one alternative expected return for the young informed and uninformed investors and for the buy and hold investor in alternative (2) $\Delta V_{t+1} > 0$ and $(r^n + A_\tau)P_{t-1} < 0$.

$$\Delta \log V_{t+1} > 0 \wedge r^n + \alpha_\tau < 0 \rightarrow E(r_{t+1}^i) = \frac{1}{2} r^m - \frac{1}{2}(r^m - \alpha_\tau - \Delta r^f)$$

$$= \frac{1}{2} \alpha_\tau + \frac{1}{2} \Delta r^f,$$

(2) $\quad \Delta \log V_{t+1} > 0 \wedge r^n + \alpha_\tau < 0 \rightarrow E(r_{t+1}^u) = -\frac{1}{2} r^m + \frac{1}{2}(r^m - \alpha_\tau - \Delta r^f)$

$$= -\frac{1}{2} \alpha_\tau - \frac{1}{2} \Delta r^f,$$

$$\Delta \log V_{t+1} > 0 \wedge r^n + \alpha_\tau < 0 \rightarrow E(r_{t+1}^{bh}) = \frac{1}{2} r^m - \frac{1}{2}(r^m - \alpha_\tau - \Delta r^f)$$

$$= \frac{1}{2} \alpha_\tau + \frac{1}{2} \Delta r^f.$$

We have one alternative expected return for the young informed and uninformed investors and for the buy and hold investor in alternative (3) $\Delta V_{t+1} < 0$ and $(r^n + A_\tau)P_{t-1} < 0$.

$$\Delta \log V_{t+1} < 0 \wedge r^n + \alpha_\tau < 0 \rightarrow E(r^i_{t+1}) = \frac{1}{2}r^m + \frac{1}{2}r^m = r^m,$$

$$(3) \quad \Delta \log V_{t+1} < 0 \wedge r^n + \alpha_\tau < 0 \rightarrow E(r^u_{t+1}) = \frac{1}{2}r^m + \frac{1}{2}r^m = r^m,$$

$$\Delta \log V_{t+1} < 0 \wedge r^n + \alpha_\tau < 0 \rightarrow E(r^{bh}_{t+1}) = -\frac{1}{2}r^m - \frac{1}{2}r^m = -r^m.$$

One alternative expected return for young informed and uninformed investors and for the buy and hold investor in alternative (4) $\Delta V_{t+1}0$ and $(r^n + A_\tau)P_{t-1} > 0$.

$$\Delta \log V_{t+1} < 0 \wedge r^n + \alpha_\tau > 0 \rightarrow E(r^i_{t+1}) = \frac{1}{2}r^m - \frac{1}{2}(r^m - \alpha_\tau - \Delta r^f)$$

$$= \frac{1}{2}\alpha_t + \frac{1}{2}\Delta r^f,$$

$$(4) \quad \Delta \log V_{t+1} < 0 \wedge r^n + \alpha_\tau > 0 \rightarrow E(r^u_{t+1}) = -\frac{1}{2}r^m + \frac{1}{2}(r^m - \alpha_\tau - \Delta r^f)$$

$$= -\frac{1}{2}\alpha_\tau - \frac{1}{2}\Delta r^f,$$

$$\Delta \log V_{t+1} < 0 \wedge r^n + \alpha_\tau > 0 \rightarrow E(r^{bh}_{t+1}) = -\frac{1}{2}r^m + \frac{1}{2}(r^m - \alpha_\tau - \Delta r^f)$$

$$= -\frac{1}{2}\alpha_t - \frac{1}{2}\Delta r^f.$$

Hence, assuming that the probability of alternatives (1) and (2) rises and the probability of alternatives (3) and (4) falls symmetrically (cancelling each other out), we obtain

$$E_t(r^i_{t+1}) = \left(\frac{1}{4}r^m + \frac{1}{8}\alpha_\tau + \frac{1}{8}\Delta r^f + \frac{1}{4}r^m + \frac{1}{8}\alpha_\tau + \frac{1}{8}\Delta r^f\right)$$

$$= \frac{1}{2}r^m + \frac{1}{4}\alpha_\tau + \frac{1}{4}\Delta r^f$$

and

$$E_t(r^u_{t+1}) = \left(\frac{1}{4}r^m - \frac{1}{8}\alpha_\tau - \frac{1}{8}\Delta r^f + \frac{1}{4}r^m - \frac{1}{8}\alpha_\tau - \frac{1}{8}\Delta r^f\right)$$

$$= \frac{1}{2}r^m - \frac{1}{4}\alpha_\tau - \frac{1}{4}\Delta r^f$$

and

$$E_t(r_{t+1}^{bh}) = \left(\frac{1}{4} r^m + \frac{1}{8} \alpha_\tau + \frac{1}{8} \Delta r^f - \frac{1}{4} r^m - \frac{1}{8} \alpha_\tau - \frac{1}{8} \Delta r^f \right) = 0$$

when $\Delta r^f > 0$. Thus, this proves that if $\Delta r^f > 0$, then the expected animal spirit profits for an uninformed (informed) investor

$$\frac{1}{2} r^m - \frac{1}{4} \alpha_t \left(\frac{1}{2} r^m + \frac{1}{4} \alpha_t \right)$$

decrease (increase) by $\frac{1}{4} \Delta r^f$. Then, with restriction $\frac{\alpha_\tau}{2} < r^m$ and $\alpha_\tau > 0$, Q.E.D.

5. Empirical Test in Global Stock Markets

5.1. *Data and methods*

We use global stock market daily data from 1 March, 1986 to 29 February, 2016. The most convenient source of such market data is the MSCI world index (*source*: www.msci.com). The MSCI indices are free float-adjusted market capitalization weighted indices. At the present time, the MSCI world index contains stock market developments in 23 developed countries: Australia, Austria, Belgium, Canada, Finland, France, Denmark, Germany, Hong Kong, Ireland, Israel, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, the UK and the USA. In addition to the MSCI world index, we include all the above countries' indices. Unfortunately Finland, Ireland, New Zealand and Portugal do not have data available for the period from January 1987 to December 1989. In addition, Israel does not have data available for the period from January 1987 to December 1995. That is, we have 19 MSCI indices altogether in nine non-overlapping periods, four MSCI indices in eight non-overlapping periods and MSCI-Israel in six non-overlapping periods. We utilize the MSCI data in local currencies, and as a risk-free rate for an investor we use the 1-month Euribor rate (1-month ECU deposit rate) (*source*: ec.europe/eurostat) from January 1999 to February 2016 (from January 1987 to December 1998).

Animal spirits can be characterized as a product of the trend-chasing rule. Seemingly, the most popular trend-chasing technique is the moving average trading rule, which dates back at least to Gartley (1935). Hence, in this test, we take the moving average rule by Gartley as a proxy for A_τ. He demonstrates a calculation of the moving average (the average of the fixed-size window that moves with time) and defines the following trading rule: when the moving average is smaller (larger) than the current closing price, the trading rule suggests buy (sell).

