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Risk and Reward: A Neurofinance Perspective

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Extreme irrational behavior of financial markets makes us question the assumption about market rationality. This assumption is the basis of traditional finance. In this paper we are trying to look at the new paradigm for finance that uses new models for measurement of risk and reward, new models to determine the relationship between these variable, based on the mechanistic approaches of neuroscience. In this paper we talk about Neurofinance techniques and theories behind those techniques. With further research in this area we will be able to identify the factors which play a role in financial decision making. That can be used as learning devise for practitioners and will improve the predictability of investors' behavior and that will lead to lesser volatility in financial markets.

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1. Introduction

When dealing with finance, there is an underlying assumption that the markets are rational. Historically, however, it can be observed that the markets sometimes behave in what seems like an extremely irrational manner. This seeming irrationality prompts the question of what forces then govern the financial markets. Literature has tried to establish a few links between emotional responses by investors as the governing forces of financial and economic theories. Since emotional responses are hard to quantify, and the mechanistic approaches of emotions are not well understood, there seems to be a deficiency in understanding the processes of finance. A paradigm shift needs to take place that explains finance through the mechanistic approaches of cognitive science and neuroscience. This will lead to an increased accuracy in decision making models, as well as a facilitation of the overall understanding of finances and other similar fields.

In this paper we will try to look at a new paradigm for finance that uses new models for risk and reward based on the mechanistic approaches of neuroscience. In the process, we will talk about the techniques and theories behind this discipline of Neurofinance. It is our hope that such a paradigm might shed light on conflicting theories with regards to risk and return, allow for a better understanding of both concepts, and more broadly look at financial theories with fewer assumptions and more facts. Additionally, we seek to clarify financial applications that could come as a result of this shift in paradigm.

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2. Rationality of Investors

The importance of risk and reward models stems from the fact that risk and reward is the essential cornerstone to any financial transaction. Risk and return provide a platform in which the efficacy of an investment can be calculated. The differing models of how risk and return are calculated in the brain seem fairly contradictory. On the one hand, a set of theories exists that are significantly based on the assumption that people and investors are rational thinkers. Another set of theories, however, challenges that assumption and states that emotional behaviors influence decision making as well as risk preference.

The gap between the adherents of both theories is quite great. On the one hand, many financial personnel and financial economists are supporters of the Efficient Market Hypothesis. This hypothesis assumes that people are rational, and as such the determination of prices occurs through competitive trading by multiple investors. According to this theory, this trading would abolish constraints by some members of the investment community, thus allowing for the fair market price, and hence Lo and Repin (2002) concluded that the price as a value that cannot be predicted.

Causal observations give multiple examples of how the Efficient Market Hypothesis and other rational expectation models are flawed, and that there are confines to the cognitive abilities of human beings. DeBond and Thaler (1986), and Huberman and Regev (2001) concluded that on a macro level the failures of the markets, due to aggregate overreactions or herding, determine that the markets really are not that efficient. On the individual level, investors have specific biases that render them irrational. According to Gervais and Odean (2001), and Tversky and Kahneman (1981) these biases might include investor overconfidence, aversion of loss, miscalculation of probabilities, regret, and irrationalities that allows for inconsistencies in the Efficient Market Hypothesis. Lo and Repin (2002) state that these inconsistencies greatly question the validity of the Efficient Market Hypothesis, but even today no substitute theory has materialized. Recently, however, an established link has been made between rationality and emotional tendencies when making a decision. This helps create a new and more complex way of looking at how decisions are made, with both notions becoming intertwined and related, rather than adversative.

3. Quantifying Feelings

The irrationalities mentioned above are also clearly linked to feelings and emotions, something that has been difficult to quantify, or look at in the objective sense. Psychology has been used as a way of capturing these feelings in relation to financial and investment decisions, and that gave way to a new alternative for the orthodoxy of the rational markets: cognitive psychology that led to the discipline of behavioral finance. The problem with behavioral finance is that it still does not quantify emotions in direct measurements, nor does it look at the source of such emotions and feelings.

This has been a problem for financial and economic theorists historically. A catch-22 existed, which is researcher have been trying to use a variable to predict investor behavior, and that variable is not measureable. Camerer, Loewenstein, and Prelec (2005) mentioned that feelings could only be gauged from behavior, but they were also meant to predict such behaviors. This showed that feelings really could not be made part of the overall equation of decision making, because it could not be quantified. Neuroscience intertwined with finance to give rise to the interdisciplinary field of Neurofinance, however, has provided such a mechanism. Feelings and thoughts, that heretofore escaped our understanding, can now be calculated using various neuroscience techniques.

