Sub-Optimal Behavior in Family Business Management: The Role of Individual Distorted Perception

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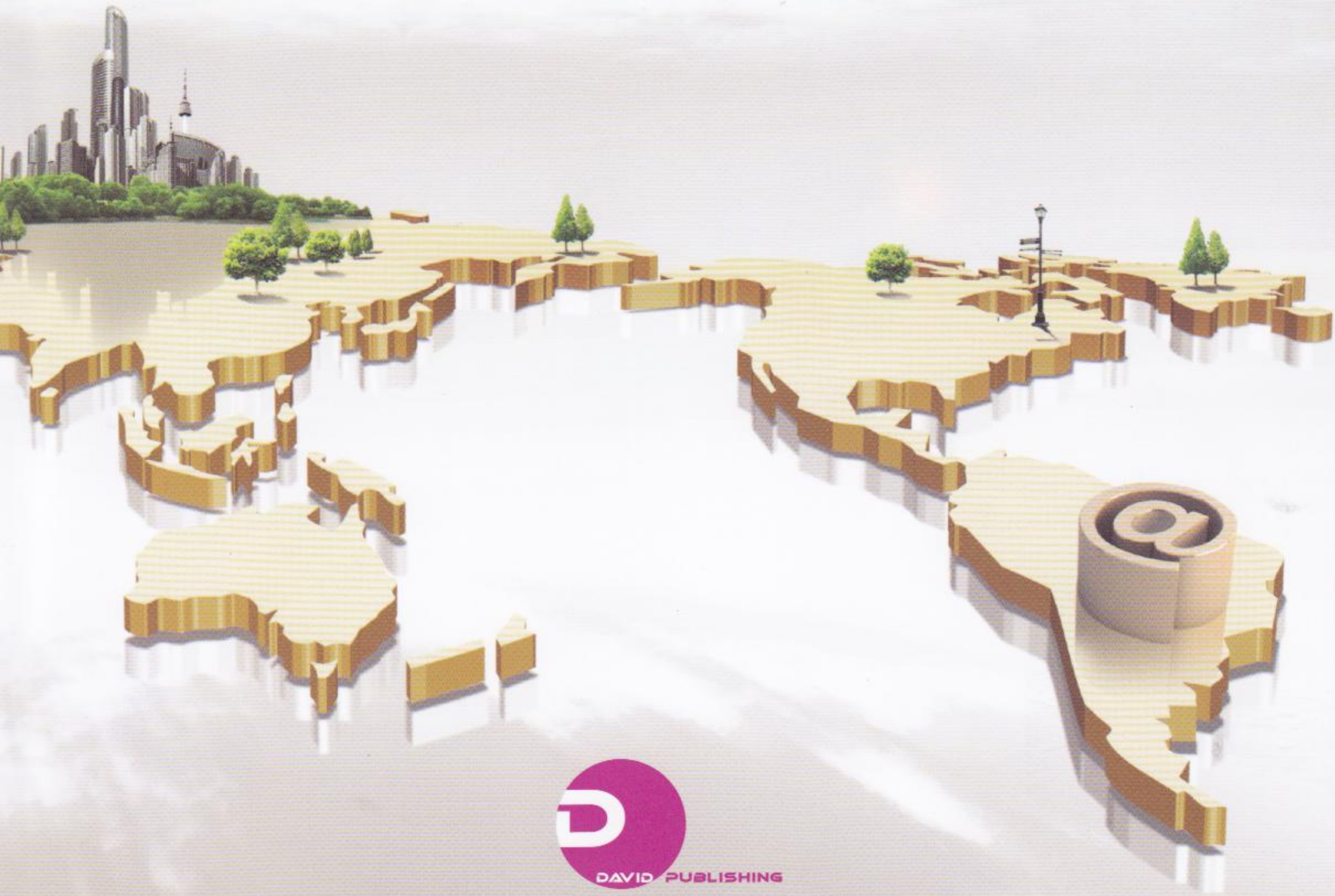

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Sub-optimal Behavior in Family Business Management: The Role of Individual Distorted Perception*