In the test, we follow the seminal paper of Brock *et al.* (1992) by choosing the best moving average rule after transaction costs in their testing period (1897–

1986), which is the 200-day moving average rule. However, to reduce the effect of false signals due to the volatility of daily prices, instead of the daily data in the rule, we use monthly data in the rule, assuming that a 10-month period is an approximation for 200 trading days. Hence, we construct a moving average with 10 monthly observations. We use a simple crossover rule. Thus, when the sign of the difference between the actual closing price and the moving average changes, it is a signal to close the current position and, at the same time, open the opposite position. Thus, during the out-of-sample period, we have either a long or a short position for the MSCI indices. Thus, our trend-chasing trading rule follows:

$$P_{t-1} > \left[\frac{P_{t-1} + P_{t-2} + \cdots + P_{t-10}}{10} \right] \rightarrow \text{next\_day} = \text{buy}$$

and $\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ (25)

$$P_{t-1} < \left[\frac{P_{t-1} + P_{t-2} + \cdots + P_{t-10}}{10} \right] \rightarrow \text{next\_day} = \text{sell},$$

where P is the monthly closing price. Hence, when the crossover appears in the index, we close our position and open the opposite site position on the following day.

In addition, to collect past prices, we assume costlessness; however, in relation to transaction costs, we follow Allen and Karjalainen (1999) and fix the cost per one-way transaction at 0.25%. In addition, we utilize a reasonable annualized 2% margin plus the 1-month Euribor rate as the short-selling costs. Finally, for the local risk-free rate in the test, we use the local 3-month interest rate r_t^{if} (*source*: http://stats.oecd.org) as a proxy.

To construct our theoretical framework, we first calculate our moving average rule returns for the MSCI index ir_t^{mi} minus the one-month Euribor return r_t^{fe}, defining this as the animal spirit excess returns. Then we calculate the buy and hold r_t^{bhi} for the index i excess returns analogously and finally we subtract the latter from the former to obtain the animal spirit excess profits. Thus, we create a dependent variable as follows:

$$r_t^{aei} = (r_t^{mi} - r_t^{fe}) - (r_t^{bhi} - r_t^{fe}).$$

Then we calculate the annualized three years' animal spirit excess profits $\tilde{r}_j^{aei}$ and annualized three years' local risk-free returns $\tilde{r}_j^{if}$ (local three-months' interest rate) for every non-overlapping period j matching every MSCI index i. To study how the local r_j^{if} explains the profitability of the moving average rule, we simply estimate a standard OLS regression as

$$\tilde{r}_j^{aei} = \beta_1 + \beta_2 \tilde{r}_j^{if} + e_j.$$

We use robust standard errors and *t*-values. Table 1 presents the regression results.

Table 1. The results for the linear OLS regression, where the dependent variable is three years annualized animal spirits excess profits ($r_t^{aei} = (r_t^{mi} - r_t^{fe}) - (r_t^{bhi} - r_t^{fe})$), where r_t^{mi} is our moving average rule returns for the MSCI index i, r_t^{fe} is the one-month Euribor return and r_t^{bhi} is the buy and hold return for MSCI index i) and it is explained by the local (country i) three years annualized three-month interest rate return. The sample size is 233.

	Coefficient	Robust standard error	t-Value	p-Value
Constant	0.0491	0.0143	3.43	0.001
Local risk-free rate	-1.5156	0.2481	-6.11	0.000

The regression results (Table 1) suggest clearly that when the risk-free rate rises (falls), then the animal spirit excess profits fall (rise) statistically significantly. In addition, the results suggests that when the local risk-free rate is zero, then the animal spirits excess profits $\tilde{r}_j^{aei}$ is $+5\%$. Figure 1 shows the regression line.

Furthermore, we observe from the regression results that the risk-free rates explain 14% of the changes in the animal spirit excess profits in the global stock markets for the last 29 years in global developed stock markets.

To control the effect of volatility in returns, we annualized three years' daily standard deviation in buy and hold returns $\tilde{\sigma}_j^{bhi}$ for every non-overlapping period j matching every MSCI index i. To study how $\tilde{\sigma}_j^{bhi}$ explains the profitability of the moving average rule, we estimate a standard OLS regression

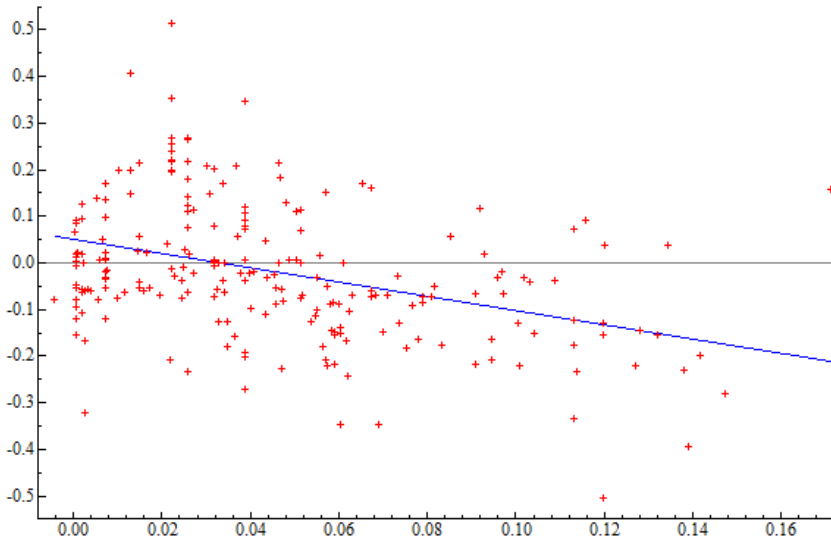$$\tilde{r}_j^{aei} = \beta_1 + \beta_2 \tilde{\sigma}_j^{bhi} e_j.$$

Figure 1. Regression line where the values of the animal spirits excess profits are in the vertical axis and the local risk-free rates are in the horizontal axis.

Table 2. The results for the linear OLS regression, where the dependent variable is three years annualized animal spirits excess profits ($r_t^{aei} = (r_t^{mi} - r_t^{fe}) - (r_t^{bhi} - r_t^{fe})$), where r_t^{mi} is our moving average rule returns for the MSCI index i, r_t^{fe} is the one-month Euribor return and r_t^{bhi} is the buy and hold return for MSCI index i) and it is explained by the (MSCI index i) three years annualized average daily volatility of the buy and hold returns $\tilde{\sigma}_j^{bhi}$. The sample size is 233.

	Coefficient	Robust standard error	*t*-Value	*p*-Value
Constant	−0.1955	0.0288	−6.79	0.000
Volatility of daily returns	0.8963	0.1627	5.51	0.000

The regression results (Table 2) suggest statistically significant positive relation between the volatility of the buy and hold returns and the animal spirits excess profits where the changes in volatility explain 12% of the changes in the animal spirit excess profits. This is consistent with the earlier results in the literature (Baker *et al.*, 2011), among others).