What these techniques allow for is the identification of regions in the brain that are highly active during decision making processes, and in this case with relation to decision making in finance. This adds a new dimension that revolutionizes the way finance can be studied. Deviations from rational choice can now be explained by scientific methods. Additionally, Camerer, Loewenstein, and Prelec (2005) mentioned that economic agents are pushed aside, and the focus becomes on why people behave or make decisions in the way that they do. These theories have provided novel constructs as a way of looking at orthodox financial theories.

4. Techniques

To really understand the ideas and the mechanics behind this amalgam of finance and neuroscience, the techniques that researchers use to conduct experiments need to be looked at. This will hopefully give the reader a superior understanding of how mechanistic this new paradigm might be in relation to the disciplines of finance, economics, and other related fields. An awareness of such methods would undoubtedly assist theorists in identifying better suited models of decision making in individual human beings, and that would subsequently help investors make better decisions.

The techniques used by Camerer, Loewenstein, and Prelec (2005) to study these theories are multiple, and they include, but are not limited to brain imaging, single neuron measurement, electrical brain simulation, psychopathology and brain damage in human beings, and psychophysical measurements. Each of these methods has advantages as well as disadvantages to the study of neuroscience in relation to finance, but all are methodological in their mechanistic approach. The most popular of these methods is the brain imaging technique which provides a picture of the regions of the brain when doing an experimental and a control task. The most widely used imaging techniques include electro-encephalogram (EEG), positron emission topography (PET), and functional magnetic resonance imaging (fMRI). EEG and fMRI are especially widespread in the research literature. EEG records neuron activity in the brain by looking at the electrical signals that electrodes measure on the scalp. The advantage of such a technique is that it is portable and relatively inexpensive with a very good temporal resolution. They state that the problem, however, is that the spatial resolution is still not very good. The fMRI on the other hand, is fairly disadvantageous in the practical sense, since it is not really portable, and it is much more expensive. On the other hand, the spatial resolution is significantly better than that of the EEG, whereas the temporal resolution is slightly weaker (Nilsson and Markowitsch, 1999; Smith, 2008; Camerer, Loewenstein, and Prelec; 2005). We can thus see that these two techniques can be used separately, or they can complement each other.

The two other essential techniques are psychopathology and brain damage in humans and psychophysical measurements. The first is a way of studying how people with damage in a certain localized brain region perform tasks differently than do people with no such damage (Widiger and Sankis, 2000). This can suggest what the function of the localized region is. Camerer, Loewenstein, and Prelec (2005) also suggest looking at essential psychophysical indicators like heart rate, blood pressure, pupil dilation and others. Pupil dilation is the effect on the pupil of the recipient of information, when information is provided to the individual. This delivers a cheap but effective proxy for studying how the brain functions.

These techniques display the mechanistic approach that these methods used. The showcasing of these approaches also invalidates the essential idea, widespread before the usage of these techniques, that there is a discrepancy between the importance of behaviors and emotions and there not being a way of measuring such values. These neuroscientific techniques are not just ways of looking at specific regions of the brain as the place for the processes. Understanding these methods and techniques, might give much more insight as to how the brain processes problems and then proceeds to solve them. This specialization by functionality also gives a better understanding as to what regions of the brain collaborate with each other, as well as what behaviors are grounded in the study of neuroscience.

5. Human Brain

Kahneman and Frederick (2002) state that the processes of the brain can be divided into two components: controlled and automatic processes. Controlled processes are those that use serial logic, and are deliberate. Automatic processes, on the other hand, happen without effort, unconsciously, and operate in a parallel manner. These processes can also be divided by where they happen in the brain. Controlled processes usually happen in the pre-frontal and orbital regions of the brain that include regions like the pre-frontal cortex as well as the forebrain. These regions of the brain were the last to develop and evolve in human beings, and are actually what distinguishes human beings from other animals (Goldman-Rakic P. S (1996). Automatic processes, on the other hand, usually happen in the occipital, parietal, and temporal parts of the brain. These include regions such as the nucleus accumbens, and the amygdala (Camerer, Loewenstein, and Prelec, 2005).