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The paper describes in detail the cognitive distortions derived from the studies of behavioural finance (BF) and moves biases, heuristics and framing effects into the context of family business management (FBM), with the goal of formally embedding them into cognitive agents, for computational modeling and simulation. BF is an approach for studying finance, economics and business management, based on the interactions among cognitive sciences and decision-making models, and explores the main cognitive distortions that could lead to sub-optimal decisions and behaviors. FBM is often characterized by sub-optimal decisions that derive from risk aversion, emotional components and the will of leaving the enterprise to the next family generation. This is the reason why the study of systematic cognitive errors brings to an improvement of FBM researches. In this paper, the most frequent behavioral distortions are analyzed in terms of FBM, and their use within computational models is proposed. A simulation model can be employed as tools for better understanding the aggregate and complex effects of emotionally distorted behaviors, as opposed to pure rational ones, when dealing with management topics of family firms. A new method for cognitive action selection is formally introduced, keeping into consideration an individual bias: ego biased learning. It allows the agents to adapt their behavior according to a payoff coming from the action they performed at time t-1, by converting an action pattern into a synthetic value, updated at each time, but keeping into account their individual preferences towards specific actions. The contribution to the field of FBM is represented by the possibility of measure how strategic choices depend on the way in which the owners/managers act, by identifying the main distortions that characterize their actions (what is good for a family and good for the enterprise, conservationism, risk aversion, irrational capital allocation and so on). The model proposes an approach to risk management and to strategic process analysis, based on the knowledge of these systematic errors, with the purpose of avoiding them and moving towards an optimal aggregate outcome.

Keywords: family business management, strategic decision making, biased behaviour

Introduction

Empirical evidences prove that the economic agent features systematic distortions, compared to the

* The article has been jointly written by the authors, and each of them equally contributed to the whole work. The authors are listed in alphabetical order.

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prescriptions coming from the traditional theories of markets efficiency. For example, it's typical for an individual to excessively suffer for the fear of having to regret about her past per-formed actions. Risk aversion, i.e., the reluctance of a person to accept a bargain with an uncertain payoff rather than another bargain with a more certain, but possibly lower, expected payoff could prevent the economic agent from fully taking advantage of earning opportunities in an optimized way, just to avoid losses she could then recriminate about. The individuals' behavior is often based on cognitive dissonances, thus giving life to an attitude defined as "refusal", referred to the defense of the performed choices, even if the empirical evidence would suggest changing strategy. Last but not least, when an individual has to choose, she is usually biased by a system of behavioral influences that is far from the rationality criterions of economic convenience (De Martino, Kumaran, Symur, & Dolan, 2006).

These distortions can be configured, in a more evident way, in the decision system regarding family business management (FBM). Irrationality and the consequences of these distorted behaviors, with referrals to enterprise management are not explained by orthodox theory and, in the financial field, are usually considered as anomalies (Shefrin, 2000). Behavioural finance (BF), on the contrary, studies these phenomena towards which the scientific community shows more and more interest. How psychology can influence financial decisions? How can it influence, in a wider sense, those decisions linked to FBM?

In the first part, the paper analyzes the most common cognitive distortions, which characterizes economic agents' behaviors in the field of BF, with the goal of extending the relations with the system of FBM.

Biases, heuristics and framing effects are systemized to qualify the potential effects of behavioral distortions deriving from them and to put them into relation with the main systematic errors characterizing the management of a family business.

In the second part, these distortions are represented through a formal model, that can be considered as the basis of an agent based computational model, allowing evaluating the effects by means of simulation methodologies.

Through this approach, it will be highlighted that strategic choices of family businesses depend on the way in which they are represented and, consequently, how they could determine situations of decisional sub-optimum, thus contributing to a knowledge increase.

Last, the introduction of a learning coefficient, based on the theory of reinforcement learning (RL), with the purpose of stimulating the activation of necessary drivers for improving the management of a family business through a higher knowledge of cognitive distortions that can lead to systematic errors, will clarify the possible declinations of the model, for future research applications.

Behavioural Finance, Cognitive Distortions and Prospect Theory

Many classical economists investigated the relationships among cognitive and economic sciences; Smith, Marshall, Pigou, Fischer and Keynes studied the psychological foundations of preferences and beliefs (Thaler, 1977). The definitive elimination of psychological elements from economic theory dates back to the seventies (Lucas, 1975). In a scientific context focalized on modeling the complete rationality for economic agents, two scientific contributions appear, still considered as the main theoretical premises to BF. These are the works by Kahneman-Tversky (1974, 1979), respectively about "heuristics and preferences" and the so called "prospect theory". These works, which approach psychology and economics, are soon followed by those by Richard Thaler

(1980). The orthodox theoretical financial discipline has been created in order to fix prescriptive rules and to describe the choices performed in the real world. BF does not mean to discuss these rules, but aims to describe reality where traditional models fail. The two research approaches are thus complementary, traditional finance gives proper indications about how to take decisions. BF effectively describes the behavior of agents within markets and organizations. The model of traditional finance is founded on the figure of a rational agent, which systematically performs the correct choices, assuming that the choice makers follow an optimizing behavior. In order to justify the validity of this approach, the possible irrationality of the agents is considered as a behavior that, since arbitrariness exists, does not determine relevant financial effects. Thus, the theoretical approach has not to be judged upon the hypotheses on which is based, but for the validity of the estimates, it could produce (Friedman, 1953).