Hence, above two regression results suggest another regression, where both $\tilde{r}_j^{if}$ and $\tilde{\sigma}_j^{bhi}$ are the explanatory variables,

$$\tilde{r}_j^{aei} = \beta_1 + \beta_2 \tilde{r}_j^{if} + \beta_3 \tilde{\sigma}_j^{bhi} e_j.$$

Table 3 shows that both the local risk-free rate and the volatility of the buy and hold returns are significant explanatory variables, when the profitability of the animal spirits profits is analyzed. These results support our theoretical results, and yield a novel finding. In addition to the volatility factor, the local risk-free rate determines independently the profitability of the animal spirits profits, when it is characterized as a product of the trend-chasing rule.

Table 3. The results for the linear OLS regression, where the dependent variable is three years annualized animal spirits excess profits ($r_t^{aei} = (r_t^{mi} - r_t^{fe}) - (r_t^{bhi} - r_t^{fe})$), where r_t^{mi} is our moving average rule returns for the MSCI index i, r_t^{fe} is the one-month Euribor return and r_t^{bhi} is the buy and hold return for MSCI index i). It is explained by the local (country i) three years annualized three-month interest rate return and by the (MSCI index i) three years annualized average daily volatility of the buy and hold returns $\tilde{\sigma}_j^{bhi}$. The sample size is 233.

	Coefficient	Robust standard error	*t*-Value	*p*-Value
Constant	−0.1184	0.0309	−3.83	0.000
Local risk-free rate	−1.3581	0.2805	−4.84	0.000
Volatility of daily returns	0.8147	0.1453	5.61	0.000

6. Conclusions

We have an economy in which an infinitely lived risky asset and constant risk-free rate exist with atomistic, short-lived, CARA risk-averse informed and uninformed investors. The natural logarithm of the dividends follows a random walk with drift. In the analysis, we analyze the expected return for investors. We assume that uninformed rational investors can coordinate their animal spirits at time *t*. The coordination assumption with short-lived CARA investors ensures that uninformed investors have an influence on the equilibrium price.

We demonstrate that the animal spirit excess profits for uninformed investors fall when the risk-free rate rises. Our model captures the idea of Shiller (2014) that uninformed investors trade on the sluggish animal spirit component in their pricing. The results are significant, because the model examines for the first time, as far as we know, the consequences of risk-free rates and animal spirit profits for investors. In addition, the empirical test results for global stock markets from January 1987 to February 2016 support our theoretical results stating that the local risk-free rate is an independent factor that determines the profitability of trend-chasing profits.

References

Allen, F and R Karjalainen (1999). Using genetic algorithms to find technical trading rules. *Journal of Financial Economics*, 51, 245–271.

Ang, A, R Hodrick, Y Xing and X Zhang (2006). The cross-section of volatility and expected returns. *Journal of Finance*, 61, 259–299.

Ang, A, R Hodrick, Y Xing and X Zhang (2009). High idiosyncratic volatility and low returns: International and further U.S. evidence. *Journal of Financial Economics*, 61, 1–23.

Baker, M, B Bradley and J Wurgler (2011). Benchmark as limits to arbitrage: Understanding the low-volatility anomaly. *Financial Analysts Journal*, 67, 1–15.

Brock, W, J Lakonishok and B LeBaron (1992). Simple technical trading rules and the stochastic properties of stock returns. *Journal of Finance*, 47, 1731–1764.

Campbell, J and A Kyle (1993). Smart money, noise trading and stock price behavior. *Review of Economic Studies*, 60, 1–34.

De Bondt, W, G Muradoglu, H Shefrin and S Staikouras (2008). Behavioral finance: Quo vadis? *Journal of Applied Finance*, 19, 7–21.

DeLong, B, A Shleifer, L Summers and R Waldmann (1990). Positive feedback investment strategies and destabilizing rational speculation. *Journal of Finance*, 45, 379–395.

Engle, R and C Granger (1987). Co-integration and error correction: Representation, estimation, and testing. *Econometrica*, 55, 251–275.

Epstein, S (1994). Integration of the cognitive and the psychodynamic unconscious. *American Psychologist*, 49, 709–724.

Fama, G (2014). Two pillars of asset pricing. *American Economic Review*, 104, 1467–1485.

Finucane, M, A Alhakami, P Slovic and S Johnson (2000). The affect heuristic in judgments of risk and benefits. *Journal of Behavioral Decision Making*, 13, 1–17.

Fisher, I (1930). *Theory of Interest.* New York: MacMillan.

Froot, K, D Scharfstein and J Stein (1992). Herd on the street: Informational inefficiencies in a market with short-term speculation. *Journal of Finance*, 47, 1461–1484.

Gartley, H (1935). *Profits in the Stock Markets*. Washington: Lambert-Gann Publishing.

Gordon, M (1959). Dividends, earnings and stock prices. *Review of Economics and Statistics*, 41, 99–105.

Hirshleifer, D, (2015). Behavioral finance. *Annual Review of Financial Economics*, 7, 133–159.

Hirshleifer, D and SH Teoh (2003). Herd behavior and cascading in capital markets: A review and synthesis. *European Financial Management*, 9, 25–66.

Keynes, J (1921). *A Treatise of Probability.* London: McMillan.

LeRoy, S (1973). Risk aversion and the martingale property of stock prices. *International Economic Review*, 14, 436–446.

Markowitz, H (1952). Portfolio selection. *Journal of Finance*, 7, 77–91.

Samuelson, P (1973). Proof that properly discounted present values of assets vibrate randomly. *Bell Journal of Economics and Management*, 4, 369–374.

Santos, M and M Woodford (1997). Rational asset pricing bubbles. *Econometrica*, 65, 19–57.

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

Shefrin, H (2008). *A Behavioral Approach to Asset Pricing*. North Holland: Elsevier.

Shiller, R (1981). Do stock prices move too much to be justified by subsequent changes in dividends? *American Economic Review*, 71, 421–436.

Shiller, R (2003). From efficient markets theory to behavioral finance. *Journal of Economic Perspectives*, 17, 83–104.

Shiller, R (2014). Speculative asset prices. *American Economic Review*, 104, 1486–1517.

Shleifer, A and R Vishny (1997). The limits of arbitrage. *Journal of Finance*, 52, 35–55.

Slovic, P, M Finucane, E Peters and D MacGregor (2007). The affect heuristic. *European Journal of Operational Research*, 177, 1333–1352.

Subrahmanyam, A (2008). Behavioural finance: A review and synthesis. *European Financial Management*, 14, 12–29.

Framed Field Experiment with Stock Market Professionals

Jukka Ilomäki

University of Tampere

We study the behavior of the stock market professionals in the experimental settings. A novelty of the experimental design is the use of real financial market data and real private information. In this study, we compare two different subject pools: the forecasts of uninformed investors whose only information is past returns and the forecasts of informed investors whose information is reliable private information and past returns. We found that the affect heuristic in forecasts occurs as both informed and uninformed investors use large financial center past returns for forecasting small country stock returns. The results suggest that stock market professionals have behavioral bias, such as the illusion of validity in this experiment.

