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BEHAVIORAL FINANCE AND POLICY FOR ENERGY INVESTMENTS



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Η Αγγελοπούλου Σωτηρία βεβαιώνω ότι το έργο που εκπονήθηκε και παρουσιάζεται στην υποβαλλόμενη διπλωματική εργασία είναι αποκλειστικά ατομικό δικό μου. Όποιες πληροφορίες και υλικό που περιέχονται έχουν αντληθεί από άλλες πηγές, έχουν καταλλήλως αναφερθεί στην παρούσα διπλωματική εργασία. Επιπλέον τελώ εν γνώσει ότι σε περίπτωση διαπίστωσης ότι δεν συντρέχουν όσα βεβαιώνονται από μέρους μου, μου αφαιρείται ανά πάσα στιγμή αμέσως ο τίτλος.

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INTRODUCTION

Traditional finance and economics operate under certain assumptions such as those of efficient markets and rational investors. The financial crisis of the last decade and the fear and panic it has caused in the markets all over the world, has drawn attention to the pivotal role of sentiment and behavior. Under these circumstances investors have not been acting that rationally. The complexity of financial markets, the relatively random factors that can influence the economy and human nature as well, lead investors to multiple errors, which in turn may lead to significant losses. Although the importance of psychology in economics was introduced early on by Smith (1759), McKay (1841) and Keynes (1936), the economic man was fully “developed”, in the late 90s, by Kahneman, Tversky, Thaler, Shefrin, Statman and many others. Behavioral finance can help trace market deviations caused mainly by the investor’s sentiment and biases and better comprehend the decision making process.

Overall, this paper aims at presenting the main principles of behavioral economics and finance and attempt their application to the constantly changing field of energy policy and investments. The first chapter tries to acquaint the readers with the fundamental concepts of traditional finance and how they are challenged by alternative approaches proposed by behavioral sciences. Transitioning from traditional to behavioral finance, requires a basic understanding of how people think and the way markets work (inefficiency). Principles like the Efficient Market Theory, Rational Investor, Expected Utility Theory and relevant fields are presented in order to demonstrate how these conventional notions actually fail to fully explain investment behavior. In the second chapter follows an exploration of the limitations of the human brain and how they affect the decision making process. Among other things, this paper tackles the most crucial cognitive and emotional biases that influence investment decisions made not only by portfolio managers and entrepreneurs but small investors as well.

An application of these concepts to energy and climate policy is attempted in order to gain a better understanding of patterns and habits and in turn identify the crucial factors that influence energy consumption, efficiency investments and Renewable

Energy investments. Climate and energy policy are completely intertwined with our planet's future and sustainability therefore actions concerning the security of energy supply and its affordability should not be overlooked. Investments need to be promoted and at times carefully subsidized along these lines. In this sense, energy efficiency measures and renewable technology seem only fitting. A short review and ex-post analysis of the Greek Renewables sector follows, mainly aiming to present how policy and certain factors (technology, size, and profit) affect investors, the level of penetration in electricity generation and the way Feed-In-Tariffs (FITs) created distortions to the market and lead to the collapse of the financial scheme that was created to support them.

The paper aims at providing evidence on the factors that affected the behavior of investors in Renewable Energy Resources (RES) in Greece. The penetration of RES has been rapid over the last years due to the attracting Feed-In-Tariffs. This has led in case of the photovoltaics on the overcoming of the expectations of the policy makers, as the 2020 sub-target was met in 2014. An econometric model is developed to quantify the effect of crucial parameters such as the Internal Rate of Return (IRR) of the investments and the evolution of the country risk over time. Those factors provide first insights on the behavior of energy investors.

CHAPTER 1

TRADITIONAL FINANCIAL THEORY

“Discovery commences with awareness of anomaly, -i.e., with the recognition that nature has somehow violated the paradigm-induced expectations that govern normal science.”

Thomas Kuhn

1.1 INTRODUCTION

Traditional finance’s main goal has been to describe the way financial markets work by using models in which agents behave rationally, meaning that these individuals will adjust their expectations upon receiving new information and will choose among alternatives, the one that maximizes their utility. The focal point of this chapter is to provide a fundamental analysis of basic financial concepts in order to ease the reader in the behavioral aspects of the following chapters. Despite the fact that plenty of studies challenge these traditional assumptions, it’s only necessary to explain them in order to comprehend not only the way markets work but investment decisions processes and behavior as well.

1.2 RATIONAL INVESTOR/ AGENT

According to Herbert A. Simon (1955), *“traditional economic theory postulates an “economic man”, who, in the course of being “economic” is also “rational”. This man is assumed to have knowledge of the relevant aspects of his environment which, if not absolutely complete, is at least impressively clear and voluminous. He is assumed also to have a well-organized and stable system of preferences, and a skill in computation that enables him to calculate, for the alternative courses of action that are available to him, which of these will permit him to reach the highest attainable point on his preference scale.”*

Thus, **Homo Economicus** or **economic man** is portrayed as consistently rational, estimating costs and benefits and by (optimally) pursuing self-interest, attempting to maximize profits, value or expected utility. Therefore, it is perceived that prudent investors can make rational choices. This has led to the formulation of the so-called **Rational Choice Theory** which, initially, assumes that an individual has preferences among alternative choices available and, consequently, makes some technical assumptions about individuals' preferences over alternatives:

- **Completeness** – the individual is able to compare and evaluate all possible alternative options and choose whether one of them is preferable or he is indifferent between them.
- **Transitivity** - if option A is preferred over option B and option B is preferred over option C, then A is preferred over C.
- **Continuity** - when there are three options A, B and C and the individual prefers A to B and B to C, then there should be a possible combination of A and C in which the individual is then indifferent between this mix and the lottery B.

Rational expectations theory assumes that this type of agent (as described above) takes into account all available information, when making predictions concerning the future valuation of financial products. These predictions are not systematically wrong, but if so, it is random. Almost every model of asset pricing uses the rational expectations equilibrium framework (REE), which assumes not only individual rationality but also *consistent beliefs* (Sargent, 1993). This means that investors not only evaluate all new information correctly but that they also have sufficient information in order to figure out the correct distribution for the variables of interest (Thaler, 2005).

Many are those who support that the economic man has only one defect. He doesn't really exist. (Alexakis & Xanthakis, 2008). Two excellent games to prove it are the "guess the number" game (Nagel, 1995) and the ultimatum game (Thaler, 2000), in which contestants didn't exactly prove to act rationally. Nobel Prize winner Simon Herbert was the first to suggest the different approach of **bounded rationality** (1955)

which postulates that important constraints arise from the limitations of the actor himself as an information processor. Such constraints are the incomplete information of the agent regarding alternative choices and limits to rationality like- risk, uncertainty, complexity or other environmental constraints- so great as to prevent the actor of calculating the best course of action.

1.3 EXPECTED UTILITY THEORY

One of the most important amongst the criteria which are used to classify choices under risk, is the evaluation of the appeal of a certain choice based on its **expected value** of returns. This method was very popular until 1783, when Nicolas Bernoulli introduced the idea of **expected utility** in order to explain the St. Petersburg Paradox¹. In this paradox, a game is considered that has an infinite expected value. The paradox was that people were not keen on paying a large sum to enter this game. This certainly leads to the logical conclusion that the expected value of the returns of an asset is unlikely to be the only criterion for an agent used to evaluate an investment. It was the expected utility that made individuals interested in the expected profits of an asset rather than its expected value². Bernoulli also introduced the concept of diminishing marginal utility of wealth, which means that utility increases as wealth grows, but in a diminishing rate.

The first axiomatic derivation of the expected utility theory was developed by John Von Neumann and Oskar Morgenstern in 1944 stating that the individual chooses between uncertain prospects by comparing their expected utility values, i.e., the

¹ In the St. Petersburg game people were asked how much they would pay for the following prospect: if tails came out of the first toss of a fair coin, to receive nothing and stop the game, and in the complementary case, to receive two guilders and stay in the game; if tails came out of the second toss of the coin, to receive nothing and stop the game, and in the complementary case, to receive four guilders and stay in the game; and so on ad infinitum. The expected monetary value of this prospect is $\sum_n (2^n \times 1/2^n) = \infty$

² Bernoulli mentions that when defining the value of an asset one shouldn't estimate its price but its value. There is no doubt that very large profits are more important to somebody poor rather than somebody rich, although they both win the same amount.

weighted sums obtained by adding the utility values of outcomes multiplied by their respective probabilities.

The analysis of expected utility theory assumes the following **axioms**³ :

1. **Completeness** - an individual has well defined preferences and can always decide between any two alternatives. This means that the individual either prefers A to B, or is indifferent between A and B, or prefers B to A.

For every A and B either $A \succeq B$ or $A \preceq B$

2. **Transitivity** - if option A is preferred over option B and option B is preferred over option C, then A is preferred over C.

For every A, B and C with $A \succeq B$ and $B \succeq C$ we must have $A \succeq C$

3. **Continuity** - when there are three options A, B and C and the individual prefers A to B and B to C, then there should be a possible combination of A and C in which the individual is then indifferent between this mix and the lottery B.

Let A, B and C be lotteries with $A \succeq B \succeq C$; then there exists a probability p such that B is equally good as $pA + (1 - p)C$.

4. **Independence** (or as frequently referred, **substitution**) - two gambles mixed with a third one maintain the same preference order as when the two are presented independently of the third one.

Let A, B, and C be three lotteries with $A \succeq B$, and let $t \in (0, 1]$; then

$$tA + (1 - t)C \succeq tB + (1 - t)C$$

5. **Dominance** – if one option is better than another in one state and at least as good in all other states, the dominant option should be chosen

³ Tversky & Kahneman (1986), Neumann & Morgenstern (1944), Alexakis & Xanthakis (2008)

6. **Invariance** – different representations of the same choice problem should yield the same preference. That is the preference between options should be independent of their description.
7. **Comparability** – means that the individual is able to determine his preferences.

It is obvious that the Von Neumann – Morgenstern expected utility axioms formalize a model of rational behavior. However, experiments have shown that people systematically violate some of them. The Allais paradox (1953) is one of the most renowned games doubting expected utility theory. The most famous structure is the following:

Table 1.1

Experiment 1			
Gamble A		Gamble A'	
Profit	Probability	Profit	Probability
\$1m	100%	\$1m	89%
		\$5m	10%
		\$0	1%

Experiment 2			
Gamble B		Gamble B'	
Profit	Probability	Profit	Probability
\$0	89%	\$0	90%
\$1m	11%	\$5m	10%

Individuals were asked to choose between the two gambles of the first experiment. After they made their decision they were presented with the second experiment and were again asked to choose between the two gambles. Most individuals chose A to A' and B' to B.

$$U(A) > U(A') \text{ so } u(\$1.000.000) > 0,89u(\$1.000.000) + 0,10u(\$5.000.000)$$

$$\Rightarrow 0,11u(\$1.000.000) > 0,10u(\$5.000.000)$$

and

$$U(B) < U(B') \text{ so } 0,11u(\$1.000.000) < 0,10u(\$5.000.000)$$

It is obvious that these results between the two experiments are inconsistent thus violating the independence axiom.

1.4 EFFICIENT MARKET HYPOTHESIS (EMH)

According to Eugene Fama (1965) the primary role of capital markets is the efficient allocation of resources. In an abbreviated version of his famous paper, which Fama wrote for the practitioner-oriented Financial Analysts Journal, he elaborated that *"An 'efficient' market is defined as a market where there are large numbers of rational, profit-maximizers, actively competing, with each trying to predict future market values of individual securities, and where important current information is almost freely available to all participants. In an efficient market, competition among the many intelligent participants leads to a situation where, at any point in time, actual prices of individual securities already reflect the effects of information based both on events that have already occurred and on events which, as of now, the market expects to take place in the future. In other words, in an efficient market at any point in time the actual price of a security will be a good estimate of its intrinsic value."*⁴ The basic assumptions that a market must meet in order to be efficient are the following:

⁴ Fama (1965b), page 56

1. Zero transaction costs
2. All investors have homogeneous expectations
3. All information is free and freely accessible
4. Price takers cannot influence market prices

Later on, in 1970, in his second landmark paper⁵, Fama introduced three levels of market efficiency in which the only difference is amount of information they incorporate:

1. **Weak form efficiency** – is achieved when the successive price changes are random and independent. Analyzing past prices cannot provide any useful information to investors, let alone a prediction for future prices. Returns on investment cannot exceed the market's return for a long period of time. In other words, investing strategies based on historical data do not work.
2. **Semi-strong form efficiency** – is achieved when prices can incorporate rapidly and completely all publicly available new information concerning financial data, such as annual reported earnings, dividends, share splits and others. Therefore, publicly known information is not useful and cannot achieve any profit as no excess returns can be earned by trading on that information.
3. **Strong form efficiency** - is achieved when prices reflect all available information, private or public, at any given time. Private information is usually created inside corporations and are held by people in strategic management positions or the board of directors. Consequently, no one can earn excess returns using such information.

All the above forms of efficiency are connected with each other and are not independent. If the market is efficient to one of the forms, then it is efficient to the lower forms of efficiency that precede it.

⁵ "Efficient capital markets: A review of theory and empirical work" for the Journal of Finance

1.4.1 RANDOM WALK

As mentioned above, no investor can earn excess returns over a long period of time. Price changes are unpredictable and random - ("random walk") - and no systematic and prolonged deviations from equilibrium prices exist. The efficient market hypothesis is tightly joined with the "random walk" hypothesis. According to this theory, the price changes cannot be predicted and if so the best prediction we could have for a price at any given time (let's say for today) is the price for the exact previous moment (yesterday). In other words, when the flow of information is uninterrupted and can be reflected directly in the prices, today's market prices will be affected by today's news and the change between yesterday and today will signify the information -or the news- which are unpredictable and unknown. Given the fact that news is, by definition, unpredictable, so should be the price changes. In order to check the validity of the efficient market hypothesis one should check for a linear association between the intertemporal returns of a series by estimating the following regression:

$$r_t = \alpha + \beta r_{t-1} + u_t$$

Where:

r_t , returns of the series' in the time periods t and t-1 respectively,

α , reaches expected return, which does not relate to past return,

β , factor which counts the relationship between past and current return,

u_t , stochastic term which reaches the volatility of returns not caused by past returns.