Empirical evidence, though, shows how the behavior of economic agents is sometimes irrational. This irrationality derives from a system of behavioral distortions that can be analyzed, classified and put in relation with the "enterprise system" and its mechanisms of governance, which could be brought back to the complex set of managerial strategic decisions.

In the following paragraphs, the main cognitive distortions and models identified by BF are analyzed in details.

Cognitive Distortions

The Many "anomalies" of the markets suggest that agents' behaviors are sometimes quite far from completely rational conducts. According to the heuristics, the financial choices are based on experience, in addition to rational basis. The cognitive distortions taking part in human behavior are divided into three categories: the heuristics, the biases, and the framing effects (Shefrin, 2000), which are a direct consequence of prospect theory (Kahneman & Tversky, 1979).

Heuristics. The heuristics are rules proposed to explain how individuals solve problems, give judgments, and take decisions when facing complex situations or incomplete information. The justification for their existence is founded on the assertion for which the human cognitive system is based on limited resources and, not being able to solve problems through pure algorithmic processes, uses heuristics as efficient strategies for simplifying decisions and problems. Even if they succeed in most cases, these systems could bring to systematic errors. When referring to economic agents' decision processes, the availability of information and the velocity with which they are supplied and spread, significantly increased over the past, thus obliging the simple investors, but also the specialized operators, to an higher effort to correctly elaborate the data. At a psychological level, when the number and the frequency of information increase, the brain tries to find some "shortcuts", allowing reducing the elaboration time, in order to take a decision anyway. These shortcuts are defined heuristics (or rules of thumb). On one side, they allow managing the information in a quick and selective way; On the other side, they could bring to wrong or excessively simplified conclusions.

As an example, we may think about the founder of an enterprise who takes her own decisions basing on the experience matured in a competitive scenario, which sometimes is significantly different.

The most significant heuristics are representativeness, availability and anchoring. The first one shows how economic agents tend to make their choices on the basis of stereotypes (e.g., "winner-loser" effect) that could lead to errors caused by wrong estimates. When referring to the availability, the individuals tend to assign a probability to an event, based on the quantity and on the ease with which they remember the event happened in the past. Once again, the heuristic error is the consequence of a simplified cognitive model.

Anchoring is the third heuristic behavior that could generate errors in the decision process. It's the attitude of the individuals to stay anchored to a reference value, without updating their estimates. It's at the bases of conservative attitudes often adopted by economic agents.

Again, we may refer to the founder of an enterprise who decides basing on her experience: The inability of adapting to change stimulates anchorage and configures a risky behavior for the whole enterprise.

Last but not least, also "affect heuristics" could impact decisions. By following emotions and instincts, sometimes more than logically reasoning, some individuals could decide to perform a decision in a risky situation, while not to perform it in other, apparently safer, ones. As an example for this, we may think of the entrepreneur that slows down or even prevents the transfer of her enterprise, for the emotional involvement.

Biases. Bias could be considered a systematic error. The most common biases are the over-optimism, confirmation bias, control illusion, and the excessive self-confidence. The concept of overconfidence is one of the most important and studied effects for BF (Lintner, 1998). Many individuals have excessive confidence in their own means, thus overestimating their capabilities, knowledge and the precision of their information. The tendency to overconfidence seems to be a natural feature of human behavior.

Conservatism is a widespread prejudice which influences individuals when taking decisions. It can be defined as the tendency of humans to keep their own beliefs and convictions, or to change them too slowly, even when they face an evidence of those being wrong. Conservative individuals find it difficult to abandon a conviction even when it's obviously wrong, and thus they have a very slow adaptation process to new beliefs and theories.