Keywords: Field experiment, Market professional, Forecasting behavior, Affect heuristic, Martingale

INTRODUCTION

The efficient market hypothesis (EMH) predicts that comovements in stock prices reflect comovements in fundamental values. Shleifer [2000] and Barberis, Shleifer, and Wurgler [2005] argue that comovements of fundamentally unrelated asset prices can be taken as evidence of the influence of investors' sentiment on asset prices. In real life asset markets, it may be difficult to separate certainly fundamental and sentiment-based information that moves stock markets. In addition, the private information of investors is unobservable. In the experimental settings, we can control the information flows that affect investors' decisions.

In this experimental study, we want to study the following: Can we find an evidence of sentiment and biases-based pricing in the experimental setting? In addition, what is the attitude of the average market professional to the Efficient Market Hypothesis?

In our experiment, we use actual data from the financial markets and real private information and place the stock market professional to a hedge fund manager role where she has to take a long or short position on the asset sequentially. We split the subjects randomly into two groups (informed and uninformed traders), and we are assume that the subjects are homogenous within the pool because all subjects are experienced stock market professionals. Thus, aggregated forecasts in the pools can be interpreted as average professional behavior. One subject pool receives consistently reliable private information and another pool is purely a noise trader where the only information comprises past returns from the financial markets.

The EMH predicts that the traders with only the past returns information should forecast the returns like a martingale model. The informed traders should use their reliable private information consistently and ignore past returns.

In other words, the EMH predicts that only fundamental information produces price changes. The forecasting behavior of the risk-neutral investor should reflect martingale property. It means that the aggregated forecasted return is just as likely to be positive or negative, and all linear forecasting rules for the next period based on the historical returns of indices should be useless. It implies that the past returns of any indices that are used in this experiment should not explain the changes in the forecasts. This is our null hypothesis for the forecasts of the uninformed pool as we examine the results of the experiment. Therefore, an alternative hypothesis is that past returns explain the forecasts of the uninformed group statistically significantly. That is a contradiction to the EMH.

The informed investor should use her reliable private information consistently. That is, she should make her forecasts

Address correspondence to Jukka Ilomäki, School of Management, FI-33014, University of Tampere 33100, Tampere, Finland. E-mail: jukka.ilomaki@uta.fi

according to economic theory and naturally ignore past price changes. It implies that any past indices that we use in the experiment should not explain statistically the forecasts of the informed investors, and the private information should explain the changes in the forecasts. This is our null hypothesis for the forecasts of informed investor pool. Thus, our alternative hypothesis is that the forecasts of the informed investor pool are explained by the past return. This is a contradiction to the EMH.

The forecasting problem of the subjects in the experiment can be considered as the dual-decision processing problem (Epstein [1994]). Finucane, Alhakami, Slovic, and Johnson [2000] argue that people use an affect as a heuristic in complex decisions. The affect heuristic refers to using the "faint whisper of emotion" in decision making (Slovic, Finucane, Peters, and MacGregor [2004]). This may imply that informed investors ignore their private signals because they have a behavioral bias, such as an illusion of validity (Kahneman and Tversky [1974]).

Another implication would be that market professionals do not believe that the stock markets are efficient. It is possible that they have noticed that the past returns may reveal something about the future returns because they believe that the majority of the investors believe that they do. Allen, Morris, and Shin [2006] argue that rational investors ignore their private information because they estimate what others are doing. In their model, a rational short-lived risk-averse investor acts in the one-asset economy such that it leads to a positive autocorrelation of the trading price changes.

We found that the uninformed investors use the U.S. returns to forecast the next return of the minor country. The informed investors use both the U.S. returns and their private information. In addition, they use the U.S. returns the most severely. This implies that informed investors do not use their private information consistently in this experiment. Thus, we can conclude that the stock market professionals do not think that the markets behave as martingale or they have behavioral biases. However, the subject of the forecasts (MSCI Holland, January 2004–December 2005) and all other MSCI indices samples used in this experiment are the random walks according to the tests. This fact suggests that the subjects have a behavioral bias in this experiment such as the illusion of validity, where the affect heuristic plays a major role.

The second section outlines related literature. The third section presents experimental design, the fourth presents the results and the fifth section concludes.

RELATED LITERATURE

Camerer and Weigelt [1991] investigate information mirages in laboratory asset markets. Anderson and Holt [1997] study whether information cascades occur in the laboratory experiments. Alevy, Haigh, and List [2007] investigate information cascades with financial market professionals. Their experiment design is close to Anderson and Holt. Drehmann, Oechssler, and Roider [2005] executed an Internet experiment to test herding behavior in financial market setting. In their experiment, the subjects have to decide sequentially in some exogenous order whether to invest in one of the two assets, A or B. Cipriani and Guarino [2005] studied herd behavior in a laboratory financial market. In their experiment, undergraduate students receive reliable private information on the fundamental value of an asset and trade it sequentially in some exogenous order with a market maker. Cipriani and Guarino [2009] re-executed their 2005 experiment with the financial market professionals.

Samuelson [1965] proposed that informationally efficient financial market price changes must be unforecastable if they are properly anticipated. He shows the link between capital market efficiency and martingales and introduced the term efficient market hypothesis (EMH). Stock prices follow martingale, if

$$E(X_{t+1}|\theta_t) = X_t, \tag{1}$$

where θ_t is an information set and X is a stock price. The martingale property implies only that the expected values of future price changes will be independent of the values of past price changes. It means that the next price change is just as likely to be positive or negative and all forecasting rules for the next period based on the historical returns of stock prices should be useless. Thus, it implies that the best forecast of tomorrow's price is today's price. In addition, the stock prices follow the random walk without the drift if

$$X_t = X_{t-1} + e_t, \tag{2}$$

where X is a stock price, and the error term e_t is independently and identically distributed with mean 0 and variance σ^2. This implies that the random walk is also a martingale.

Grossman and Stiglitz [1976] show that there are no gains to be made by looking at current and historical prices when uninformed investors have rational expectations. In addition, a rational informed investor cannot expect to have gains from trade when she takes account for other investors because she has to consider a possibility that other informed investors have the same private information. This insight goes back to Tirole [1982]. These theoretical results support the EMH.

Shefrin [2000] notes that behavioral finance is everywhere that people make financial decisions. He continues that heuristic driven biases and frame dependence may cause prices to stray from fundamental values. The main biases are overconfidence, excessive optimism, representativeness, conservatism, availability bias, recency bias, the illusion of validity, the ambiguity aversion, and the gambler's fallacy bias. The main phenomena due to frame dependence are loss aversion, mental accounting, hedonic editing, regret aversion, and myopic loss aversion. The two building blocks of behavioral finance are cognitive psychology (how people

think) and the limits of arbitrage (when markets will be inefficient).