If β is statistically important, it is implied that past returns present a forecasting ability concerning future returns and can then reject the random walk hypothesis.

1.4.2 MARKET ANOMALIES

Over the years, numerous studies have identified market movements that could not be explained by the assumptions of the efficient market hypothesis. These inconsistent market movements are called market **anomalies** and could happen only once and vanish (or they could be recurrent). Tversky and Kahneman (1986) defined anomalies as “a deviation from the presently accepted paradigms that is too widespread to be ignored, too systematic to be dismissed as random error, and too fundamental to be accommodated by relaxing the normative system.” Anomalies could be broadly categorized as **calendar anomalies** and **non-calendar anomalies**. A more specific and concise categorization can be seen on the following table⁶:

Table 1.2

Time series	Cross-sectional	Other
January effect	Size effect	Closed-end fund discount
Day-of-the-week effect	Value effect	Earnings surprise
Weekend effect	Book-to-market ratios	Initial public offerings
Turn-of-the-month effect	P/E ratio effect	Distressed securities effect
Holiday effect	Value Line enigma	Stock splits
Time-of-day effect		Super Bowl
Momentum		
Overreaction		

1.4.2.1 Calendar anomalies

Anomalies that are related to a particular time period (week/month/year) are called calendar anomalies. Some of them are the following:

1. **The weekend effect** - describes the tendency of stock prices to be likely lower on Mondays, meaning that closing prices on Monday are lower than closing prices on the previous Friday. One interpretation to this anomaly was based on the NYSE clearing practices (Lakonishok & Levi, 1982) while another was based on the fact that bad news tend to be announced during the weekend in order to be smoothly absorbed by the market (French, 1980). The weekend

⁶ CFA Institute

effect was really intense during the 1970's, but as soon as investors caught on to this trend it was reversed.

2. **The turn of the month effect** – refers to the tendency of stock prices to likely increase in the last trading day of the month and the first three days of the next month. An explanation for this anomaly according to psychology is that it is highly likely that investors are trying to postpone their decisions until the beginning of each time period. For example, if they were in a position to buy something, it is more likely that they would wait for the first day of the month to do so. It is obvious that this behavior is inconsistent with the rational investor hypothesis in which the individual would buy as soon as the circumstances were favorable.

3. **The turn of the year effect** – describes a pattern of increased trading volume and higher stock prices in the last week of December and the first two weeks of January.

4. **The January effect** – describes the phenomenon when (small) company stocks outperform other asset classes and the market during the first two to three weeks of January. Occasionally, the turn of the year effect and the January effect are addressed as the same trend. Several explanations have been theorized for the January effect. One of them suggests that many investors unload poorly performing shares in order to realize capital losses and in turn reduce taxation burdens. Then, in January, they assume their previous positions in the market by repurchasing those stocks, thus driving up the prices. Another explanation for this phenomenon is a strategy used by mutual funds and portfolio managers, called window dressing. In order to improve the appearance of the portfolio's performance managers will sell risky stocks or with large losses near the end of the year and repurchase them once the New Year begins to rebalance the portfolio. A final explanation could be attributed to investor psychology. January, as the first month of the year symbolizes for many a new start and a beginning for the New Year's resolutions while for others the time to invest their year-end bonus.

1.4.2.2 Non calendar anomalies

1. **The size effect** – first documented by Rolf W. Banz (1981), suggests that smaller firms and consequently firms with smaller capitalization tend to outperform larger companies. An interpretation to this anomaly proposes that smaller companies have a much longer runway for growth than larger companies and thus a bigger force behind the performance of their stock. Others support that smaller firms are perceived as a riskier investment thus they should yield higher returns.
2. **The value effect** – refers to investors mistakenly overestimating the prospects of growth companies and underestimating value companies. Josef Lakonishok, Robert W. Vishny and Andrei Shleifer concluded that *“value strategies yield higher returns because these strategies exploit the mistakes of the typical investor and not because these strategies are fundamentally riskier”*.⁷ There are many criteria that fall under the value categorization. A commonly used technique is to divide an index into high price to book value (growth) stocks and **low price to book value** (value) stocks. Research has shown that stocks with below average price-to-book ratios tend to outperform the market. Although it seems plausible, it is unfortunately a relatively weak anomaly as low price-to-book stocks outperform as a group. Another criterion is the **price to earnings ratio (P/E)**. Basu (1977) proved that portfolios of low P/E ratio stocks can outperform the market and other portfolios with high P/E stocks.
3. **Closed end mutual funds anomaly** – refers to phenomenon documented by several studies where closed-end investment fund shares are being sold at average discounts of 4-10 percent from net asset value. Closed-end mutual funds have a certain amount of shares in their portfolio, while their own stock is being traded on the stock market. Theoretically, in an efficient market dominated by rational agents, their stock should be traded on the net asset

⁷ Josef Lakonishok, Robert W. Vishny and Andrei Shleifer “Contrarian investment, extrapolation and risk” working paper No. 4360, NBER, May 1993

value of their portfolio stocks with minor or random deviations. However, closed-end mutual fund stocks tend to be traded on a discount most of the time (Malkiel, 1977). According to McMillan *et al* “*an explanation for the discount is that tax liabilities are associated with unrealized capital gains and losses that exist prior to when the investor bought the shares, hence, the investor does not have complete control over the timing of the realization of gains and losses. Although the evidence supports this hypothesis to a certain extent, the tax effect is not large enough to explain the entire discount. It has often been argued that the discounts exist because of liquidity problems and errors in calculating net asset value. The illiquidity explanation is plausible if shares are recorded at the same price as more liquid, publicly traded stocks; some evidence supports this assertion. But as with tax reasons, liquidity issues explain only a portion of the discount effect.*”

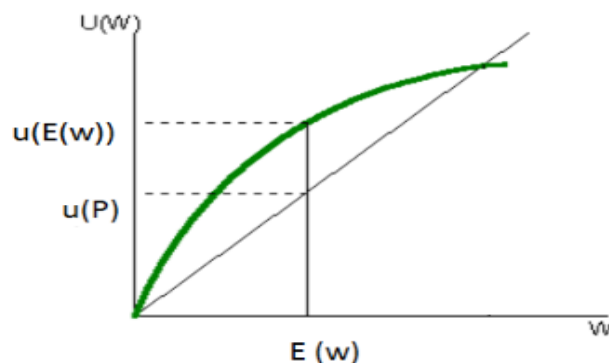
4. **The momentum anomaly** – is a well-documented phenomenon with evidence from around the world that suggests that securities which have experienced high returns in the short term usually continue to generate higher returns in the following period. However, researchers have argued whether this effect truly consist an anomaly to rationality and efficiency by claiming that it is possible to have shocks to the expected growth rates of cash flows and that these shocks induce a serial correlation that is rational and short-lived.
5. **The overreaction anomaly** – suggest that stock prices can either be inflated for companies releasing good news or depressed for those releasing bad news. This is caused by the investors’ tendency to overreact to the release of unexpected information (DeBondt & Thaler, 1985).

1.5 RISK AVERSION

It is a well-known fact that individuals tend avoid risk and in order to take on a risky investment they seek to be compensated. The risk of an investment stems from the uncertainty the individuals face when they try to calculate their expected returns. The uncertainty of whether or not the actual returns of an investment with risk are going to be less than those expected. The amount of risk an individual is ready to take on should be carefully defined before making any investment decisions. The maximum amount of risk that an investor is willing to accept for any given increase of his expected returns is called **risk tolerance**. In other words, risk tolerance is the trade-off between risk and the desirable expected returns. For example, when investors choose between two options offering the same expected returns they will prefer the one that incorporates less risk. On the other hand, when these options are equally risky, they will prefer the one offering bigger expected returns. A **risk averse** investor is willing to make a payment in order to avoid risk. This payment is called **certainty equivalent** and is defined as the wealth level that makes an individual indifferent between a perspective and a certain level of wealth. Depending on the investor's attitude towards risk, the utility function differs. In this case, the utility function is concave meaning that the utility of a certain wealth level is greater than the utility of a perspective. This type of investors usually stays away from high risk stocks and investments and generally stick to index funds and government bonds.

Diagram 1.1

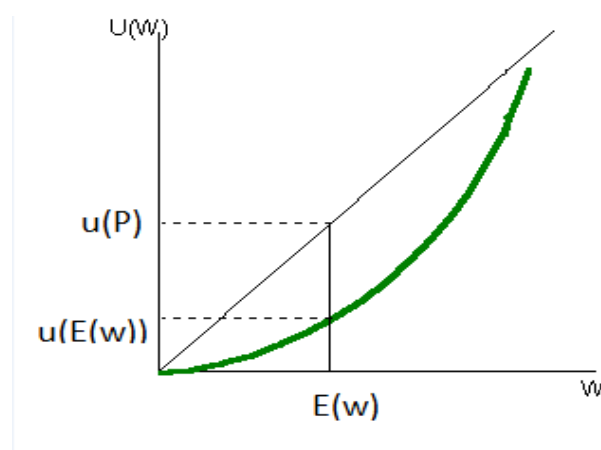
Risk Averse Investor



Although most investors tend to be risk averse, in some cases they are **risk seekers** or **risk loving**. They choose to behave in a way that favors riskier investments than playing it safe and settling for the certainty of the expected returns. They search for greater volatility and uncertainty in exchange for anticipated higher returns. For example, when a risk seeker is faced with a choice of 50€ for sure or a 50-50 gamble with payoffs of 0€ and 100€, he will choose the gamble while a risk averse type would prefer the certainty of the 50€ payment. This type of investors usually prefers small-cap stocks, international stocks and growth investments over value investments. In this case the utility function is convex as seen below:

Diagram 1.2

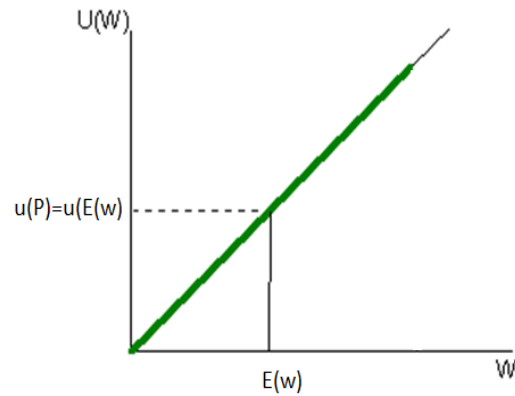
Risk Seeker or Risk Loving Investor



Finally, there is a type of investor who is actually indifferent between taking on a risk and a certain payoff. This type is also known as **risk neutral**. In other words, this investor makes decisions based solely on the expected returns and not the respective risk. In the case of the aforementioned example he would be indifferent between the expected payoff (50€) and the gamble as their expected returns are the same. The utility function is linear as the utility of the expected payoffs is equal to the expected utility of the payoff.

Diagram 1.3

Risk Neutral Investor



According to empirical research, there are certain factors that can influence the level of risk aversion between investors. Watson and McNaughton (2007) presented an in-depth review of these factors, presented below.

Several psychological studies have suggested that the investor's *gender* can play a pivotal role concerning the level of risk aversion. Byrnes, Miller and Schafer (1999) after reviewing 150 studies and examining the differences of risk taking between the two genders concluded that women on average would take on less risk compared to men. One study conducted by Weber, Blais and Betz (2002) demonstrated that women were more risk averse when it comes to financial risks, health and safety risks, recreational and ethical risks but not when it comes to social risk. Similarly, Hinz, McCarthy and Turner (1997), Sunden and Surette (1998) and Olsen and Cox (2001) found that increased risk aversion affects the investment choices of women. Riley and Chow (1992) found that they tend to allocate less of their portfolios to volatile assets. Both biological and socio-cultural explanations have been proposed by Felton, Gibson and Sanbonmatsu (2003) in order to explain these basic differences between men and women concerning risk aversion. Wilson and Daly (1985) propose that risk taking in males has evolved due to sexual selection, meaning that males are willing to take on risk in order to accumulated resources which in turn are going to help to attract mates. On the other hand, women, have developed a lower preference for risk caused by different evolutionary pressures such as the biological investment in any offspring

(LaBorde, 1994). Moreover, according to Zuckerman (1994) females tend to have higher levels of the enzyme monoamine oxidase, responsible for the reduced sensation of seeking. However, according to the socio-cultural approach, other researchers have argued that socialization may play a certain role in creating these differences when it comes to risk. These authors propose that pressures placed on children growing up in order to adopt appropriate sex roles can lead to greater caution and less confidence in women and men more prone to risk (Beyer & Bowden, 1997; Slovic, 1966; Deaux & Emswiler, 1974; Byrnes, 1998).

Other studies have gone a bit further, expanding the gender issue by introducing differences caused by the role of *marital status*. According to Daly and Wilson (2001), increased marital responsibilities proliferate risk aversion for investors. In particular, Sunden and Surette (1998) found that both for men and women, marriage increases risk aversion when it comes to decisions concerning future pension plans. Risk preferences also seem to differ depending on whether or not the individuals have children. In other words, married couples with children are more risk averse than individuals without any offspring. Furthermore, Arano *et. al.* (2010) suggests that, in married couples, wives are more risk averse than their husbands. On the other hand, a man with a wife who can take on risk, is more prone to risk than a man with a risk averse wife although the same doesn't apply for a woman and her husband. On the contrary, Save-Soderbergh (2003) argues that marriage usually reinforces risk taking as the family income is higher than the individual one, thus allowing riskier investments. Another important finding by Jianakoplos and Bernasek (1998) suggests that children can both increase risk tolerance in a family as well as decrease it for a single mother.

Besides gender and marital status, *age* can also play an important role in explaining risk taking behavior. Jaggia and Thosar (2000) propose that the level of risk taking decreases as the age of an individual goes up. De Bondt's (1998) rule of thumb suggests that the percentage of (risky) stocks in a portfolio should be equal to 100% minus the investors' age. Moreover, according to Halek and Eisenhauer (2001) elderly individuals are more likely to be risk averse than younger ones. Although risk aversion can increase with respect to age, it can also decrease. Specifically, older individuals

were found to be, on average, more risk tolerant than younger ones in relation to financial issues (Grable, 2000). Similar findings were also proposed by Wang and Hanna (1997) and Bellante and Green (2004). Despite the fact that discrepancies may appear between existing research on the subject, point is that age has an impact on risk preferences.