This model provides a distinct way to look at decision making. Decisions made by automatic processes tend to happen with no conscious effort, and at times, people do not quite understand why they made such decisions. Interestingly enough, this is what the brain does most of the time, and it is the default mode of the operations in the brain (Camerer, Loewenstein, and Prelec, 2005). Spara and Zak (2010) state that automatic processes are much more widely used than controlled processes, because of the constraints in resources. Only when an unexpected interruption occurs does the brain move on to the controlled processes, because the situation becomes new (Schneider and Chein, 2003). In traditional finance the investment is considered good investment if the returns are according to the risk associated with that investment. Hence, the processes of risk and return, measuring and the relationship between these variables, both are central to the study of finance, and can be looked at in this light. In fact, neurofinance, opened doors that were heretofore unknown, and provided new ways of looking at both risk and return.

6. Risk

Knutson, Fong, Bennett, Adams and Homer (2003) state that risk is processed in the evolutionarily new functional mesial prefrontal cortex which is activated in certain situations especially when certain stimuli such as pain are induced. In a sense, human beings can feel risk, and the brain system consequently feels an adverse reaction to these risks. Emotional responses play a very significant role in allowing for the management of risk, and these emotional responses are guided by experience. Experience is thus the mechanism by which these emotions are translated into intuitive signals. Lo and Repin (2002) concluded that traders in financial markets, for example, have an amplified sense of fear during the volatility of the markets as seen from physiological responses from traders. Experiences of these traders help provide memories that can map out strategies that they can use. These memories establish expected outcomes as related to similar inputs. Thus the weight of fear decreases, and traders can take risks (Sapra and Zak, 2010). However, when a certain situation that induces a significant amount of fear transpires, that would inversely mean that there is very little experience to rely on. In such a case traders would be very risk averse.

It is well documented in medical literature that different areas of brain are used for different functions. Just as importantly, it seems that there are distinctive areas in the brain that process risk. The midbrain region (the oldest region evolutionarily) relates to the wanting of rewards, the temporal region of the brain relates to the risks taken, and the prefrontal cortex (evolutionarily the most recent of the regions) assesses the utility function (Knutson and Peterson, 2005). Different types of risks and risk mistakes also occur in distinct areas of the brain. Research was conducted to look at the mistakes that traders seem to be making in their investment strategies. They found that these mistakes can be placed into two categories: risk seeking and risk aversion. Through an fMRI scan, it was shown that the nucleus accumbens is activated before risk seeking mistakes as well as before choices that were risky. Risk aversion mistakes as well as choices with little to no risk were preceded with the activation of the anterior insula. These different neural circuits with different expected outcomes lead to differing financial choices, and the disproportionate instigations of such circuits might induce errors in investments, given that these neural circuits are strengthened over time (Kuhnen and Knutson, 2005).

7. Reward

The anticipation of rewards highly influences human behavior, especially in general situations where scarcity is the norm. Anticipated rewards may take on multiple forms such as sexual actions and food (Sapra and Zak, 2010). Knutson and Bossaerts (2007) concluded that acquisition of money is similarly gratifying as reward. The midbrain region encodes for this gratification and allows for the appliance of effort and the taking of risks. It does that by making the venture of seeking rewards very enjoyable by means of allowing emotions that follow a rush pathway similar to that of sex or drugs.

There are two interesting aspects to the anticipatory rewards: the 'novelty of rewards' effect and the inhibition of seeking potentially new reward targets. The 'novelty of rewards' effect is the brain's gratifying response to new rewards. When the brain adapts itself to a specific reward system, the gratification starts to decrease. To maintain a similar high, the brain seeks to generate more reward, either by increasing the amount of activity that concludes with that reward or by seeking new choices (Sapra and Zak, 2010). In the financial sense this is fairly applicable. Financial investors who routinely perform trade deals worth several million dollars will start to use automatic processes when performing them. This happens because the brain does not see the benefit of using controlled process which would expend an increasing amount of energy. Thus, the "emotional valence to large trades is diminished" (Sapra and Zak, 2010). To counter this deterioration in emotional valence, investors would then seek to either increase the number of trades they perform, or invariably maintain a lookout for new choices that render new variables, and as such would allow the midbrain to once again experience acquiring rewards in the form of money.