The dual-decision processing (Epstein [1994]) means that people have two modes of thinking and information processing: an emotionally driven experiential system and rational analytical system. In this experiment, we can interpret that private information-basis thinking represents analytical system and past returns represents experiential system in the decision problem. Slovic, Finucane, Peters, and MacGregor [2007] argue that the affect heuristic has a major influence in the experiential system when people make decisions in the complex situations. The affect heuristic is a mental shortcut that people use automatically and often unconsciously. Slovic et al. [2007] note that people automatically consult their experiential affect pool where they search associations to the current problem. In this experiment, it means that the subjects may use U.S. past returns to forecast small country returns because it feels right, perhaps unconsciously. That is, their affect pool may have positive associations with the past returns and the forecasting performance. In addition, the informed subjects may feel that the private information does not always give the right signals.

Hong and Stein [1999] argue that the informed investors in their model obtain signals about future cash flows but ignore information in the history of prices and the uninformed investors use the history of prices. Daniel, Hirshleifer, and Subrahmanyam [1998] note that behavioral biases are increased when there is more uncertainty. Shiller [2000] argues that even rational investors may participate to herding behavior when they take into account the judgments of others even when they know that everyone else is behaving in a herd-like manner. He continues that herding behavior produces group behavior, which is irrational.

According to Akerlof and Shiller [2009], the main driving force for investors is stories. They argue that the story-based patterns of human thinking make it difficult for us to comprehend the role of pure randomness in our lives, since purely random outcomes do not fit into stories. Akerlof and Shiller note that if stories themselves move markets, then stories no longer only explain the facts. They are the facts, but these stories are not stable but vary over time. Thus, the investors have the illusion of validity. The illusion of validity means that people make predictions by selecting a particular outcome that is the most representative of the input (Kahneman and Tversky [1974]). Here the forecast that the story produces is the output and the input is the variables that the story utilizes.

Shleifer and Summers [1990] and De Long, Shleifer, Summers, and Waldman [1990] argue that the technical analysis is likely to affect prices. The technical analysis is trying to predict future price changes from past price changes. They note that in the presence of trend chasers, it might be rational for speculators to jump on the bandwagon. Allen, Morris, and Shin [2006] show that in a one-asset economy, where rational investors are risk averse, the equilibrium price of the asset may differ from their fundamental value under noisy expectations. In their model, this leads to a positive autocorrelation of the trading price changes.

EXPERIMENTAL DESIGN

Subjects

The following experiment belongs to the framed field experiment category and is executed with the stock market professionals from the Scandinavian financial institutions (19 participants). The subjects are experienced (at the minimum five years), professional traders (five participants), and investment bankers (14 participants) with a master's degree in economics or finance. There are 15 men and four women in the experiment group. In order to achieve a permission to run this experiment, we were forced to apply strict anonymity policy concerning the participants. Thus, we have only general information about the characteristics of the subjects.

Task

We split the subjects into two groups: informed and uninformed. In this experiment, we have 12 informed investors and seven uninformed investors.

There is a major investment country index, MSCI-USA, and minor investing country indices, MSCI-Ireland, MSCI-Denmark, MSCI-Austria, and MSCI-X, where all subjects are informed about the last return. Only the name of the country X (Holland) is not revealed.

In this experiment, 24 period sequential data are taken from monthly data between January 1970 and January 2009. We randomly chose the data from January 2004 to December 2005 and the exact period is not revealed to the subjects.

Subjects are told that their task is to *forecast next step ahead return* (one-month return) of their minor western European country index X. In other words, if a subject predicts negative return, she shorts the minor index X and if she predicts positive return, she buys the minor index X. Uninformed subjects' only information is the previous returns from the MSCI-USA index, Ireland index, Denmark index, and Austria index and from the minor country index X, which they can write down as the experiment goes on.

In the beginning, all subjects are told a return of the USA index, Ireland index, Denmark index, Austria index, and the minor country index X at period *zero*. Then after the subjects have made their predictions about the return their minor index X for the period *one*, they receive information about the realized returns of the indices at the period one the same procedure is repeated as the experiment goes on. Thus, every

subject recognizes his or her own forecasting accuracy after each period (24 periods).

Private Information

The *private information* for the informed investors is the following. We reveal the observed change of the spread between the minor country X (USA) 10-year government bond yield (the U.S. 10-year government bond yield) and three-month Euribor (the U.S. three-month Treasury bill) for the forecasting month. According to economic theory, expanding (narrowing) of the spread between long-term bond yield and short-term interest rate should happens at the same time as the falling (rising) of the stock prices in the ceteris paribus (see, e.g., Fama and French [1989]). In other words, we reveal the forward-looking information concerning the forecasted month that is approximately reliable private information. The fact that private information is actually to be realized information is not revealed to the subjects. We simply announce to the informed subjects that this is the forecasted (by the extreme reliable source) change of the spread.

Payoffs

There is going to be 24 time steps to predict the return. The subject will earn observed return if she correctly predicts the sign of the return and she will earn two times observed return if she correctly predicts the return (in whole numbers). The subject will lose realized return if she wrongly predicts the sign of the return. Communication between the subjects is prohibited, and the subjects are seated such that no subject could observe another individual's decision and payoffs during the experiment. Thus, the participant can not get any feedback on how or what other participants are doing during the experiment. Naturally, the subjects will notice their own performance as the experiment goes on. The methodology of the experiment can be found in the Appendix.

RESULTS

Theoretical Predictions

The EMH predicts that only fundamental information produces price changes. Thus, uniformed investor forecasting behavior should reflect martingale property relatively to all past prices.

In addition, the EMH predicts that an informed investor should use her reliable private information consistently. That is, she should make her forecasts according to economic theory and ignore all past price changes.

The expectations of other people's expectations theory (Allen, Morris, and Shin [2006]) predicts that there is a correlation between observed returns and subjects' forecasts because investors believe that other investors believe that technical analysis forecasts future returns. Thus, in our setting,

this theory predicts that informed subjects and uninformed subjects may behave the same way.

The behavioral finance theories predict that framing and different heuristic driven biases affect the forecasts of the subjects. Therefore, if the informed investors ignore their private signals they may have the illusion of validity. The dual-decision processing theory (Epstein [1994], Finucane et al. [2000], Slovic et al. [2007]) predicts that the affect heuristic influences human thinking in complex decisions. Hence, in this experiment, the informed subjects may have a feeling that private information will not always give right signals and using the past returns feels right. Akerlof and Shiller [2009] predict that popular story (some popular technical analysis) affects the forecasts of the informed traders as well as the forecasts of the uninformed traders. Hong and Stein [1999] predict that the informed traders use their private information consistently and ignore past returns but the uninformed traders use past returns.