Another factor which may influence risk attitude is the *income or wealth* of an individual. Individuals appear to be more risk inclined at higher levels of wealth and income as it can make it considerably easier to deal with possible losses. Benzion and Yagil (2003) and Jianakoplos and Bernasek (1998) found that higher levels of wealth can lead to lower levels of risk aversion. Also Tanaka *et. al* (2010) suggested that a higher income can make people more risk tolerant. Not only is income important but tenure can also decrease risk aversion (Agnew *et al.*, 2003). Respectively, according to Bajjelsmit and Vanderhei (1997) and Hinz *et al.* (1997), individuals with lower incomes tend to be more risk averse.

Other approaches to help explain a persons' behavior towards risk are *education* and *past experiences*. An investor who has already suffered considerable losses during periods of financial crises is more likely to prefer conservative strategies by taking on minimal financial risk. On the other hand, if an investor in the past, has invested in risky securities with returns higher than those of conservative/defensive choices, he would probably choose to invest again in the same way in the future. As far as education is concerned, Riley and Chow (1992) suggest that individuals with a low level of education are more risk averse and that they also tend to take into account their income. According to Olsen and Cox (2001), education and experiences can reduce but not eliminate completely the influence of gender factors when it comes to risk aversion.

Risk preferences can also be influenced by factors such as *nationality, ethnicity* and *religion*. Statman (2008) suggests that individuals can be greatly influenced by their culture. Especially, people coming from different countries will have different perceptions, expectations and emotions. In order to test this assumption he performed an experiment with participants from 22 countries, checking their tendency to take on risk and concluded that people coming from poor countries

(China, Vietnam) were willing to take on more risk, so that they could ameliorate their lives. Race could also make a difference regarding risk tolerance. Sung and Hanna (1996) suggest that Blacks and Hispanics in the U.S. are more risk averse than Whites. However, Weber and Hsee (1998) claim that this effect only comes from the fact that people from different cultures perceive risk differently. As mentioned above religion can also have an effect on risk tolerance. For example, religious people are more risk averse than non-religious and atheists.

In summary, gender, marital status, age, income, wealth, education, past experiences and factors such as nationality, ethnicity and religion have been found, among others, to influence an investor's risk tolerance and should be taken into account in order to understand and explain the choices and behavior of an investor.

CHAPTER 2

Heuristics and Behavioral Biases

*People in standard finance are rational.
People in behavioral finance are normal.*

—Meir Statman, Ph.D., Santa Clara University

2.1 INTRODUCTION

This chapter focus on the transition from traditional economics and finance to behavioral, hence we could say it is a transition from rationality to psychology. The main point of this analysis is mainly the differences between traditional and behavioral economics and finance, the limitations of the human brain and how they affect the decision making process. Among other things, this chapter tackles the most crucial cognitive and emotional biases that influence investment decisions made not only by portfolio managers and entrepreneurs but small investors as well.

2.2 PROSPECT THEORY

Shortly after the appearance of the Expected Utility Theory by Von Neumann-Morgenstern (1944), came the first objections concerning its adequacy as a descriptive model of decision making analysis (Allais, 1953). The first significant alternative approach concerning human behavior under risk was **Prospect Theory**, proposed by Kahneman and Tversky in their article “*Prospect Theory: An Analysis of Decision Making under Risk*” in 1979. Such was the impact of this theory, that Daniel Kahneman was awarded the Nobel Memorial Prize in Economics, in 2002. After conducting a series of experiments in various locations they concluded that, even when the choice problems were framed differently or involved different prizes the results followed the same pattern. The results showed that preferences consistently violated the axioms of the Expected Utility Theory and, specifically, the substitution

axiom. The writers labeled such a tendency as the **certainty effect**, meaning that individuals overweight outcomes that are considered certain, relative to outcomes which are merely probable. But they also concluded, that in a situation where winning is possible, but not probable (i.e. has very low possibilities), individuals choose the prospect that offers the larger gain, violating yet again the substitution axiom.

The writers were quite ingenious to furthermore uncover the **reflection effect** which occurred not only when the choice problems involved possible gains, but possible losses as well. When a negative prospect was presented, people's preferences would be more often than not a mirror image of their preferences over positive prospects. In other words, while individuals are risk-averse over prospects involving gains they become risk-loving when it comes to negative prospects.

Another finding was that individuals frequently dismiss factors which are shared by alternative choices and focus on those that differ, so as to simplify the choice they have to make. This phenomenon is referred to as the **isolation effect** and brings to light the fact that inconsistent preferences may emerge, in the sense that prospects can be decomposed in different ways, thus leading to different results. Given the axiomatic violations of the Expected Utility Theory and the effects described above, prospect theory was developed as an alternative model to decision-making under risk.

According to the authors *"the theory is developed for simple prospects with monetary outcomes and stated probabilities, but it can also be extended to more involved choices. Prospect theory distinguishes two phases in the choice process: an early phase of **editing** and a subsequent phase of **evaluation**"*. Editing describes the preliminary analysis of the offered prospects and involves the following major operations:

1. **Coding:** individuals usually perceive outcomes as gains and losses instead of a final state of wealth. It goes without saying that gains and losses are defined as relative to some reference point. Nevertheless, the location of the reference point and thus the consequent coding of outcomes as gains or losses, can be altered depending on the formulation of the offered prospects and by the expectations of the individual.

2. **Combination:** prospects are usually simplified by combining the probabilities associated with identical outcomes. For example, the prospect (200, 0.25; 200, 0.25) will be reduced to (200, 0.5).
3. **Segregation:** certain prospects contain a riskless component that gets separated from the risky component. For example, the prospect (300, 0.8; 200, 0.2) is decomposed into a sure gain of 200 and the risky prospect (100, 0.8)
4. **Cancellation:** one form of cancellation is the isolation effect described above. It can also be presented by discarding common outcome and probability pairs between choices. For example, the pairs (200, 0.2; 100, 0.5; 20, 0.3) and (200, 0.2; 300, 0.4; -50, 0.4) are reduced to (100, 0.5; 20, 0.3) and (300, 0.4; -50, 0.4).
5. **Simplification:** prospects are likely to be simplified by rounding probabilities or outcomes and discarding extremely unlikely outcomes. For example, the prospect (101, 0.49) is likely to be recorded as an even chance to win 100.
6. **Detection of Dominance:** offered prospects are scanned in order to detect dominated alternatives, which will be rejected.

Following the editing phase, the individual should be able to evaluate all of the edited prospects and choose the one with the highest value. An important part of Prospect Theory is that the carriers of value are *changes* in wealth or welfare, rather than final states. It is much simpler for a person to apprehend change by using reference points rather than an absolute value. For instance, when dealing with temperatures a reference point is needed in order to understand any changes. An object, at a given temperature, can be perceived either as hot or cold in reference to its usual temperature. The same thing occurs with wealth or prestige. The same level of wealth may imply severe poverty for one and great riches for another. The emphasis placed on changes should not lead us to the conclusion that a change is independent from its initial state. On the contrary, value should be perceived as a function of the asset position that serves as reference point and the magnitude of the change, positive or negative.

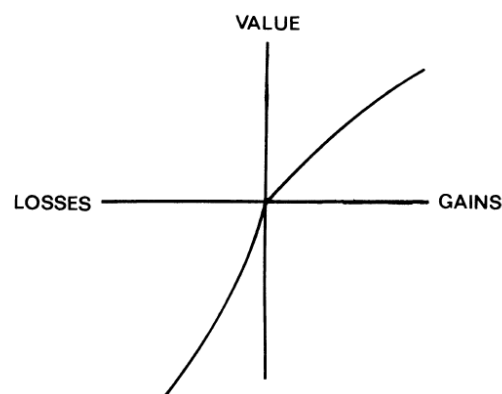
The way many people understand changes in several notions is described by a concave function of the magnitude of physical change. For example, it is easier to tell between a change of 3°C and a change of 6°C, than it is to tell between a change of 13°C and a

change of 16°C. This principle also applies to the evaluation of monetary changes. Thus, the difference in value between a gain of €100 and a gain of €200 appears to be greater than a gain of €1.100 and a gain of €1.200. In the same sense, the difference between a loss of €100 and a loss of €200 seems greater than a loss of €1.100 and a loss of €1.200. It should also be noted that the level of annoyance an individual experience in losing a sum of money appears to more severe than the level of joy associated with gaining the same amount.

In summary the authors have proposed an S-shaped value function that is:

1. defined on deviations from the reference point
2. generally concave for gains and commonly convex for losses, meaning that individuals tend to be risk averse when it comes to gains and risk loving when it comes to losses
3. steeper for losses than for gains.

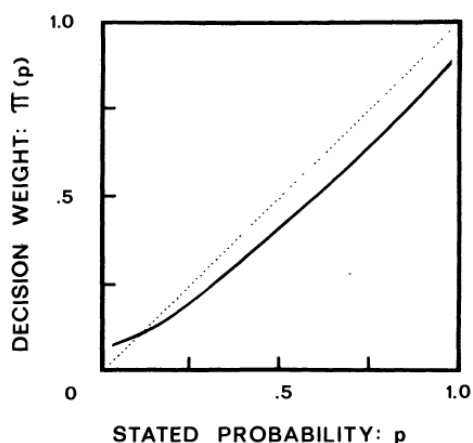
Diagram 2.1 – A hypothetical value Function



According to Prospect Theory, the value of each outcome is multiplied by a decision weight, which is not a probability, but a measure of the impact of events in the desire for certain outcomes. A decision weight isn't the simple estimated probability of the realization of a certain prospect, without excluding though such a possibility. According to empirical findings by Kahneman and Tversky, individuals attach reduced weight to merely probable outcomes than certain ones (certainty effect). Decision weights are usually lower than their respective probabilities of appearance, with the exception of extreme low probabilities. So it appears that more weight is given to

prospects with a low probability to happen than prospects with a medium or high probability to happen. For instance, people still spend money on lotteries believing they could win, even though the probability of such a prospect is very low.

Diagram 2.2 – A Hypothetical Weighting Function



Years later, Tversky and Kahneman (1992) developed an updated form of Prospect Theory, named "**Cumulative Prospect Theory**". This version employs cumulative, rather than separable, decision weights and expands the original theory in several respects. It applies to uncertain, as well as risky, prospects with any number of outcomes and allows different weighting functions for gains and losses as well. The theory suggests a fourfold pattern concerning risk attitudes, which involves risk aversion for gains and risk seeking for losses of high probability, and risk seeking for gains and risk aversion for losses of low probability.

2.3 THE THREE THEMES OF BEHAVIORAL FINANCE

According to Hersh Shefrin (2000), in his book, “Beyond Greed and Fear”, there are a few psychological phenomena that spread throughout the entire field of finance.

These phenomena are organized into three themes:

1. Behavioral finance, contrary to traditional finance, suggests that individuals commit errors because they rely on rules of thumb. Given the limited amount of time, memory and processing abilities, the human brain has evolved, through natural selection, and uses simple rules (rules of thumb) in order to solve problems, called **heuristics**. The definition of heuristics refers to the process by which individuals learn how to do things on their own through trial and error. This process usually leads people to develop these rules of thumb although this doesn't necessarily mean that the right outcomes will follow (Shefrin, 2000). Despite the fact that heuristics facilitate calculations and reduce the amount of time necessary to come to a result, they do not always lead to the right or most efficient solution. For instance, it has been said “past performance is the best predictor of future performance, so invest in a mutual fund having the best five-year record”. Of course this rule of thumb has been proven wrong one too many times. Another popular example, used by most researchers, is the following optical illusion, in which the subjects are asked to decide which of the lines is longer.

Diagram 2.3

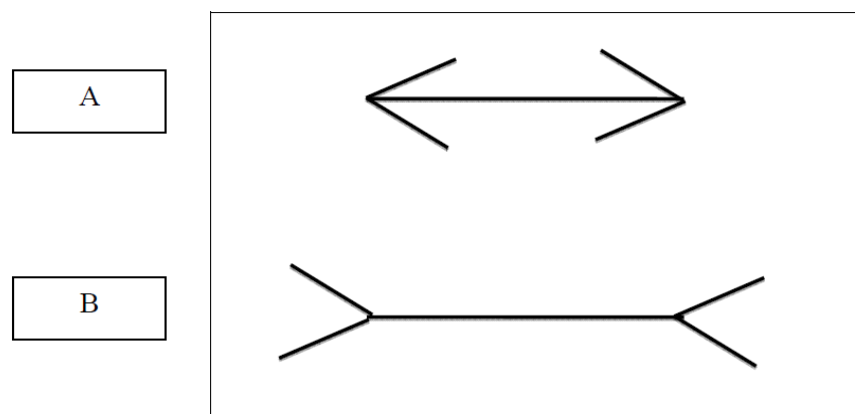
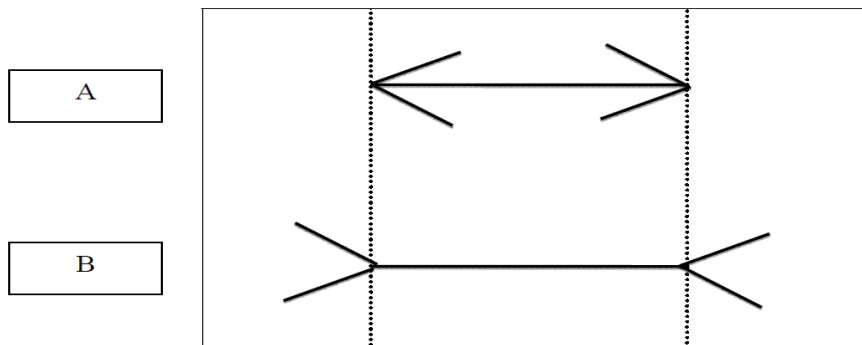


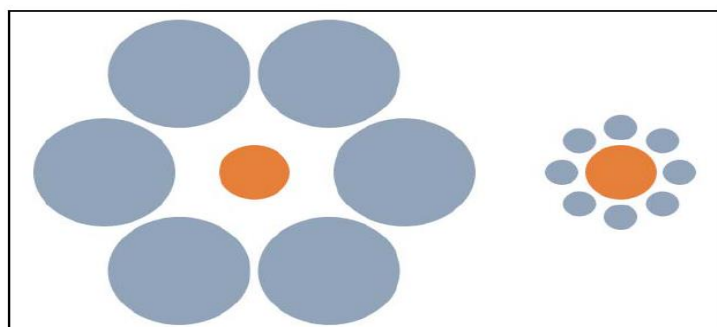
Diagram 2.4



Although both lines have been designed to have the exact same length (as seen in diagram 2.4), most reply that line B appears to be longer. The optical illusion is created by the arrows drawn on each end of the line. In line B, the backwards arrows, create a sense of depth and make the line appear longer than it actually is. This happens as the human brain tries to process three-dimensional images by using a certain rule, which leads (the brain) to the understanding that anything distant is bigger than it appears to be and anything close by is smaller than it seems. So for line A, the brain is tricked into believing that is closer, therefore smaller, and the exact opposite for line B. But one should always keep in mind that although we can study, acknowledge or even understand the miscalculations caused by heuristics, it is extremely difficult to overcome these behavioral patterns.