Confirmation bias is a mental process which consists in giving the most importance, among the information received, to those reflecting and confirming the personal believes and, vice versa, in ignoring or debasing those negating inner convictions. This process, if exploited, could be even a powerful control tool, and could even lead an individual or a community to deny the obvious. On the contrary, the hindsight bias consists in the error of the retrospective judgment, i.e., the tendency of people to erroneously believe, after an event has taken place, that they would have been able to correctly predict it a priori. In the final phase of the judgment process, the individuals usually tend to create an expectation of success often higher than the objective one. An illusory control model is that based on wishful thinking, according to this phenomenon an event is considered as more probable than another one, simply because it is seen as more desirable. At the same way, linked to the illusion of control there is also the concept of the fear of regret. That's the tendency of feeling distressed for a wrong choice rather than being sad for the effect it produced. The consequence is that of postponing or even avoiding making a choice, justifying this with the necessity to gather more information, even if these won't change the decision maker's mind. Another basic behavioral principle is the so called "aversion to ambiguity", often referred to as "uncertainty aversion". This can be synthesized in the sentence "people prefer the familiar to the unfamiliar" (Shefrin, 2000) and describes an attitude of preference for known risks over unknown risks, which can bring people to running a higher, though known, risk, over a potentially lower, but unknown, one. That it is not the same as "risk aversion", which is the reluctance of a person to accept a bargain with an uncertain payoff rather than another bargain with more certain, but possibly lower, expected payoff. Many persons use to be unsatisfied when they are convinced that they didn't perform the best possible action. In order to avoid this, some people modify their behavior in an apparently irrational way. This is the regret theory that people know that when they make a decision they will feel regret if they make the wrong decision. They take this anticipated regret into account when they decide, thus modifying their decision accordingly. Among two alternatives, a person will choose the one for which she feels rejoicing, i.e., the one with the most desirable consequence, over the one for which she feels regret, i.e., the one with the least desirable consequence. The problem arises when a personal conviction is wrong and a person realizes that (cognitive dissonance). This is a form of regret a priori, influencing the final decision. Some persons could even find fancy and twisted argumentations to support their original idea and reduce the cognitive dissonance, in order to avoid the inner conflict caused by the evidence of being wrong.

Framing effects. The term "framing" is referred to a selective influence process on the perception of the meaning of words and sentences. These distortions are derived from prospect theory, whose aim is to explain how and why the choices are systematically different from those predicted by the standard decision theory. Prospect theory is alternative to that of expected utility, when it comes to understanding the human behavior under uncertainty conditions, and adopts an inductive and descriptive approach. This theoretical foundation can be interpreted as a synthetic representation of the most significant anomalies found in decisional processes under uncertainty. The analysis carried on in Kahneman and Tversky (1979) who highlights some behaviors seen as violations to the expected utility: the certainty effect, the reflect effect and the isolation effect. The certainty effect is referred to the fact that, when facing a series of positive results, people tend to prefer those considered as certain or almost certain, when compared to others with a higher expected value, but not certain. Many other important framing effects are derived from the certainty effect, e.g., aversion to certain lost, bringing people to secure choices, even if less economically worthy. The reflect effect happens when turning the previous situation upside down, i.e., instead of considering the probability of a positive outcome, that of a negative outcome is indeed considered. While when considering positive situations, the individuals are risk-averse, and tend to become risk-seeking when all the alternatives seem to be negative (they often choose the least certain ones, even when apparently worst, possibly hoping that they will turn less negative). The isolation effect is the tendency to disregard the common elements among more possible choices, just focusing on the differential elements. This can lead to errors, since the apparently equal aspects of different situations can be indeed different, when coupled to others (there could be several ways to decompose a real problem, and many situations are indeed complex, thus stressing the interaction among the parts).

Family Business and Perception Biases

Managerial enterprises, funded on separation among control and property, and organized with professional managerial teams are, according to researchers, more innovative and efficient than a family business (Chandler, 2004). Also theories about value creation consider the concentration of property in one or few families as an element that does not contribute in a positive way to protect minorities and to maximizing the share value (Carney, 2005).

In spite of these theoretical criticisms, the empirical evidences show that family businesses, both in emergent and developed economies, have a significant role in terms of contribution to the growth of GDP and to create new job places (Ifera, 2003). Governance, generational passage, strategic management, internationalization and finance are themes that, in the present global competitive scenario, most of the family businesses have to face and manage. To this extend, the family model is not inadequate or overtaken, but on the contrary, it seems to need further research examinations and analysis. This is especially true from a strategic point of view and referring to the impact that the features of family business have towards enterprise performance.