The Experiment

We ran the experiment in the major Nordic financial institutions between October 19 and November 12, 2009, in four separate sessions. The participants are experienced stock market professionals (19 participants who are traders or investment bankers). The sessions started with the following written instructions given to all subjects:

Your task is to act as a fund manager for 24 months and take long or short positions to the MSCI country index X. That is 24 time steps. In other words, your investing subject is real MSCI (Morgan Stanley Capital International) country index X. MSCI index describes the developments of individual country stock prices where stock weights have been defined by Morgan Stanley. Your country X is a minor western European industrialized country. Twenty-four period sequential data is taken randomly from MSCI monthly data between January 1970 and January 2009. You will see last returns of MSCI-USA, MSCI-Ireland, MSCI-Denmark, MSCI-Austria, and MSCI-X and you can write down the returns as the experiment goes on. All subjects open a position every month for the index X by forecasting coming return in whole numbers. The position is closed at the end of the month when we observe the return. For example, if you forecast three percent negative return for the coming month you will write down your paper −3%. After all participants have made their forecasts for the month, the answering papers is collected and after that realized returns is revealed to all five indices for that month.

Payoffs: If you forecast return correctly, your payoff will be two times realized return. There are no short selling costs. For example, if you forecast −3% return for a coming period and a realized return is −3% your payoff would be +6 €. If you forecast correctly only a sign of the return, you earn the realized return. For example, if you forecast −1% return and the realized return is −3%, your payoff would be +3 €. If

TABLE 1
Descriptive Statistics of the Hit Ratios

	number of subjects	number of time steps	mean of the correct sign forecasts	minimum of the correct sign forecasts	maximum of the correct sign forecasts	variance of the correct sign forecasts	hit ratio
Informed investors	12	24	12.6	10	15	3.54	53%
Uninformed investors	7	24	10.1	6	12	4.48	42%

you forecast wrongly the sign of the return, you would lose realized return. For example, if you forecast +3% return and the realized return is −3%, your cumulative payoff account is deducted by −3 €. However, after the experiment nobody has to redeem her possible negative cumulative payoffs.

In addition, the informed investor pool got the following information.

Private information: You have *reliable private* information that expected change of the spread between your country (10 years) long-term bond yield and short-term (three-month) interest rate for the forecasting month is _____ and the expected change of the spread between U.S. government (10 years) long-term bond yield and short-term (three-month treasure bill) interest rate for the forecasting month is _____.

Analysis of the Results

According to the EMH the informed investor should use her reliable private information consistently. If informed market professional used her private information consistently in this experiment, her hit ratio would be 57% with the help of the spread change of Holland, or 65% with the help of the spread change of the USA index. The hit happens when the sign of forecasted price change is the same as the sign of the realized price change. Average hit ratio for the informed subjects is 53%, and average hit ratio for the uninformed subjects is 42%. Table 1 shows descriptive statistics from the hit ratio data.

We test whether the performance of the informed market professionals differs statistically from the performance of the uninformed market professionals. We use two-sample t-test for equal means (with unequal variances), because according to tests, the distributions of the number of the correct signs

forecasts of the participants in the pools come from normal distribution, according to the small sample-adjusted Jarque and Bera test. The p-value for the test is 0.014, where H_0 is that the means are the same and H_1 is that the average of the informed subjects (53%) > the average of the uninformed subjects (42%). Thus, we conclude that private information produces better performance in this experiment. That is it produces more correct sign forecasts. This result is consistent with the EMH.

We have two pools of investors, the informed pool and the uninformed pool. Now we calculate aggregate forecasts for the groups for every time step. That is 24 aggregated forecasts for both pools. Here we assume that the pools have rational investors with homogeneous information within the pools. Thus, we get two representative stock market professionals; informed and uninformed. According to the small-sample adjusted Jarque and Bera test and Ljung-Box test (Table 2), all MSCI returns, the forecasts of aggregated informed participants, and the forecasts of aggregated uninformed participants are normally distributed and there are no autocorrelations.

Average payoffs for the informed market professionals are +15.2 € and for the uninformed market professionals −0.1 €. Thus, we can conclude that private information used in this experiment produces better payoffs. This is consistent with the results from the performance test and with the EMH.

Analysis of aggregate informed (uninformed) trader with OLS

To analyze whether these groups use past returns to develop forecasts, we construct the OLS regression of subjects' aggregated forecast at the time t (24 observations) on the last revealed return USA, X, Denmark, Ireland, and Austria. In

TABLE 2
Descriptive Statistics of the Variables in the Regressions

	Min	Max	Mean	small sample Jarque & Bera test [p-value]	autocorrelation test Ljung-Box [p-value]
Forecasts of the aggregated informed investor	−1.0%	+2.8%	+0.8%	0.29 [0.87]	1.37 [0.71]
Forecasts of the aggregated uninformed investor	−1.3%	+5.1%	+1.5%	0.32 [0.85]	0.70 [0.87]
MSCI Holland returns	−6.1%	+6.4%	+0.8%	0.94 [0.62]	1.71 [0.63]
MSCI USA returns	−3.6%	+4.9%	+0.7%	0.70 [0.70]	1.22 [0.75]
MSCI Denmark returns	−5.3%	+7.4%	+1.9%	1.04 [0.59]	2.20 [0.53]
MSCI Ireland returns	−8.1%	+9.6%	+1.3%	0.72 [0.70]	3.07 [0.38]
MSCI Austria returns	−4.9%	+12.5%	+3.2%	0.18 [0.91]	0.66 [0.88]

TABLE 3
The Forecasts of the Informed Pool (the Uninformed Pool) as Dependent Variable

	R^2 informed	t-value informed (p-value)	R^2 uninformed	t-value uninformed (p-value)
USA as regressor	**0.44**	**4.17 (0.0004)**	**0.41**	**2.60 (0.016)**
Holland as regressor (X)	0.21	2.43 (0.023)	0.16	2.02 (0.056)
Denmark as regressor	0.23	2.56 (0.018)	0.15	1.94 (0.065)
Ireland as regressor	0.23	2.55 (0.018)	0.01	0.55 (0.590)
Austria as regressor	0.15	1.94 (0.066)	0.02	0.67 (0.512)

The OLS regressions are the following:
Aggregate informed investor forecast$_t = \beta_1 + \beta_2 *$ USA$_{t-1}$ + u$_t$.
Aggregate informed investor forecast$_t = \beta_1 + \beta_2 *$ Holland$_{t-1}$ + u$_t$.
Aggregate informed investor forecast$_t = \beta_1 + \beta_2 *$ Denmark$_{t-1}$ + u$_t$.
Aggregate informed investor forecast$_t = \beta_1 + \beta_2 *$ Ireland$_{t-1}$ + u$_t$.
Aggregate informed investor forecast$_t = \beta_1 + \beta_2 *$ Austria$_{t-1}$ + u$_t$.
Aggregate uninformed investor forecast$_t = \beta_1 + \beta_2 *$ USA$_{t-1}$ + u$_t$.
Aggregate uninformed investor forecast$_t = \beta_1 + \beta_2 *$ Holland$_{t-1}$ + u$_t$.
Aggregate uninformed investor forecast$_t = \beta_1 + \beta_2 *$ Denmark$_{t-1}$ + u$_t$.
Aggregate uninformed investor forecast$_t = \beta_1 + \beta_2 *$ Ireland$_{t-1}$ + u$_t$.
Aggregate uninformed investor forecast$_t = \beta_1 + \beta_2 *$ Austria$_{t-1}$ + u$_t$.