Another typical example of an optical illusion is the following one by Ebbinghaus.

Diagram 2.5



The two circles in the middle are the exact same size, but the way that they have been placed creates the illusion that the circle in the right shape is bigger. The size and distance of the surrounding circles plays a crucial part in the way one perceives the orange circles in the middle.

Eyesight is a very complex function for the human brain. Our eyes receive a plethora of information every single second that have to be processed very quickly into the image we finally see. It's only logical that mental shortcuts would be developed in order to minimize processing time and these shortcuts actually work well most of the time, until they are used for information that are suitable for and, in this case, lead to optical illusions.

Another example of how people use heuristics is their tendency to develop patterns. In a simple experiment of a coin toss subjects were asked to answer the following question:

“Which one of the following three sets of results seems more typical?”

HHHHTTTTHHHTTTHHTT HHHHHHTTTTTTTT HHTHTTHTHHTHTHTTT

Most replied the third as it seems heuristically more random. In reality though all three sets have the same probability of appearance since the possibilities for heads and tails are independent. Same thing tends to happen with analysts in the stock market. When they try to make predictions for the movement of the stocks according to past performances they tend to develop patterns that may actually not exist (Alexakis & Xanthakis, 2008).

According to Hirshleifer (2001), there are also other errors stemming indirectly from cognitive restrictions. Trivers' Self-deception Theory (1985, 1991) suggests that natural selection didn't shape the human brain to only make correct decisions and as a result individuals are led to believe that they are actually better (or smarter, or stronger) than they really are so that they can persuade everyone else for their abilities. It also seems that emotional loss of control, such as love or anger, functions as mechanism that enables people to connect to one another and protect themselves from possible enemies respectively (Hirshleifer, 1987; Frank, 1988; Nesse, 2001). Heuristic

simplification and self-deception, as well as emotional loss of control, can alone explain the majority of errors occurring during the decision making process (Hirshleifer, 2001).

2. Shefrin (2000) suggests that in behavioral finance, individuals' perceptions of risk and return are highly influenced by how decision problems are framed. So the second theme refers to the form or description of a decision problem, called **framing**. On the contrary, traditional finance assumes *frame independence*, meaning that individuals make decisions only by weighting risk and return. As seen above, Kahneman and Tversky in their article on Prospect Theory provide evidence of frame dependence. People that tend to exhibit frame dependence can do it both for emotional and cognitive reasons. The emotional aspects concern the way individuals feel as they register information and cognitive aspects deal with the way individuals organize that information.
3. Heuristic-driven bias and framing effects influence market prices as they cause deviations from fundamental values, thus challenging the efficient markets hypothesis proposed by traditional finance. Therefore, the third theme refers to **inefficient markets**.

Except these three themes, there are also two more distinct differences between traditional finance (and neoclassical economics) and behavioral finance and economics:

➤ **Time-Varying Discount Rates**

Intertemporal choices involve decisions concerning future consequences and payoffs and their trade-off against immediate consumption. Time-discounting refers to the subjective way of valuing outcomes as a function of their time delay, so that immediate results are highly valued compared to those which are delayed. In other words, agents use a higher discount rate over a longer period of time. According to behavioral economics and finance this can be perceived as an anomaly and hyperbolic discounting is proposed instead. This type of discounting postulates low discount rates for long horizons but higher rates for short periods

of time. This suggests that when all outcomes are realized in the future, individuals will be more levelheaded and prudent than the case of having immediate outcomes. Agents with time-varying discount rates could display a change of preference in the future. For example, someone may prefer \$110 in 31 days over \$100 in 30 days but also choose \$100 now over \$110 tomorrow (Frederick et al, 2004). It is evident that, exponential discounting is not applicable to this particular example as time preferences should not reverse since the 30-day delay is common between the above options. Time-inconsistent preferences and time-varying discounting rates could explain the inability to lose weight, stop smoking, save enough for retirement (Wilkinson, 2007) and the tendency to procrastinate. For instance, given a choice between carrying out five hours of a tedious task today and five and a half hours of the same task tomorrow, most choose the second option and therefore delay the task. However, when given a choice of five hours of the unpleasant task in a month and five and a half hours in a month and a day, individuals tend to choose the first option. Nonetheless, for those that decide to do the task in a month, when that day comes, they would again prefer to delay it until the next day (O'Donoghue and Rabin, 2000). Sometimes, as it has been shown empirically, when individuals become aware of their tendency to procrastinate they try to find devices that will "force" them to commit. Such a device would be for example a savings account that restricts when funds can be withdrawn (illiquid asset) or paying in advance for a yearly gym membership.

➤ **Pro-Social Behavior and Fairness**

Neoclassical theories assume that agents are purely selfish, only caring about their own consumption of public goods and will often demonstrate a tendency to free ride. Also, public goods will be insufficiently provided unless measures are taken, usually in the form of taxation. It has been suggested as well that people make choices counting entirely on their own monetary payoffs and consumption. Additionally, it is predicted that only very wealthy individuals will make donations and as global population grows those contributions should reach zero. However, behavioral economics and finance challenge those assumptions, since empirical studies and experimental games have shown that individuals can value fairness

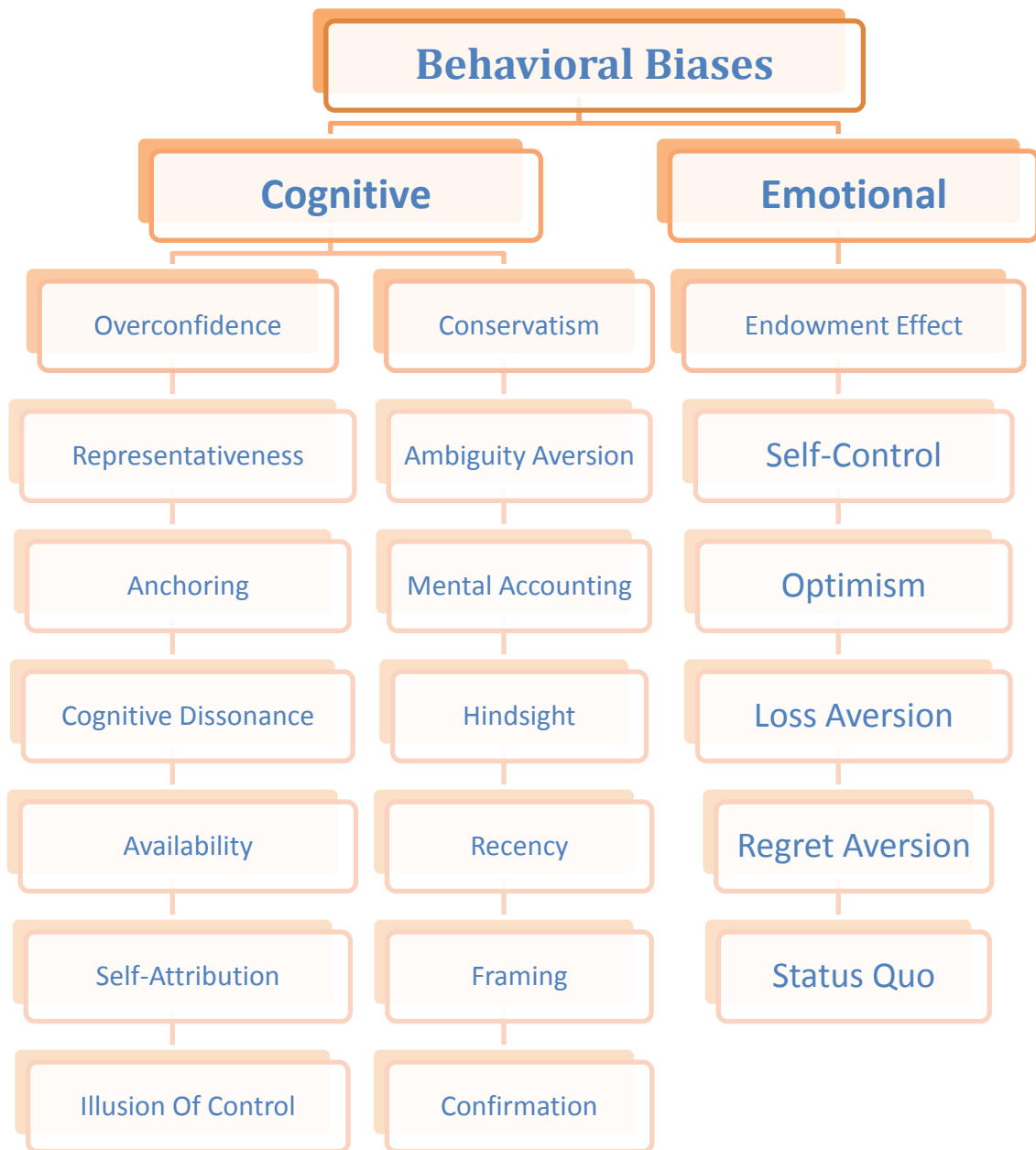
and tend to act pro-socially. Two behavioral explanations that can reveal aspects of an individual's attitude towards providing for public goods are that individuals are not entirely selfish and the "warm-glow" effect. To begin with, people do not only value their own consumption but also the consumption of others, hence they do not only think of themselves. It has been suggested that, people will contribute to public goods if they are certain that others will do as well (Ostrom, 1998). Secondly, people like to contribute because of the "warm-glow" effect, which refers to the notion that individuals like to contribute as it generates nice feelings, which stem from the fact that they either feel good about themselves or that others think highly of them. Of course, this doesn't entail that they actually care about the greater good.

2.4 BEHAVIORAL BIASES

After years of research, empirical studies, under the field of behavioral finance, have shown that the decision making process can be disturbed by the continuous appearance of behavioral errors, both emotional and cognitive. These behavioral biases are broadly defined, the same way systematic errors in judgment are. Depending on the author biases can be also referred to as heuristics (rules of thumb), beliefs, judgments or preferences (Pompian, 2006). A lot of scholars, Shefrin amongst them, classify biases as cognitive or emotional. For the purpose of this paper, this sort of bias taxonomy proposed by Pompian (2006) is useful in order to explain why people operate under biases and a further more elaborate classification, as proposed by other authors, will not be attempted.

Diagram 2.6

Bias Taxonomy as proposed by Pompian (2006)



2.4.1. COGNITIVE BIASES

Cognitive biases can be defined as statistical errors, errors during processing information or even a slip of memory. According to Pompian they could also be described as dark spots or disturbances of the brain stemming mainly from subconscious mental procedures during information processing.

2.4.1.1 *Overconfidence Bias*

Unjustifiable faith in one's intuitive reasoning, judgments and cognitive abilities can sum up the most basic ways overconfidence can manifest itself. Extensive research, experiments and surveys support the empirical conclusion that individuals tend to overestimate the accuracy of the information they have acquired, as well as their predictive skills. According to De Bondt and Thaler (1995), overconfidence may as well be the most important factor in the psychological analysis of decisions. As it has already been established, people are not particularly good at estimating probabilities and usually think that they have everything under control. This type of behavior is also very common in all kinds of professions. For instance, it has been proven that investors are overconfident in their investing abilities. Two common mistakes made by these investors are that they either assign to their investments predictions that are too narrow or that they are overly certain of their judgments. These mistakes are caused by types of this undue overconfidence and are called *prediction overconfidence* and *certainty overconfidence* respectively. For example, due to prediction overconfidence investors, when estimating the future value of a stock, don't account for substantial deviation in the range of expected payoffs (predicting around 10%), while experience drawn from past events calls for much more drastic standard deviations. As far as certainty overconfidence is concerned, individuals often become fixated on their investments thinking that it might as well be the "next hot stock", only to be disappointed when it performs poorly (Pompian, 2006).

Typical characteristics of overconfident investors is that they trade excessively as they tend to believe that information is limited to their knowledge only and as a result usually face inadequate returns over time. They also tend to hold poorly diversified portfolios and thus accept more risk than they would normally tolerate.

2.4.1.2 *Representativeness Bias*

As mentioned above, the human brain uses heuristics in order to reduce the complexity of processing new information. Representativeness bias is a result of this procedure and one of the most crucial behavioral errors. The brain assumes that similar things or situations are the exact same thing, therefore this bias concerns judgments based on stereotypes. Stereotypes are concrete beliefs that people form

about other people or situations based on specific characteristics they portray. So when individuals face new information that resemble familiar elements, the classification reflex leads to deception, producing false understanding of the situation. This framework, although very useful, will, more often than not, lead to incorrect investment decisions and choices, since decisions are based on how representative a certain characteristic can be.

According to Pompian, two primary interpretations of representativeness bias apply to individual investors. First, is the *base-rate neglect*, when investors try to predict the outcome of an investment by contextualizing it in a familiar classification, while ignoring variables that could affect it. The other interpretation is the *sample-size neglect*, when investors try to calculate the possibility of an investment outcome and often fail to consider the sample size of the data on which they are based. The assumption that all sample sizes (especially small ones) are representative of the population is inaccurate. When individuals are faced with a situation they do not understand they will rush into assumptions relying only on a few of the available data.