Seeking potentially new reward targets is therefore something human beings are constantly doing. There is, however, an inhibitory mechanism for what reward targets are worth seeking and what are not. The pre-frontal cortex measures how much of an effect these rewards have, and adjusts behavior based on these rewards. It should be noted that the prefrontal cortex is the last to fully develop in human beings, and develops faster in females than males (Sapra and Zak, 2010). This renders younger males as riskier in collecting rewards than all other groups. This also highlights the fact that reward anticipation becomes more blurry due to variables such as age and gender as well as other circumstantial variables. For example, it has been shown that when the midbrain is fully active (the midbrain in this instance being the location that seeks rewards) it clouds the function of the pre-frontal cortex which determines the cost benefit analysis for the rewards sought. In a very famous recent study, pornographic images of females were shown to heterosexual males which roused their reward systems, and were then asked to choose between portfolios of safe bonds and risky stocks. The statistically significant result showed that these males overwhelmingly chose the risky portfolio when compared to other heterosexual men who did not view the pornographic images (Knutson, Wimmer, Kuhnen, and Winkielman, 2008).

Additionally, human beings are the only species able to postpone the satisfaction felt from rewards if a greater reward can be anticipated in the future. The prefrontal cortex allows for this with a substantial effort, which is why human beings do not always wait for anticipated rewards (McClure, Laibson, Loewenstein, and Cohen, 2004). The effort of postponing this satisfaction must also not be mired by other demands that tax the prefrontal cortex. When and if this miring does occur, individuals will seek to acquire immediate satisfaction rather than postponing it for later bigger rewards. In a financial setting this is seen with the volatility of the markets, which require a lot of attention from the prefrontal cortex in investors (Shiv and Fedorikhin, 1999). This toll on the prefrontal cortex would not allow it to perform the function of delaying gratification. As such, investors would then make decisions based on instantaneous contentment rather than on increased rewards and more money that might be incurred later on.

8. Applications

The applications of neuroscience in the discipline of finance are many, and neurofinance delivers ways of looking at the discipline of finance that were until this past decade nonexistent. This mechanistic approach through both the techniques used and the results found, relay the idea that the theories of finance can very closely affect the practices of finance. For example, once the distinct and separate regions for risk, reward, and utility are established, it is not difficult to see that multiple potential problems exist. The prefrontal cortex (the region for utility), might be disconnected from the risk and reward regions in the brain in chronic risk takers. This disconnect would consequently only increase, and excessive risk taking behavior would then also increase (Sapra and Zak, 2010). Investors such as Bernard Madoff and Nick Leeson are good examples of this concept. Analysts and financial personnel still wonder why they kept on taking risks after it seemed much more sensible to be more risk averse. Their risk taking practices might have come as a result of muting the intuitive signaling pathway that told them to avoid taking such risks (Sapra and Zak, 2010). Conversely, some investors do not take risks. It becomes harder for them to do take risks when the rewards are great, because there are not enough connections. This is a maladaptive practice which pushes investors towards the primitive instincts of fear, and financially cripples them.

Other applications also exist. In terms of reward highs, investors must not allow the pleasure of investments and subsequent rewards to make them take excessive risks or trade with more than they can to achieve that high (Sapra and Zak, 2010). Rather, a self-reflective approach is needed, whereby investors recognize whether they have become addicted to the rewards, and what steps are needed to be taken to achieve a more risk averse approach if that is the case. Additionally, since volatility taxes the prefrontal cortex, and that means that investors will in many cases forgo long term returns for short term gains, there needs to be ways to mitigate such effects. Not making a quick decision, stepping away from the investment portfolio, and coming back later allow the prefrontal cortex to make a better decision both through automatic and controlled processes.

9. Conclusion

The new paradigm of neurofinance is breaking new ground in achieving the ultimate goal of understanding what forces govern the markets. It also shows us how weak we are as individuals and groups, and that preferences, thoughts, and biases of the human brain are not as simple as some researchers have made them seem. At the same time, financial personnel and investors can infer ways of mitigating the negative effects that were uncovered through the discipline of neurofinance, and can teach themselves how to not only reverse these negative aspects, but also develop better financial analysis skills. Achieving this would help investors minimize loss, and would provide more stability to the markets. Finally, as neuroscience techniques become less expensive and more practical, the intersection of finance and neuroscience promises to bring even bigger developments to the field.

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