other words, we construct the following regressions:

$$\text{Aggregate informed investor forecast}_t$$
$$= \beta_1 + \beta_2 * \text{country returns}_{t-1} + u_t.$$
$$\text{Aggregate uninformed investor forecast}_t$$
$$= \beta_1 + \beta_2 * \text{country returns}_{t-1} + u_t.$$

Table 3 shows the t-values and the R^2 of the regressions. Diagnostic tests have performed in the following way. The autocorrelation test is done by (Breusch-Godfrey) LM-test. Heteroscedasticity is tested with White's test. The normality distribution of the residual is tested with a small sample-adjusted Jarque and Bera test. All regressions have well-behaved residuals, according to these diagnostic tests. Thus, we can interpret with confidence the regression results. Table 3 shows that the USA index has the most significant t-value and R^2 in both pools. The reason why the regressions, where the aggregate informed investor's forecasts are dependent variable, has statistically significant t-values also with Holland, Denmark, and Ireland is the fact that all indices are simultaneously correlated at the time t. The correlation between the USA index and the Holland index is 0.83; between USA index and Denmark index, 0.70; and between USA index and Ireland index, 0.73. However, the correlation between the first lag of USA index and Holland index at the time t is 0.05. Thus, there is no significant correlation with a lead-lag between USA index and Holland index.

Analysis of private information results with OLS

There might be a correlation between lagged USA-index and private information. To address this question we construct OLS regressions where private information (The term spread of Holland and the term spread of USA) is explained

by lagged USA index. Similarly, private information is explained by lagged Holland, lagged Ireland, lagged Denmark, and lagged Austria. Tables 4 and 5 show the results from these estimations.

Table 4 shows the results of the following OLS regressions:

$$\text{(Holland) Private information}_t$$
$$= \beta 1 + \beta_2 * \text{country returns}_{t-1} + u_t$$

According to the regression results, the term spread of Holland at the time t is not correlated with the first lag of country indices. According to diagnostic tests, all regression residuals are well behaved. This result implies that reported correlation between the first lag of USA index and forecasts with private information is not due to correlation between the first lag of USA index and private information (Holland).

TABLE 4
The Regression Results Where (The Term Spread of Holland) Private Information is Dependent Variable.

	t-value	R^2
1. lag of USA	−1.06	0.05
1. lag of Holland (X)	−0.22	0.00
1. lag of Denmark	−1.58	0.10
1. lag of Ireland	−0.35	0.01
1. lag of Austria	−0.19	0.00

The OLS regressions are the following:
(Holland) Private information$_t = \beta_1 + \beta_2 *$ USA$_{t-1}$ + u$_t$
(Holland) Private information$_t = \beta_1 + \beta_2 *$ Holland$_{t-1}$ + u$_t$
(Holland) Private information$_t = \beta_1 + \beta_2 *$ Denmark$_{t-1}$ + u$_t$
(Holland) Private information$_t = \beta_1 + \beta_2 *$ Ireland$_{t-1}$ + u$_t$
(Holland) Private information$_t = \beta_1 + \beta_2 *$ Austria$_{t-1}$ + u$_t$

TABLE 5
The Regression Results Where (The Term Spread of
USA) Private Information Is Dependent Variable

	t-value	R^2
1. lag of USA	−0.40	0.007
1. lag of Holland (X)	0.03	0.000
1. lag of Denmark	−1.07	0.049
1. lag of Ireland	0.38	0.007
1. lag of Austria	1.26	0.068

The OLS regressions are the following:
(USA) Private information$_t$ = β_1 + β_2* USA$_{t-1}$ + u$_t$
(USA) Private information$_t$ = β_1 + β_2* Holland$_{t-1}$ + u$_t$
(USA) Private information$_t$ = β_1 + β_2* Denmark$_{t-1}$ + u$_t$
(USA) Private information$_t$ = β_1 + β_2* Ireland$_{t-1}$ + u$_t$
(USA) Private information$_t$ = β_1 + β_2* Austria$_{t-1}$ + u$_t$

Table 5 shows the results of the following OLS regressions:

$$\text{(USA) Private information}_t$$
$$= \beta_1 + \beta_2{}^* \text{ country returns}_{t-1} + u_t$$

According to the regression results, the term spread of USA cannot explain the reported statistically significant correlation between the first lag of USA index and the forecasts with private information.

We have two kinds of private information, the change of the term spread of Holland and the change of the term spread of USA. To study whether the aggregate informed investor uses her private information, we construct the following OLS regressions (Table 6):

$$\text{Aggregate informed investor forecast}_t$$
$$= \beta_1 + \beta_2{}^* \text{ the change of the spread (Holland)}_t + u_t.$$

$$\text{Aggregate informed investor forecast}_t$$
$$= \beta_1 + \beta_2{}^* \text{ the change of the spread (USA)}_t + u_t.$$

According to the regressions results, aggregate informed market professional uses the change of the spread of Holland but not USA. According to diagnostic tests, all regression residuals are well behaved.

TABLE 6
Aggregate Informed Investor Forecast is Explained by
Private Information

	t-value (p-value)	R^2
Private information (Holland)	**−2.85 (0.009)**	**0.27**
Private information (USA)	−0.76 (0.456)	0.02

The OLS regressions are the following:
Aggregate informed investor forecast$_t$ = β_1 + β_2* the change of the spread (Holland)$_t$ + u$_t$.
Aggregate informed investor forecast$_t$ = β_1 + β_2* the change of the spread (USA)$_t$ + u$_t$.

TABLE 7
Regression Results Where The Forecasts of
Aggregate Informed Market Professional is Dependent
Variable

	t-value (p-value)	Partial R^2
1. lagged USA	**3.07 (0.0006)**	**0.44**
private information (the spread of Holland)	−2.98 (0.0126)	0.26

The OLS regression is the following:
Aggr. informed forecast$_t$ = β_1 + β_2* USA$_{t-1}$ + β_3* the change of the spread (Holland)$_t$ + u$_t$.

To study the proportion of explanatory power of private information (the change of the term spread of Holland) and the first lag of USA index in the forecasts, we construct OLS regression where aggregate informed market professional's forecasts are explained by the first lag of USA index and private information (Holland). Table 7 shows the results of this regression. According to diagnostic tests, regression residuals are well behaved.

In Table 7 we can see that the first lag of USA index explains better the forecasts of the private information pool than private information. This is a clear evidence of the affect heuristic in their forecasts. The strategy of the subjects, which is based on the large financial center (MSCI-USA) return guidance for the minor country (MSCI-Holland) next return, is the illusion of validity, because the minor country return is actually the random walk and the lagged USA return will not give any guidance for Holland return. However, MSCI-USA return and MSCI-Holland return are *simultaneously* correlated.