2.4.1.3 Anchoring

When individuals are faced with the task of estimating values, with unknown magnitude, in order to make a decision at first they tend to rely on intuitive guesses or on a suggested reference point – called “anchor”- which they can adapt to any additional information in order to reach their final estimate. Nonetheless, several studies have shown that individuals don’t adjust their anchors properly, producing thus biased results (Pompian, 2006). According to Kahneman and Tversky, when individuals don’t have sufficient information in order to make an estimate, they can even be influenced by random numbers. In one of their studies, individuals spun a wheel to select a number between 0 and 100 and were then asked to estimate the percentage of the United Nations that were African nations. The results were that the participants whose wheel stopped on 10 gave an estimate of around 25%, while participants whose wheel stopped at 65 gave an estimate of around 65%.

Another example is that of Northcraft and Neale (1987), who asked real estate agents to estimate the value of a house, which they could visit and had prior knowledge of the price the owners asked. Those agents were divided into two groups and were

given different asking prices. The first group was given the price of \$65.900 and the second group the price of \$83.900. Then they were asked to reach an estimate. The first group proposed the price of \$67.811 while the second the price of \$75.190 – a 12% difference. Although they were all professionals and made estimates about the exact same house they resulted in different estimates, influenced by the different asking price which in this case acted as an anchor.

Same thing can happen in the financial market as well. In absence of any (solid) information, past prices are usually the most important factor in order to determine future prices. In the case where one would be asked to estimate a market's index, the anchor would be the most recent price an individual can recall.

2.4.1.4 Cognitive Dissonance

According to social psychology, cognitive dissonance is a mental state which causes individuals to feel uncomfortable when new information contradicts preexisting understandings. It is a state that arises when opposing beliefs, emotions and values intersect. In order to relieve this discomfort, individuals try to either harmonize the contradicting cognitions, beliefs and actions or reject, ignore or even discredit the opposing belief. But, mostly, people will always try to find new arguments in order to support what they already believe. A well-known example is a study by Festinger, who examined the behavior of a religious cult that preached that the world would end at a certain date. When that date obviously passed and nothing happened, the cult, instead of admitting its mistake, claimed that the world was indeed to be destroyed but it was instead spared, thanks to their prayers (Cohen D., 2001).

Most people would like to think of themselves as very capable and smart and so, any information contradicting these beliefs should be discarded. They also like to believe that they always make the right decision and know what is best. For example, when an individual decides to purchase a certain vehicle brand, he tends to avoid commercials of rival models, since they could provide new information, which in turn could lead to the conclusion that the decision for that particular brand was a mistake all along (Alexakis & Xanthakis, 2008). People will go to great lengths to convince themselves that their decision is actually better than the alternative, so that they can avoid the unpleasant feeling caused by cognitive dissonance.

In the financial world, when investors make choices that turn out to be profitable they tend to attribute it to their wit, strategy, patience and anything else that will potentially make them look good. However, when their choices turn out to be fruitless they will not blame themselves but will probably attribute such a result to bad luck or someone else's fault.

According to Pompian (2006), scholars have identified two different aspects of cognitive dissonance that are relevant to decision making:

1. *Selective Perception*: individuals with selective perception can only register information that confirms their chosen course, creating in this way a misguided perception of reality. They are not able to understand new evidence impartially, thus becoming inclined to misjudgments. For example, if two negative and one positive announcement is made concerning a company that the individual has invested in, he will keep in mind the positive one, which confirms his initial choice.
2. *Selective Decision Making*: individuals displaying selective decision making, behave in that way when the commitment for a particular choice or decision is high. This process is about the rationalization of the actions that enable the individual to choose that particular course of action even at a high cost. For example, investors will keep investing in securities that have been proven poor choices in order to support their initial decision and avoid the realization of their mistake and the consequent loss.

2.4.1.5 Availability bias

Availability bias, according to Pompian (2006), is *"a rule of thumb, or mental shortcut, that allows people to estimate the probability of an outcome based on how prevalent or familiar that outcome appears in our lives"*. It is almost the same when it comes to investors, they evaluate a situation based on the information that is conveniently and directly accessible in their environment.

An illustrative example set by Shefrin (2000) was the simple question *"which is the most frequent cause of death in the United States, homicide or stroke?"* If individuals

find it easier to recall homicide instances they will answer “*homicide*” and the exact opposite, of course. Most people rely on the press, media and internet for their information. Let’s assume now that one cause of death is newsworthy while the other one isn’t, it is only logical that it will get much more media coverage and people that exhibit the availability bias will recall instances related to that same cause. In the same way investors are more likely to believe that investment choices, such as mutual funds, which are regularly advertised in the media are better choices than others and as a result the decision making process is disrupted. It has also been observed that in cases of infrequent events like a homicide or even more so a plane crash, individuals tend to overestimate the probability of such an occurrence in the future and it will cause individuals to overreact (Fuller, 2000). This phenomenon is also known as *saliency*.

2.4.1.6 Self-Attribution Bias

Self-attribution bias refers to the tendency, that characterizes individuals, to attribute their successes to personal abilities but when it comes to their failures, blame external factors, such as bad luck. In other words, when people fail it’s purely incidental and under no circumstances their fault, while success can be the result of hard work, talent, foresight, intelligence and the list could go on. A simple example is that of students and exams. If they do well then most definitely will credit their devotion and wit, but those who failed might claim unfair grading.

According to Pompian (2006), this phenomenon can be broken down into two subsidiary biases:

1. *Self-enhancing bias*, refers to an individual’s tendency to insist on an unreasonable degree of recognition for their achievements. From a cognitive perspective such a behavior can certainly be explained, as people set out to succeed, if they manage to do so, they will perceive success as the result of trying to achieve what they originally intended. Therefore, they will seek more credit for success, since they aimed to succeed and not fail.
2. *Self-protecting bias*, describes the illogical denial of accountability for failure. From an emotional perspective it can be explained as people will always try to psychologically protect themselves from the realization of their mistakes.

Self-attribution bias can lead investors to trade more than they should, hold under diversified portfolios or take on too much risk, especially in cases of prolonged profits as profits are translated into smart investors and losses to bad luck or other situational factors.

2.4.1.7 Illusion of Control

Another cognitive bias affecting people's decisions is the illusion of control, which is the belief that we, individuals, can actually control or even influence the outcome of an event. A very common example of this bias is the game of "craps" at a casino, during which players genuinely believe that the way they toss the dice can help them get the numbers they need.

Ellen Langer, Ph.D., of Harvard University's psychology department, observed that individuals that were allowed to pick their number of preference in a hypothetical lottery game were eager to pay a higher price for the ticket, than those gambling at random. This happened of course due to the illusion of control bias, meaning that we can alter an outcome merely by our participation in the process. Langer also found that choice, competition, task familiarity and active involvement can inflate confidence and generate such illusions (Pompian, 2006).

This bias can lead investors to trade more than they should. Especially those trading online have been found to believe that they hold more control over the results than they really do, which could lead to reduced returns. It can also lead to poorly diversified portfolios and in general can contribute to the overconfidence bias.

2.4.1.8 Conservatism

Conservatism bias refers to the tendency of not accepting and incorporating new information in one's decisions, but, instead, sticking to prior beliefs or predictions. Investors are a very common example of this bias, when they receive negative information about a company's earnings that contradicts another prior estimate, they sometimes *underreact* to that new information and maintain previous opinions, rather than change their position. Ward Edwards was the first to define the conservatism bias in 1986 and conducted the classic following experiment in order to demonstrate the technical side of the bias. He presented the participants with two

containers: The first one contained 3 blue balls and 7 red balls, while the other one, 7 blue balls and 3 red balls. Then he informed them that someone had randomly drawn balls 12 times from one of the containers and after each draw the ball was put back again and the results were, 8 red balls and 4 blue ones. The participants were then asked what was the probability that the draw was made from the first container. The majority replied around 70% while the correct answer is 97% as they overweighed the base rate of 50% of the initial choice between containers and ignored the new information about the ratio of the balls as it required careful processing.

An explanation to this bias was given by Hirshleifer, who suggested that processing new information and updating beliefs is cognitively costly (Pompian, 2006). Abstract and statistical information can be cognitively costly and, therefore, are weighted less. On the other hand, people tend to overreact to easily processed information, such as robust scenarios and examples. At this point, it is important to point out that the conservatism bias may appear to clash with the representativeness bias, when people overreact to new information. But individuals can actually exhibit both. Assuming that new information emerges, if it seems representative of an underlying model then individuals could overweight that information, but if there is no representative relationship, conservatism prevails and new data is underweighted.

2.4.1.9 Ambiguity Aversion

Ambiguity aversion bias refers to the individual's fear of uncertainty. Most people would hesitate in front of unknown or ambiguous situations, as they do not like to take chances, when probability distributions appear to be dubious. According to Knight (1921) risk is defined as "*a gamble with a precise probability distribution*" while uncertainty "*materializes when the distribution of possible outcomes resulting from a gamble cannot be known*" and, as a matter of fact, people are more averse to uncertainty, than they are to risk (Pompian, 2006).

An alternative to the expected utility theory was developed by L. Savage in 1954, called Subjective Expected Utility Theory (SEUT), proposing that under certain circumstances an individual's expectation of utility is weighted by his subjective probability assessment. Daniel Ellsberg (1961) used that theory and conducted the following experiment. He presented the subjects with two boxes: One had 50 white

and 50 black balls, while the other one contained an unknown ratio between white and black balls, but still the same total of 100. They were then asked to gamble on the result of a random draw between the two boxes. Results showed that most of the subjects preferred the box with the known ratio of the balls to make their bet. Individuals tend to avoid situations that don't provide certainty concerning the probability distribution of a gamble. So the results were inconsistent with SEUT as it does not succeed to incorporate the individual's level of confidence in a probability distribution and does not capture ambiguity aversion, as it cannot predict the outcome of the experiment.

This bias may cause investors to seek higher returns when investing in uncertain assets. It can also limit investors to their own nation indexes as they might appear safer and more familiar compared to foreign ones. Moreover, it causes investors to believe that the stock of a company that employs them is safer than others.

So we could just say that people tend to prefer the familiar to the unfamiliar (Shefrin, 2000).

2.4.1.10 Mental Accounting

Mental accounting was described by Thaler (1980) as people's innate tendency to use distinct mental accounts for each of their investment choices. The gains and losses of each choice fall into the same mental account, which in turn is evaluated separately from other choices and their respective mental accounts. Each account represents a different way of coding, categorizing and evaluating of economic outcomes. Evidently, mental accounting implies an irrational way of thinking and processing decisions, as it leads to treating sums of money in different ways, based on where these sums are mentally categorized, for example if they inherited the money, or it comes from work or even gambling. These sums can also be categorized based on the way they can be spent like leisure, investing, retiring, etc. For instance, someone can mentally separate his investment plan for buying a house from his retirement plan. This mechanism helps individuals to better grasp and control the future of their investments.

In order to understand mental accounting, a very important part is the concept of *framing*⁸, when individuals change their perspectives according to the circumstances that appear. Thaler conducted the following experiment: He gave \$30 to a group of people and the following choice: either simply take the money and go or gamble on a coin toss, wherein a win would add \$9 and a loss subtract the same. Most of the subjects of this group (around 70%) chose to gamble as they considered the money as a windfall and had nothing to lose gambling it. The other group was outright presented with the following question: would you gamble on a coin toss, wherein you get \$39 for a win and \$21 for a loss or would you just take \$30 and refrain from the gamble? This time, that the money wasn't just awarded to the participants, results were different as only 34% decided to gamble.

An interpretation of mental accounting is provided by Shefrin and Thaler (1988) in **Life-cycle Theory**, which proposes that individuals allocate wealth in their minds in three categories: Current income, current assets and future income. The tendency to consume is highest for the current income and lower for future income. For example, if you were informed that you were about to receive a \$6.000 bonus in twelve equal payments of \$500 along with your monthly salary, how much would you spend today to increase your consumption level? The most common answer is \$200. But if you were given the \$6.000 in one payment that was immediately bound in bank account for a year? Most said \$0. So it seems that in the first case the payments were perceived as current income while in the second as future. And still, even people with liquefiable assets are not willing to use them in order to cover current expenses.

Another interpretation of mental accounting suggests how different decisions can be evaluated separately or jointly. For instance, in an experiment conducted by Kahneman and Tversky most of the subjects refused to pay for a new theater ticket, which would replace the one they had paid for but lost. However, when they changed the phrasing and told them to imagine that there wasn't any lost ticket but they lost an equivalent amount of money and then asked them if they would buy a theater ticket for the first time, the majority replied it would. In the first case, we can see that

⁸ Further analyzed on page

the two incidents are under the same mental account so re-buying the ticket would represent two losses in the same account. While in the second case, the cash and the ticket are under different mental accounts and therefore evaluated separately.

2.4.1.11 Hindsight Bias

Hindsight bias refers to the tendency to think that an event -that has now happened- was predictable all along, even in cases that it actually wasn't. According to Pompian (2006) "*this behavior is precipitated by the fact that actual outcomes are more readily grasped by people's minds than the infinite array of outcomes that could have but didn't materialize. Therefore, people tend to overestimate the accuracy of their own predictions.*" A typical example of this bias, are stock bubbles. During the bubble, investors would never admit to what was happening to the stock market was actually a bubble, but, of course, after the fact, they supported that they were certain all along of what was going on (Montier, 2007).

An individual, subject to hindsight bias will assume that the outcome he expects to be realized is the only one that was ever possible. As a result, he underestimates the uncertainty of an event realizing and underrates the possible outcomes that could have been. Such individuals are more likely to take on excessive risk as investors, as they fool themselves into thinking that they possess superior predictive powers. This bias can also prevent learning from past mistakes and boost an investor's confidence into believing that the market can be more predictable than it actually is.