A new perspective can come from cognitive sciences, which focus on the main behavioral distortions, which characterize human decisions. Within enterprise system, it's possible to refer these researches to management and government decisions. The individuals that manage an enterprise are subject to psychological phenomena that affect any decision makers, and the knowledge about behavioral distortions can represent an important learning element for analysis and management of enterprise strategic process.

Nature and structure of management and property in a family business are deeply different from those pertaining other kinds of enterprises. So, behavioral distortions affecting a manager of a family business are empirically deducible by analyzing the behavioral system of decision makers within the enterprises based on this model.

The goal of this paragraph is to make a systemic analysis of the links that can be identified among sub-optimal decisions of a family business and the cognitive biases of decision makers. In particular, the consequences are highlighted, which derive from systemic errors that can be proper of the management of a family business.

In the following paragraphs, it will show how to represent some of these distortions within a computational framework that, by identifying a learning technique (reinforcement learning) allows proposing an approach integrated with performance evaluation and, consequently, a possible improvement strategic management of family businesses.

In general behavioral distortions cause a diminishing of the enterprise value, and this loss is often linked with the increase (or under esteem) of risk, but also to the higher weighted average cost of capital (WACC) and to the low propensity to growth that, especially in the present competitive scenario, can become direct causes for the unsuccessful future of a family business.

Many of the psychological phenomena examined within BF are confirmed by cognitive decisions characterizing family business management. The entrepreneur of a family business, for a series of motivations known in literature, could decide to postpone her decisions about succession and inheritance without properly planning the phenomenon, with the consequence of increasing the systemic risk within the family business. This mood is typically linked with biases like excessive optimism and overconfidence.

The latter is linked (especially for the owner of a family business) to the excessive trust in her own capabilities, often arisen in deeply different historical contexts. Within an enterprise where decisional power is often centralized in the figure of the owner/manager, the individual can be clever and endowed with government capabilities, but risks to become arrogant and, thinking of knowing more that she really knows, can cause value losses to the family business. This kind of manager also uses to ignore information which are in contrast with her opinion, shaped overtime, and to consider only those that confirm it (confirmative bias). These prejudices are often linked to the fact of thinking, erroneously, that what is good for the family is also good for business (Zahra & Sharma, 2004). This determines a slowness of family business to adapt itself to the changes occurring in the surrounding environment and, once more, a value loss, and in the short terms, a profit loss. The owner of a family business that provokes a postponed or eluded succession (Brockhaus, 2004) can be subject to the illusion of control. In other terms, she overestimates her capability to control the business, forgetting that every decision depends both on ability and on fortune. Overtime, the latter could vanish. The effects of the "illusion of control" are higher costs for the family business that, doing so, looses the efficiency linked to a known feature (i.e., having lower costs when compared to other enterprise models).

Also heuristics, i.e., rules adopted to simplify the complexity of super and sub systems of enterprise's decision processes, are a feature of family businesses. The family business managers adopt stereotypes and simplifications more than the managers of other kinds of enterprises.

Representativity, availability, anchoring as well as affect heuristics produce recurrent cognitive distortions to family business management.

As an example, we can think of the simplifications that a manager of a family business could adopt in choosing her successor or, more generally, in choosing human resources (often among family members), and last but not least, in the allocation of financial resources (Gallo & Vilaseca, 1996).

An increase of risk, costs, WACC and a diminishing of enterprise value are some of the consequences of the simplifications.

The endemic overlapping of family system with the enterprise system determines, as known, a higher risk aversion for an owner of a family business (Adams, Manners, Astrachan, & Mazzola, 2004).

Literature about family business states the existence of a relationship among the familiar character of the enterprise and the cost of capital used by the enterprise itself to evaluate the convenience of investment opportunities that it considers overtime (Zellweger, 2006). In order to be able to fully understand the essence of a family business, it's necessary not only to study the personality of each member separately, but, on the contrary, to analyze the complex relationship system existing among the individuals of the same family that, inevitably, ends with influencing behaviors and emotions (Kets de Vries, Carlock, & Florent-Treacy, 2007).

Family businesses would then be characterized by a higher risk aversion (Gallo, Tapies, & Cappuyns, 2004), i.e., an amplified perception of risk that could influence decisional processes of managers and members of the family, when they need to make strategic long-term choices with unavoidable potential effects on the equilibrium of both the enterprise and family.