CONCLUSIONS

The results suggest that the stock market professionals do not expect the markets to be efficient if we define that efficient market prices follow martingale relatively to all past prices. However, the subject of the forecasts, MSCI-Holland and all other MSCI indices are actually random walks in our sample period according to the tests. This implies that the subjects have a behavioral bias in this experiment such as the illusion of validity.

We can conclude these interpretations because the subjects knew that the data used in the experiment are real minor western European MSCI monthly data. If the stock market professionals believed that the stock markets follow martingale or random walk, they would not try to take a hint for future returns from the USA returns.

The experiment is an example of the dual decision processing problem where the affect heuristic plays a major role. The subjects use the past returns, because it may feel right.

In this experiment, both subject pools, informed and uninformed use the USA returns to forecast the next return the most severely. This strategy is a contradiction to the Efficient Market Hypothesis. The USA returns explains 44% (41%) of

the forecasts of the aggregate informed (uninformed) market professional. In the spirit of Akerlof and Shiller [2009], we can interpret that the strategy, which is based on the large financial center (U.S.) return guidance for the minor country return, is a story that the market participants believe in this experiment.

ACKNOWLEDGMENTS

REFERENCES

Akerlof, George and Robert Shiller. *Animal Spirits*. New York: Princeton University Press, 2009.

Alevy, Jonathan, Michael Haigh and John List. "Information Cascades: Evidence From a Field Experiment with Financial Market Professionals." *Journal of Finance*, 112, (2007), pp. 151–180.

Allen, Franklin, Stephen Morris and Hyun Shin. "Beauty Contest and Iterated Expectations in Asset Markets." *Review of Financial Studies*, 19, (2006), pp. 719–752.

Anderson, Lisa and Charles Holt. "Information Cascades in the Laboratory." *American Economic Review*, 87, (1997), pp. 847–862.

Barberis, Nicholas, Andrei Shleifer and Jeffrey Wurgler. "Comovement." *Journal of Financial Economics*, 75, (2005), pp. 283–317.

Camerer, Colin and Keith Weigelt. "Information Mirages in Experimental Asset Markets." *Journal of Business*, 64, (1991), pp. 463–493.

Cipriani, Marco and Antonio Guarino. "Herd Behavior in a Laboratory Financial Market." *American Economic Review*, 95, (2005), pp. 1427–1433.

Cipriani, Marco and Antonio Guarino. "Herd Behavior in Financial Markets: An Experiment with Financial Market Professionals." *Journal of European Economic Association*, 7, (2009), pp. 206–233.

Daniel, Kent, David Hirshleifer and Avanidhar Subrahmanyam. "Investor Psychology and Security Market Under- and Overreaction." *Journal of Finance*, 53, (1998), pp. 1839–1885.

De Long, Bradford, Andrei Shleifer, Lawrence Summers and Robert Waldmann. "Positive Feedback Investment Strategies and Destabilizing Rational Speculation." *Journal of Finance*, 45, (1990), pp. 379–395.

Drehmann, Mathias, Jörg Oechssler and Andreas Roider. "Herding and Contrarian Behavior in Financial Market: An Internet Experiment." *American Economic Review*, 95, (2005), pp. 1403–1426.

Epstein, Seymour. "Integration of the Cognitive and the Psychodynamic Unconscious." *American Psychologist*, 49, (1994), pp. 709–724.

Fama, Eugene and Kenneth French. "Business Conditions and Expected Returns on Stocks and Bonds." *Journal of Financial Economics*, 25, (1989), pp. 23–47.

Finucane, Melissa, Ali Alhakami, Paul Slovic and Stephen Johnson. "The Affect Heuristic in Judgments of Risks and Benefits." *Journal of Behavioral Decision Making*, 13, (2000), pp. 1–17.

Grossman, Sanford and Joseph Stiglitz. "Information and Competitive Price Systems." *American Economic Association*, 66, (1976), pp. 246–253.

Hong, Harrison and Jeremy Stein. "A Unified Theory of Under Reaction, Momentum Trading and Overreaction in Asset Markets." *Journal of Finance*, 54, (1999), pp. 2143–2184.

Kahneman, Daniel and Amos Tversky. "Judgment Under Uncertainty: Heuristics and Biases." *Science*, 185, (1974), pp. 1124–1131.

Samuelson, Paul. "Proof That Properly Anticipated Prices Fluctuate Randomly." *Industrial Management Review*, 6, (1965), pp. 4–12.

Shefrin, Hersh. *Beyond Greed and Fear*. New York: Oxford University Press, 2000.

Shleifer, Andrei and Lawrence Summers. "The Noise Trader Approach to Finance." *Journal of Economic Perspectives*, 4, (1990), pp. 19–33.

Shiller, Robert. *Irrational Exuberance*. New York: Princeton University Press, 2000.

Shleifer, Andrei. *Inefficient Markets*. New York: Oxford University Press, 2000.

Slovic Paul, Melissa Finucane, Ellen Peters and Donald MacGregor. "Risk as Analysis and Risk as Feelings: Some Thoughts About Affect, Reason, Risk and Rationality." *Risk Analysis*, 24, (2004), pp. 1–12.

Slovic Paul, Melissa Finucane, Ellen Peters and Donald MacGregor. "The Affect Heuristic." *European Journal of Operational Research*, 177, (2007), pp. 1333–1352.

Tirole, Jean. "On The Possibility of Speculation Under Rational Expectations." *Econometrica*, 50, (1982), pp. 1163–1181.

APPENDIX: Methodology of the Experiment

1. The subjects are experienced stock market professionals.

2. There are two groups (informed and uninformed) and the subjects are chosen randomly.

3. The subjects are seated such that they make their decisions independently. The communication between the subjects is prohibited.

4. The task of the subject is the following: to forecast next month return for the minor western European country index X in the whole number accuracy with the available information.

5. There are 24 forecast to be made for every subject.

6. Twenty four period sequential data is taken randomly from MSCI index monthly data between January 1970 and January 2009. We chose the data from January 2004 to December 2005.

7. The country index X (MSCI-Holland) or the time period is not revealed to the subjects.

8. The subject has her 24 answers sheets and she write down independently her forecast after she has told to do so in every step.

9. The subject that has selected to be in the informed group gets her private information in the answering sheet.

10. The private information is reliable information and that is told to the subjects.

11. The common information (realized monthly returns from the MSCI-USA, MSCI-Holland, MSCI-Ireland, MSCI-Denmark, and MSCI-Austria) is revealed after the subjects have made their forecast for the month. This leads to the fact that every subject recognizes her own forecasting accuracy as the experiment goes on.

12. The subjects can write down the historical information as the experiment goes on.

13. The subject earns that realized return (1% = 1€) if the sign of the return is correct and she lose that return if the sign is incorrect. If the sign and the whole number are correct, the subject earns the return on double.