2.4.1.12 Recency Bias

Recency bias refers to a cognitive situation during which individuals are inclined to recall facts that have happened recently and emphasize solely on them while disregarding other facts that have happened further in the past. Psychologists in order to study human memory use an experiment called *free recall*. In this particular experiment subjects are given a list of words and are then asked to recall them in a random order. The results showed that the words that were most easily recalled were the ones that were either presented first -primacy effect- or those that were presented last -recency effect- (Pompian, 2006).

More or less the same thing happens when it comes to investment decisions. Recency bias can lead investors to make projections based on a sample that is either too small or too recent and thus renders them vulnerable to purchasing at price peaks. These investors usually enter asset classes at the wrong time and rarely make any profit. It can also cause them to only focus on a recent upward trend and overvalue asset classes and again realize losses when prices return on their average.

2.4.1.13 Framing

Framing bias refers to the investor's tendency to respond to problems or situations in a different way, based on the way the frame is set. In other words, it is nothing more than the way a logical problem is presented to an individual. For instance, often we see in stores promotional offers like "2 for 2€" or "3 for 7€" and more often than not, the case is that you will not be able to find both the offer "3 for 7€" as well as the single unit priced at 2.33€. When this happens we immediately think that the offer implies a discount, but this is not always the case. It is possible for a problem to be framed in more than one way. For example, an outcome can be phrased in two ways: "25% of people will be saved if they are given the proper treatment" – formulated as a gain- and "75% of people will die without the proper treatment" – formulated as a loss. Those who are presented with the gain frame are more likely to adopt a risk averse behavior and those who are presented with the loss frame are more likely to engage in risk seeking behavior (Pompian, 2006). This bias can also include a sub categorical phenomenon known as *narrow framing*, which happens when individuals focus their attention on one or two aspects of a problem, disregarding other aspects no matter how important they are. For example, when an individual desires buying a coffee maker, if he is working with a very narrow frame of reference, he might purchase an appliance that is simply quick and ignore other aspects such as pressure, water flow and other factors that affect the quality of his coffee.

As seen above, framing can shape an investor's tolerance towards risk and cause them to make decisions that are either excessively conservative or aggressive. Moreover, the optimistic or pessimistic manner in which an investment suggestion is framed can affect one's willingness to invest.

2.4.1.14 Confirmation

Confirmation bias refers to the tendency that individuals display, to perceive situations or ideas that confirm their beliefs, while disregarding those that contradict them. For instance, after someone purchases a car, it is very common that he will stop paying attention to advertisements of rival models so that he can avoid a situation where he has to doubt his initial choice (Mangot, 2007).

Consequently, this bias can cause investors to ignore all available information that doesn't confirm their choice and thus end up with losses. It can also lead investors to hold undiversified portfolios, as they can fixate on certain stocks which might not be particularly profitable for them.

2.4.2 EMOTIONAL BIASES

2.4.2.1 Endowment effect

Endowment effect refers to the individual's tendency to value a possession of theirs more than its actual value. In other words, when they hold property rights over an asset, automatically they would ask a lot more money than the asset really costs in order to sell it and in most cases money that they would not be willing to pay if tables were turned. It is evident that economic theory is inconsistent with the endowment bias as a person's *willingness to pay* should be equal to the person's *willingness to accept dispossession*. One of the first ever experiments done in order to study this behavior was conducted by Professor Richard Thaler. He gave to a number of students a coffee mug with the university logo that anyone could buy for \$6. These students were then asked, what was the price they were willing to sell their free mug at and the average was \$5, 25. But when students with no possession of the mug were asked at which price would they be willing to buy the mug, on average they replied \$2, 75. That is almost a 100% difference between asking and selling price.

In a similar manner, endowment effect can cause investors to hold on to assets that they have inherited, disregarding any possible losses. It can also investors to hold on to securities (they already own) as a result of the decision paralysis caused by the unreasonable price they demand in order to dispose of the endowed asset. Moreover,

it can cause investors to hold securities that they have either inherited or purchased because they are either familiar with their characteristics or they do not want to incur the transaction costs of selling.

2.4.2.2 Self-control bias

Self-control bias refers to the lack of self-control demonstrated by people every day, it is the conflict between desire and the inability to act in order to achieve these aspirations due to lacking willpower or self-discipline. For instance, a student that desires to excel in his studies should limit in a way his social life and focus on his courses. Often, individuals will succumb to gratification by choosing to consume now rather than saving for the future (Pompian, 2006). When it comes to money, people are known to be hasty and irrational. Reality has shown that people are particularly good at sabotaging themselves by sacrificing their long-term goals for temporary satisfaction.

Obviously, this lack of self-control causes investors to spend money now instead of saving thus failing to make proper retirement plans that can secure a stable future. It can also cause imbalances to asset-allocation due to specific preferences like income-producing assets that facilitate current consumption in the expense of long-term wealth.

2.4.2.3 Optimism Bias

One of the most serious emotional biases is excessive optimism or alternatively put, wishful thinking (Barberis & Thaler, 2003) displayed by individuals. In other words, their tendency to perceive that it is more likely to have positive outcomes happen to them (or a smaller probability of negative outcomes). For example, most people underestimate the chance of a serious illness or accident happening to them. However, they think that their marriage or business can beat all odds. Of course this optimism is crucial when the individual has to overcome life's uncertainties with fortitude (Mangot, 2007). It also appears to be that it is actually the "default setting" of the human brain and it has definitely contributed to the survival of our species (Montier, 2010). Nonetheless, due to this optimism, people tend to rank themselves as above average just because they have a positive perception of their traits (beauty, intellect, abilities, etc.).

Investors tend to be overly optimistic as well and as a result they might overload on certain stocks because this bias can make them think that other stocks are more likely to register losses. Also, employees feel greater comfort holding stock of the company they work at as they perceive it as a less risky investment. Moreover, it can cause investors to read too much into promising scenarios and ignore other information.

2.4.2.4 Loss Aversion Bias

Loss aversion is one of the most significant emotional biases and was originally introduced by Kahneman and Tversky (1979) as part of Prospect Theory. In Prospect Theory, loss aversion refers to a situation where individuals try to avoid losses in a more intense way than they try to pursue gains. Consequently, it appears that the negative effect that losses have is more powerful than the positive effect of winning an equal amount of money (Tversky & Kahneman, 1979, 1991). Several studies on loss aversion have concluded to a common rule of thumb: *“Psychologically, the possibility of a loss is on average twice as powerful a motivator as the possibility of making a gain of equal magnitude”* (Pompian, 2006). In other words, a loss-averse individual might ask for at least a two dollar gain for every dollar he risks.

Loss aversion can cause investors to stick to unprofitable investments for too long as they hope that if they hold the investment long enough they might get what they lost. However, it can also cause investors to sell winning investments way too early as they fear that if they don't sell they could lose their profits. Additionally, due to loss aversion, investors could take on more risk than they knowingly want and hold unbalanced portfolios.

2.4.2.5 Regret Aversion Bias

Investment decisions have both financial as well as emotional significance for a person. No one likes to lose and most of the time regret can hurt more than an actual loss. Regret aversion is a mental state associated with avoiding actions out of fear that their results could possibly prove less than optimal. This tendency aims at averting the pain of regret that appears after a bad decision. According to research in experimental psychology, under conditions of uncertainty, regret can influence the decision making process (Pompian, 2006). Individuals usually try to avoid actions that might cause them to feel regret (Loomes & Sugden, 1982) and will prefer to act on a situation that

could boost their self-esteem. Regret will also cause individuals to question their past decisions and doubt their beliefs. People who exhibit regret averse behavior try to avoid consequences that arise in two ways: by *errors of commission*, that occur after committing a misguided act and *errors of omission* that stem from inaction (i.e. missed opportunities). That feeling of regret will be more intense in the cases of errors commission rather than those of omission.

Regret aversion can cause investors to hold on to losing positions for too long out of fear of finally realizing losses. It can also cause investors to be cautious of entering markets that have recently gone down as they fear that the downward trend could continue and thus lose potential opportunities that emerge in periods of depressed prices. However, it causes investors to hold onto winning stock for too long as well as they fear that if they sell they might be missing out on potential profit. In many cases regret aversion might lead to *herding behavior*, given the fact that by following a common consensus, the potential of regret is limited.

2.4.2.6 Status Quo Bias

Status quo bias was introduced by William Samuelson and Richard Zeckhauser (1988) and is an emotional bias that “predisposes people facing an array of choice options to elect whatever option ratifies or extends the existing condition (i.e. the “status quo”) in lieu of alternative options that might bring about change.” In other words, this bias operates when individuals are faced with many alternative options and will avoid any action that might bring about any significant change.

This bias can cause investors to hold investments that are not compatible with their preferences concerning risk and/or return as they avoid to take any action. They can also find themselves holding on to securities that they have either inherited or purchased or for any other reason feel fond of as they get a certain level of personal comfort. Status quo bias can also be combined with loss aversion bias when the status quo situation versus alternative scenarios, offers the investor a lower probability of losing.

CHAPTER 3

Behavioral Theory and Energy Policy

“To invest successfully over a lifetime does not require a stratospheric IQ, unusual business insight, or inside information. What’s needed is a sound intellectual framework for decisions and the ability to keep emotions from corroding that framework.”

Warren Buffett

3.1 INTRODUCTION

An application of all the concepts mentioned in the previous chapters to energy and climate policy is attempted in order to gain a better understanding of patterns and habits and in turn identify the crucial factors that influence energy consumption, efficiency investments, Renewable Energy investments and energy policy. Climate and energy policy are completely intertwined with our planet’s future and sustainability therefore actions concerning the security of energy supply and its affordability should not be overlooked. IEA estimates that by 2020, about 34% of the global decrease in carbon emissions in a “450 scenario” compared to the reference scenario should come from energy efficiency measures, thus investments need to be promoted and at times carefully subsidized along these lines. In this sense, renewable technology seems only fitting. A short review and ex-post analysis of the Greek Renewables sector follows mainly aiming to present how policy and certain factors (technology, size, profit) affect investors, the level of penetration in electricity generation and the way Feed-In-Tariffs (FITs) created distortions to the market and lead to the collapse of the financial scheme that was created to support them.

3.2 BEHAVIORAL THEORY IN ENERGY

In order to change our energy-use habits that involve reducing our consumption, a lot of effort needs to be put into curtailment suggestions such as altering tariffs, billing and payment methods, giving non-pecuniary incentives, the influence of social norms, information provision and the choice of electricity suppliers.

Household electricity consumers have been facing for years flat electricity tariffs, although the marginal cost of production fluctuates throughout the day and is

especially high during peak time. If demand could follow a smoother pattern, utilities could not only reduce energy costs but also curb CO₂ emissions, both associated with the use of peaking plants. Lately, policy makers and utilities have put on the table the idea of tariffs that will change depending on the time of usage, such as,

- time-of-use tariffs (TOU), meaning that depending on the time of day consumers will face different charges,
- peak-time rebate, meaning that consumers will be paying a flat rate but will also get a discount if their usage is under a certain threshold during critical times through the year,
- critical peak pricing (CPP), meaning that during certain critical periods of the year consumers will have to pay higher rates, and
- Real-time pricing, meaning that the tariffs the consumer has to pay will be in accordance with the real time wholesale electricity prices.

Of course, in order for these measures to be applicable, smart meters have to be installed. According to Michael G. Pollitt in his article “The Role of Behavioural Economics in Energy and Climate Policy” (2011), trying to estimate the potential for demand-side response to **fluctuating tariffs** requires a customer behavioral response and is a subject that can benefit from behavioral notions such as the following.

The *endowment effect* reflects the unwillingness that consumers may present facing the possibility of dynamic pricing which entails a shift to their consumption habits and routines. Since they have been, for long, insulated from fluctuating rates they may be reluctant to alter the cost-benefit structure of the way they consume electricity. Consequently, proper care should be given to the design and marketing of the new scheme.

What is more, the *status-quo bias* reflects that most customers will remain on the default plan of flat tariffs even if it is not the most suitable for their consumption patterns. Research has shown that when presented with a utility bill with a default option, most customers will not change it (Brennan, 2006).

Time-varying discounting rates reflect the individual’s tendency to have higher discount rates for the future and hence dismiss the possibility that the costs are worth

the benefits since savings initially might be miniscule. While behavioral adjustments are set in motion in response to the shift to dynamic pricing, electricity bills will skyrocket and customers might not be patient enough and abandon their efforts.

Moreover, *loss aversion* reflects the value consumers attach to gains and losses. If they value losses more than they value gains, rate increases during peak-time may have to be compensated with larger rate decreases during off-peak periods.

Last but not least, *concern for fairness* reflects the opinion shared by many opponents of dynamic pricing, that it is not fair towards the vulnerable. Such households are usually those of the elderly, poor and disabled and there is really little they can do change their consumption. However, those who are pro dynamic pricing support that it is not fair that these households subsidize through flat tariffs the ones that peak.

The way consumers pay their **utility bills** and the way those bills are framed and designed may be associated with how they consume energy. An Irish study concerning consumption and top-up behavior of households showed that consumers with payment meters tend to consume more electricity as they usually purchase relatively small top ups and in order to adjust to increases in tariffs they increase their number of top-ups instead of just increasing the amount (Brutscher, 2011_{a,b}). It also showed that when the minimum top-up amount was increased, energy consumption decreased. This entails that that consumers have different *mental accounts*, perceiving costs differently and would probably be more cautious of their consumption after a large to-up.

Studies have also tried to conduct **non-pecuniary interventions** in order to reduce energy consumption. Although they were carried out with small samples and did not monitor the interventions for a long period of time, they found that competition, public commitment and goal setting can be effective in motivating costumers' cutback on their consumption. A study by McClelland and Cook (1980) showed that competition between residential buildings on energy savings (combined with information concerning energy savings, usage feedback and a very small reward) had effective results. Another study by Pallak and Cummings (1976) found that people who signed a public commitment showed lower rates of increase in gas and electricity use

than those who signed a private one or those in the control group. Another study by Becker (1978) found that goal setting has a significant effect on consumption as the households that had a difficult goal (20% savings) achieved a significant change in their consumption (15% savings).

Social norms have been proven to create guidelines and decide about what is considered to be acceptable or not. As a result, increasing awareness in social norms might influence energy consumption. However, it remains to be seen if the results of such behavioral interventions can be sustained. A study has shown that providing information about the energy demand of a test subject's neighbor led to a decrease of his energy demand. Another study confirms this result, one of the largest randomized field experiments, OPOWER, mailed home energy reports to costumers, comparing their usage to their neighbors. This intervention reduced demand by 1,11% to 2,78% from the baseline usage.

As proven above, information and feedback are of outmost importance when trying to achieve behavioral changes. According to Pollitt, the residential electricity market has always suffered from asymmetric information. Meters have been providing information and data concerning consumption, which are not always useful to a consumer as they don't know which appliances use most power and when. **Information asymmetry**, is a market failure, which is studied under the specter of behavioral sciences. When the communication of information considers the behavioral failures and heuristic decision making, messages can be framed to reinforce behavioral response. Visual cues and vivid descriptions have proven to be effective as individuals are more easily influenced by salient information. Also since costumers are more affected by losses than gains, messages should emphasize on the fact that energy is being wasted while it could be saved.

Unregulated monopolies rarely have motives to keep prices down so competition between suppliers translates to lower prices for consumers. Surprisingly thought, there is evidence that when costumers are shopping around and are presented with too many options, in the end they do not switch suppliers. This can be explained either by the status-quo bias or information overload. Information isn't really free or that easily accessible (as proposed by traditional economics) and as the average consumer

has trouble even understanding an electricity bill, the unwillingness to switch providers can be explained.

3.3 ENERGY EFFICIENT INVESTMENTS

In order to reduce overall energy consumption and curb CO₂ emissions, great importance must be given to increasing energy efficiency. These types of investments involve large amounts of capital but will result in cost savings (as well as energy savings) in the long run. Although the importance of efficiency is stressed, we are far from what is considered to be the optimal energy use (energy efficiency gap) and behavioral sciences can try to explain that puzzle.

First, individuals might be willing to invest in energy efficiency but they are either procrastinating or don't have the discipline to put the money for initial investment together. Due to the endowment effect, people might be attached to their old appliances since they have proven durable and will be unwilling to make a change to more efficient ones. Heuristics also refer to an individual's tendency to try and assess his energy consumption by using patterns that most likely aren't fit for such use, just because they have worked for other situations (bounded rationality).

Incentives have been proven very helpful for the deployment of energy efficiency schemes by policy makers and utilities. These techniques have drawn from past experiences of behavioral and market failures and now use insights from behavioral theories in order to reinforce energy savings. Income tax credits or deductions have been helpful instruments, to achieve efficiency. Another beneficial intervention was to encourage home owners to upgrade their buildings by installing energy-saving improvements at no upfront cost and they payments would be made using the savings from the consumer's energy bill. According to Stern (2000), interventions and incentives interact and their combined effect is often bigger than the sum of each intervention on its own.

3.4 PUBLIC GOODS, PRO-ENVIRONMENTAL BEHAVIOR AND IMPLICATIONS FOR POLICY

According to Pollitt, endorsing green energy and combating global warming is a public good. In the case that individuals feel like supporting these causes and want to contribute voluntarily, public policy could greatly benefit from such actions and in turn reinforce them through suitable mechanisms that would render such donations more likely.

Under-provision of public goods can be dealt with mechanisms such as taxes and provision point mechanisms (PPMs). This type of mechanism gives individuals the opportunity to contribute voluntarily to a project, under the condition that if the necessary benchmark amount is not collected, the contributors will be refunded. Strangely enough, it has been proven that these mechanisms are usually even more effective than voluntary contribution mechanisms (VCM). For example, Traverse City Light and Power in Michigan, actually built a windmill (Holt, 1996_a) and in Colorado money was raised for three separate wind turbines (Holt, 1996_b), both using the PPM.

Another “instrument” public policy could put in good use is public image, meaning that it could use to its advantage the individual’s innate tendency to display publicly their contributions and donations and use token gifts such as pins, mugs, stickers, etc. in exchange for these contributions.

Energy, power and more specifically electricity are commodities that are of utmost importance for everyday life that are considered among the bare essentials along with food, water and housing. Thus increasing prices could be considered socially unfair even in times of need like outages, blackouts, etc. It has been proven (and supported by IEA as well), by real cases such as these of California, Australia, New Zealand, Brazil, that public appeals for energy conservation can be very effective. Governments have used televised or not public appeals to urge households to reduce energy consumption by conveying concise and direct messages accompanied by energy saving advice. IEA (2005) also recommends, that while raising prices during times of shortfalls is the immediate response, it is not always the best option but alternatively,

it is imperative to educate consumers, raise awareness and make conservation a way of life.

3.5 RENEWABLE INVESTMENTS AND BEHAVIORAL ASPECTS

Climate change has been a major problem in recent years as CO_2 emissions have not yet been reduced. Many support that, a viable solution would be a transition to a low-carbon society by increasing the amount of energy produced by renewable technologies among other things (i.e. energy efficiency, decrease energy consumption, etc.). Renewable energy has a much lower environmental impact than conventional technologies, therefore should play a pivotal role in our efforts to ameliorate current predicaments. Thus a shift towards such sustainable sources is paramount and should concern policy makers around the world. In particular, the European Union (EU), has set some very aspiring goals. According to Directive 2009/28/EC, the use of energy, produced by renewable technologies is to be increased to a minimum of 20% by 2020. A portfolio containing renewable energy will not only give a much needed diversification but will also provide countries with certain benefits that are not fully internalized in current energy market prices, such as: energy security, strategic economic development including rural development, the agricultural sector and high-tech manufacturing, energy access through distributed or off-grid solutions and last but not least the desirable environmental impacts including a decrease in greenhouse emissions and local pollutants (IEA). Although investments in renewable technologies have been growing the past years, still additional investments are needed in order to achieve a low-carbon economy. Despite all these benefits, there are still several technical and economic obstacles that delay their penetration. Market failures occur that are associated to the energy sector itself, which is designed for fossil fuel power plants and to the specific nature of renewable technologies (Dinica, 2006; Helm, 2002; Jefferson, 2008; Wüstenhagen and Menichetti, 2012). High up-front capital costs, long pay-back periods, diverse risks (i.e. technical, performance, etc.) combined with high regulatory dependencies can often render RE unattractive for investors. Therefore, in order to cope with these constraints, it is imperative to create a stable and reliable framework that provides plenty of options that can help stimulate the diffusion of RE.

3.6 LITERATURE REVIEW

As it has already been established, a crucial part of RE investing is the policy framework, which aims at giving incentives, correcting externalities, setting the Feed-In-Tariff (FIT), reducing associated risks, etc. Despite the fact that, for the time being, policy is one of the most important drivers, it cannot singlehandedly keep leading investment, so a basic theoretical background is provided, in order to better understand what does and does not affect an investor's decision process and behavior.

As mentioned above many focus on the policy part of RE investing while ignoring who actually invests in these technologies. As a result, few empirical studies have identified factors that influence investment behavior. Masini and Menichetti (2010) found that a priori beliefs can influence an investor's decision to back RE projects, proven reliability is a necessary condition for investment and that market inefficiencies can be corrected with well-adjusted policies. Other studies show that personal characteristics (sex, age and risk propensity), access to financial resources and previous experience affect willingness to invest (Aguilar and Cai, 2010; Bollinger and Gillingham, 2012; Drury et al., 2012). Other studies of providers of financial capital for investments in renewable energy plants found as well that risk propensity, access to capital, motives (i.e. tax vs. strategic motives or amount of profit desired) and previous experience affect the decision of these providers to finance investments and how they do it. Barradale (2010) suggests that risk propensity and motives can affect the investors' choice of ownership models.

Concluding, this review shows that the differences between investors concerning motives, available capital, previous experience, technical resources and personal characteristics are likely to affect what agents decide to invest in and the way they will do it.

What is clearly evident now, is the need to develop a conceptual model that incorporates the human factor to traditional financial analysis and takes into account the way agents assess risk, their rules of thumb and how they forecast expected scenarios (Masini and Menichetti, 2010).

This paper aims to help gain an insight to the factors that affected the behavior of RES investors in Greece from 2009 to 2013.

3.7 THE CASE OF GREECE

The past two decades have been very important as the greek government introduced a number of policies aiming at the diffusion of renewables. With the Law 2244/1994, the Feed-In-Tariff was introduced for the remuneration of RES and with the Law 2773/1999 liberalized the electricity market, in compliance with the European Directive 96/92/EC. The years to follow were crucial as favorable policies for the penetration of RES were adopted, like the Law 3851/10 that facilitated the licensing procedure by eliminating bureaucracy and set favorable guaranteed prices for the purchase of electricity and the Law 3851/2010 that played a crucial role in the expansion of RES and especially photovoltaics due to its supportive pricing policy. However, this promotion was not suitably designed and coupled with the unexpected economic crisis led to market dysfunctions. Back then, the general trend in the EU was decreasing energy costs coming from RES and so the framework that was adopted in order to solve these problems aimed at the viability of RES market and decreasing energy cost (Lychnaras and Dagoumas, 2015). Nonetheless, the legal framework of RES after all became part of the obligations the country had to meet for the memorandums. Then in 2012, the Law 4093 was introduced imposing a steep solidarity levy to RES and Co-generation units for the following two years and changing contract prices from the previous higher “locked” level to the price in force at the beginning of the trial operation of the unit. Following in 2013, the Law 4152 imposed an annual fee for the producers in order to maintain their electricity production permits and suspended any new contracts for the connection of photovoltaic units until 31 December of 2013 so as to halt their expansion and manage the deficit of the special account of RES.

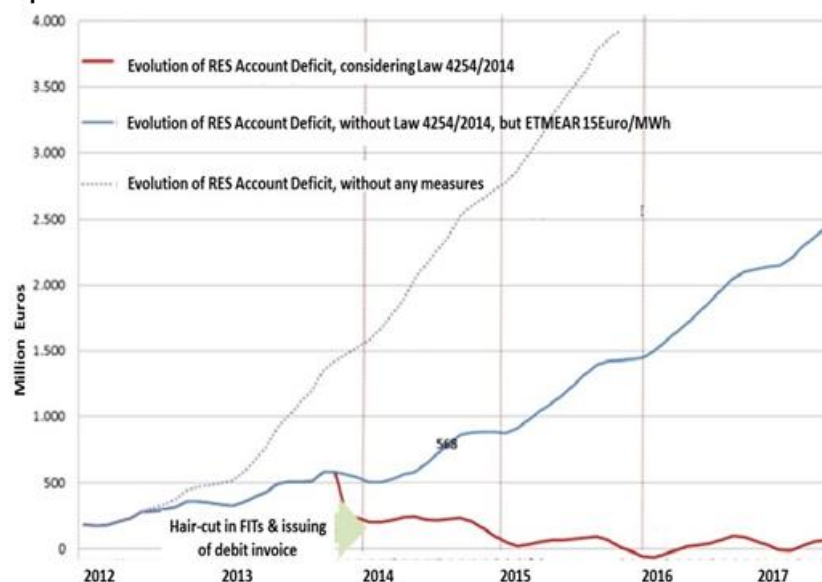
FITs proved to be extremely favorable, especially in the case of photovoltaic units due to capital cost reductions that came from increased global competition, causing an installation plethora which in turn lead to the swift growth of the deficit of the special RES account, which is operated by the Electricity Market Operator (LAGIE). The

following figure presents the evolution of the deficit of the RES account, under three cases:

- No measures on the high FITs
- increase of the ETMEAR at 15Euros/MWh, namely a special levy for supporting the RES, paid by all electricity consumers
- The implementation of Law 4254/2014 which imposed a 30% hair-cut in FITs and also the issuing of a debit invoice for part of unpaid historical RES generation.

Figure 3.1

Evolution of the deficit of the RES and CHP account considering the implementation of critical policies: (Law 4254/2014) and RES tariff (ETMEAR) increase, source: LAGIE Monthly Report on RES Account, October 2015



Source: LAGIE

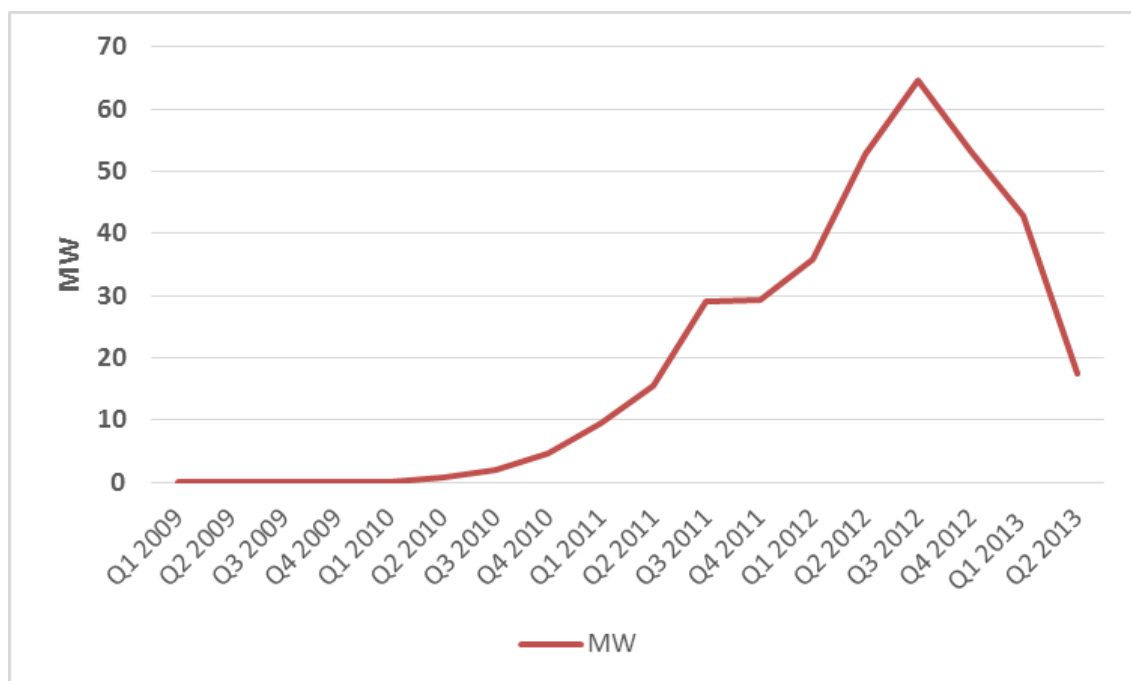
What is evident from Figure 3.1, is that the account was unsustainable, even from the early stages of 2012-2013. Then in 2014, Law 4254 was introduced as the “new deal” to redefine selling prices of existing RES units at lower levels in order to rationalize the electricity market and decrease if not eliminate the special account deficit (Lychnaras and Dagoumas, 2015).

3.7.1 Renewable Energy Investments in Greece

This sections presents the evolution of Renewables in Greece, over the period 2009-2013, where the majority of the investments have been implemented, as can be seen for LAGIE monthly reports. Special attention is paid at the Photovoltaics as their penetration was rapid, mainly due to the exceptionally high Feed-In-Tariffs (FITs), which in turn lead to high Internal Rate of Returns (IRRs). Considering that this paper aims at shedding further light on the behavior of investors, it focuses on the following two categories: Roof PVs and PVs with installed capacity up to 100kW, which together account for almost 50.000 installations, namely the vast majority of the total number of investors. Roof PVs account for more than 35.000 investments, while PVs up to 100 kW, account for approximately 11.000 investments, over the period Q1 2009- Q3 2013.

Figure 3.2

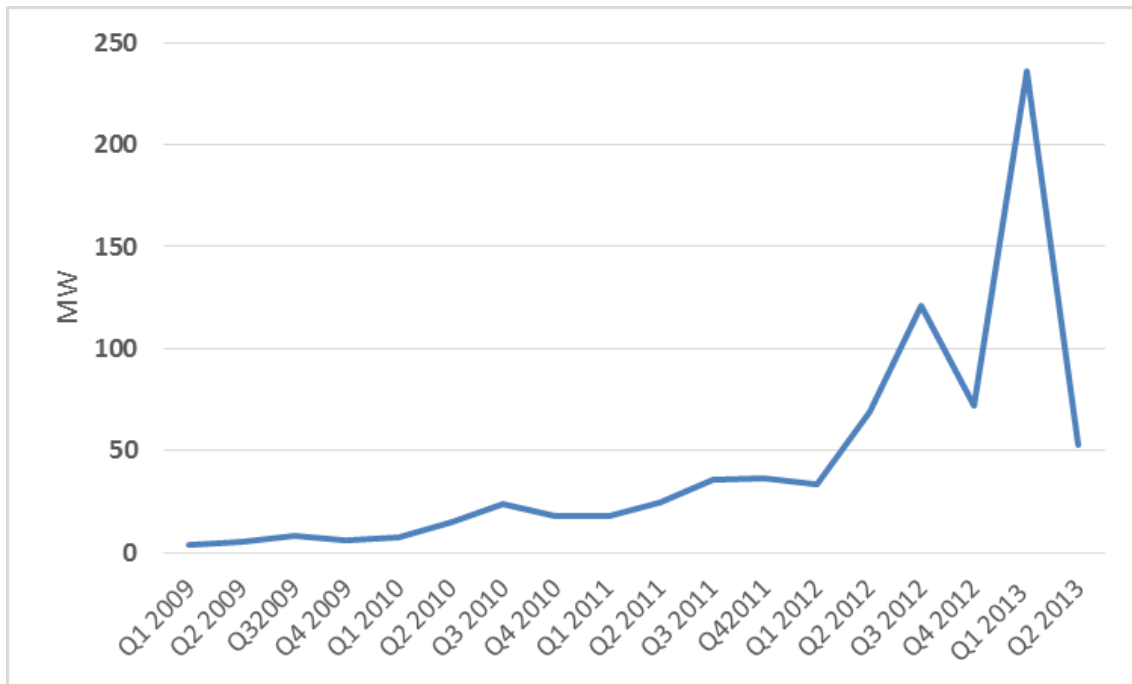
Investments in MW per quarter over the period Q1 2009 – Q2 2013 for small Roof PVs



Source: LAGIE

Figure 3.3

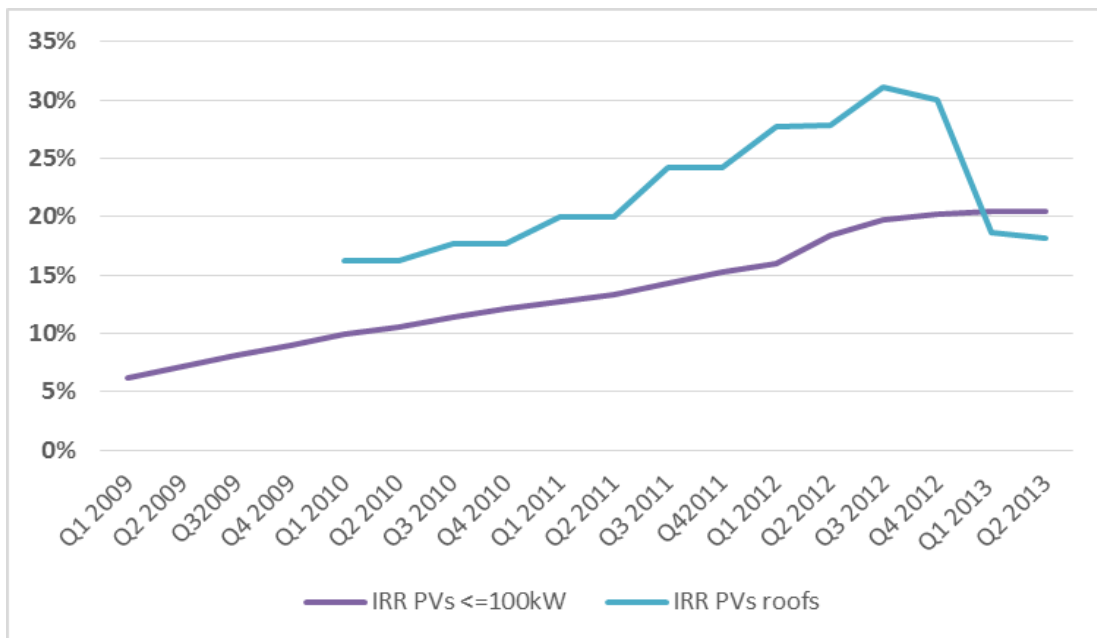
Investments in MW per quarter over the period Q1 2009 – Q2 2013 for small Roof PVs



Source: LAGIE

Figure 3.4

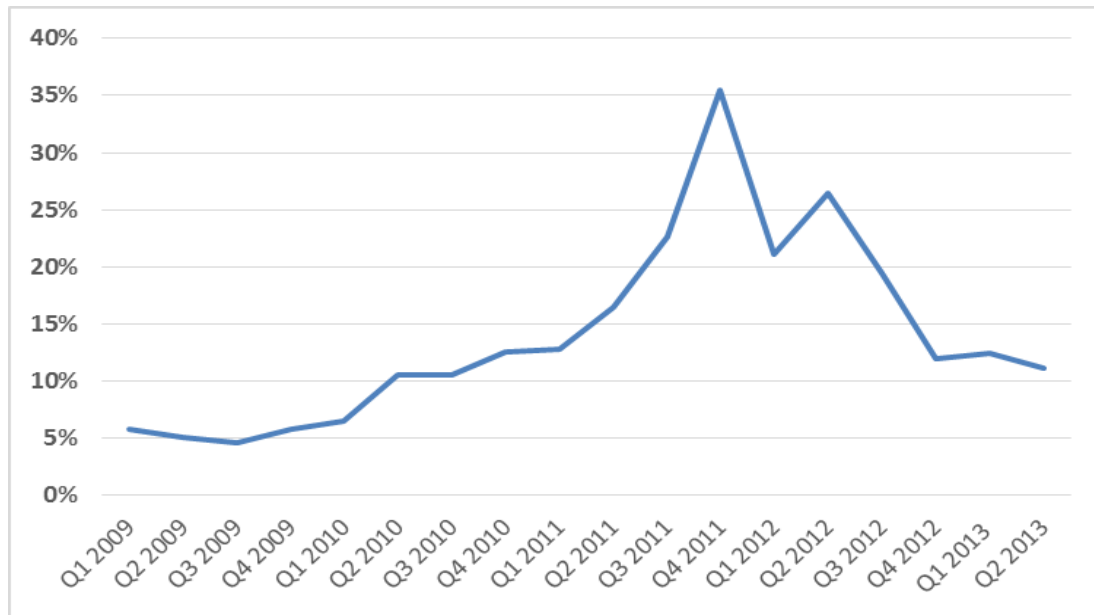
Evolution of estimated initial, before the implementation of FIT cuts, IRRs for the PVs investments for roofs and for installations with capacity up to 100kW, per quarter over the period Q1 2009 – Q2 2013



Source: Author & Athanasios Dagoumas

Figure 3.5

Evolution of 10-year bond per quarter over the period Q1 2009 – Q2 2013



From these figures, it is obvious that both categories, and especially the PVs in roofs, provided exceptionally high IRRs. This is mainly attributed to the fact the decrease of FITs was not in accordance with the rapid decrease in the capital cost of those investments. Moreover, at the same time Greece underwent (and still is) a deep economic crisis, which is evident by the extremely low ratings from rating agencies and the rapid increase of its 10-year bond, which is chosen as the variable to depict the country risk (due to lack of more suitable data).

Different econometric models have been implemented, in order to quantify the effects of different variables on the behavior of the RE investors.

The models that have been tested, had the generic form:

$$\begin{aligned} RECapacity_{(t)} &= b_0 + b_1 * RECapacity_{(t-th)} + b_2 * CountryRisk_{(t)} + b_{1,2} \\ &* CountryRisk_{(t-th)} + b_3 * IRR_t + b_{3,1} * IRR_t + e \end{aligned}$$

Those models, considered the following variables:

- $\text{CountryRisk}_{(t)}$, represented by the 10-year bond
- $\text{CountryRisk}_{(t-th)}$, referring to the previous Quarters
- $\text{IRR}_{(t)}$, representing the expected profitability of the investment
- $\text{IRR}_{(t-th)}$, referring to previous Quarters
- $\text{RESCapacity}_{(t)}$, representing the installed capacity
- $\text{RESCapacity}_{(t-th)}$, referring to previous Quarters

$th = 1$ or 2 means the previous quarter or the previous 2 quarters respectively

A number of models have been implemented. The majority of the models for the PVs in roofs have shown very good fitting, adjusted R^2 even higher than 0.9. The sign of the estimated parameters was in accordance with economic theory for most cases, namely positive for the IRR variable and negative for the CountryRisk variable. The magnitude of the IRR variable is significantly higher than that of the Country Risk variable, which is attributed to the fact that the Investors in Roof PVs are local investors. The effect of the latter variable is higher in the case of investments in PVs under 100kW, since according to the data some foreigners are also participating. However, the fact that the IRR for the PVs in 100 kW category is not as exceptionally high as in the case of Roof PVs has led to worse fitting of the different models tested. However, as the higher fitting of the model were at the levels of 0.6, the relevant results are not presented. Therefore, additional focus should be given to the Roof PVs category.

In order to incorporate variables that represent the impact of psychological, social, cognitive and emotional factors on the investments, the authors examined the literature on relevant qualitative research on RES investors' preferences. However, the existing research could not be combined with the data that was available for use in the analysis. Therefore, the authors aiming at incorporating any further behavioral effects, incorporated the historical RESCapacity ($t-th$) variable, in order capture the effect of the *social environment*. This variable, as shown in the following Table, improved significantly the fitting of the model in case of the PVs in the roofs. This is attributed to the fact that investors in PVs at roofs are affected strongly by neighbors or their social environment in general.

Table 3.1

	Model 1 (Roof PVs)	Model 2 (Roof PVs)
Adjusted R2	0.75	0.91
Intercept	-55.222	-38.203
RESCapacity(t-1)		0.486*
CountryRisk (t-1)	-0.113	-0.196
IRR(t)	3.739*	2.490*

* denotes the significance at 1% level

EPILOGUE

We cannot even begin to achieve any change whatsoever if we cannot understand that changing our planet's future is a matter that affects every single one of us. Achieving sustainability is not only about efficiency, energy investments and preserving our natural resources by cutting down our energy consumption, but it's an overall behavioral change that should occur to every imaginable aspect of our everyday lives. Only by combining policy and individual action, will we achieve the desirable results.

Behavioral theories may overturn basic assumptions proposed by traditional financial and economic theories but they also provide a new, more appropriate, framework for analysis, where agents are irrational and markets are inefficient, which brings us a lot closer to reality. Evidence indicates that there are limitations to the function of the human brain leading to cognitive and emotional biases, which in turn influence overall behavior.

RE proponents imply that renewable energy sources could potentially be the key in the reduction of carbon emissions and fossil fuel consumption in all sectors of the economy. Of course such investments could be particularly challenging in the current context of global economic uncertainty and destabilization. Although investors could mobilize capital for such investments, they often seem reluctant to do so. This is where policy comes in by trying to stimulate such investments. However, so far the results have been moderately effective due to the fact that policy by itself cannot singlehandedly achieve the desirable results. Failing to understand and incorporate the behavioral context to policy measures could prove detrimental for energy investments. The above literature review and model try to shed a bit more light to any additional drivers that could be incorporated to future suggestions in order to positively influence energy policy.

The econometric model, that has been developed, provides the first insights on the influence of some critical parameters such as the internal rate of return, the country

risk and the influence of the social environment. In order to incorporate variables that represent the impact of psychological, social, cognitive and emotional factors on the investments, the authors examined the existing literature on relevant qualitative research on RES investors' preferences. However, that particular research could not be combined with the available data for the purpose of this analysis. Therefore, the authors aiming at incorporating any further behavioral effects, incorporated the historical investment over the previous quarters, in order capture the effect of the social environment. This variable has improved significantly the fitting of the model, which is attributed to the fact that investors in PVs, especially at small installations such as those on roof-tops, are affected strongly by neighbors' behavior or their social environment in general. A continuation of this work is expected to provide further insights, depending on the category of the investment.

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