This perceptive distortion is funded on two features of family businesses: The overlapping of enterprise's assets and family's assets, and the fact that the decision maker can have at the same time different (and potentially conflicting) interests towards the enterprise.

When analyzing the decisional behavior of a familiar entrepreneur, we can think, once more, to the wrong identification of the priority due to the emotional component, determining an anchorage to family values and not allowing the right emotional distance. A diminishing of value, perceptive under evaluation and low growth propensity are the main consequences.

The entrepreneur of a family business judges as correct what she feels at an emotional level, falling in the "affect reaction". Thus, it's possible to affirm that emotional determinants can influence the owners/managers of family businesses in the process of quantification of the WACC, and in the consequent evaluation of internationalization, innovation and growth strategies. By using this research perspective to decode the process of strategic management of a family business, those perceptive determinants represent elements of sub-optimum within family business. By accepting the existence, in a family business, of cultural, social and economic conditions that influence under the emotional-psychological way the managers' behaviors, by bringing them to a risk adverse attitude, one could deduce that emotional factors could bring a super-perception of the cost of capital, that determines, ceteris paribus, a higher WACC and hence, in perspective, a lower profitability of the investment hypotheses, evaluated one by one.

Lastly, by referring to the framing effects and the prospect theory, it's important to remember that the owner/manager of a FB perceives the loose of control as a higher cost when compared to the benefit deriving from the opening of management or capital towards other subjects. This negative trade-off determines sub-optimal decisions in the choice of allocating human resources, and brings to renounce to strategies that involve these kinds of resources (e.g., internationalization). The fear of losing the enterprise can lead the entrepreneur to invest or to give as a warranty the assets of her family, in order to keep the business alive, and this also happens when measurable elements should make it better to cease the activity or to open to new partners (with the consequent loss of power and control). Synthesizing, we can maintain that all these distortions determine a systematic loss of value for the family business, and this function can be represented, referring to loss aversion of the individuals, as in Figure 1.

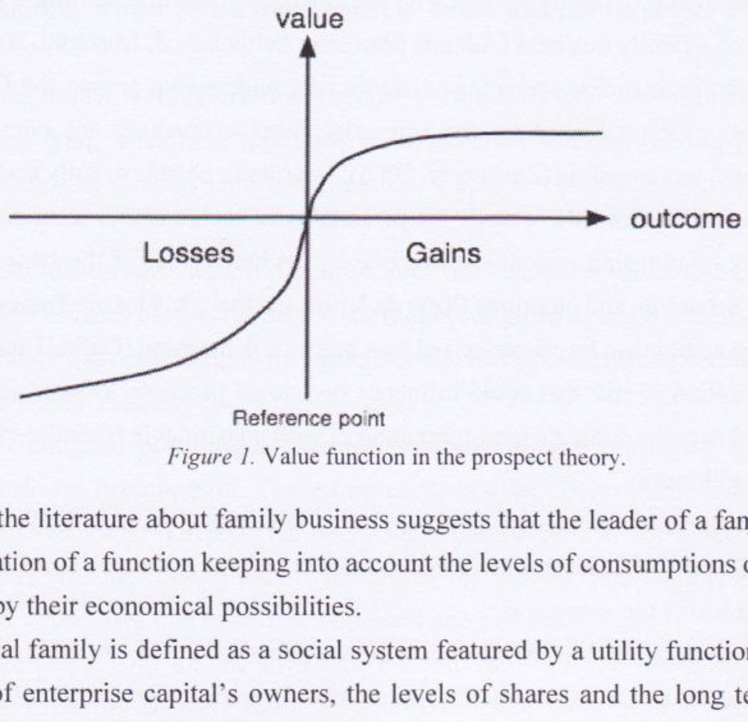

Figure 1. Value function in the prospect theory.

Speaking of this, the literature about family business suggests that the leader of a family should have as her own goal the maximization of a function keeping into account the levels of consumptions of the family members, and that is influenced by their economical possibilities.

The entrepreneurial family is defined as a social system featured by a utility function keeping into account the levels of income of enterprise capital's owners, the levels of shares and the long term process of wealth accumulation. Family businesses have to face goals of a different nature (not only economical but also financial) that can be comprised by the concept of "trans-generational value creation" (Habbershon, 2003). In Table 1, a series of psychological phenomena that could lead to cognitive distortions in the management of a FB.

In Figure 2, a chart about decision making is depicted within the boundaries of systemic risk. The relations influence both the family and the enterprise (not necessarily in the same way) and, in turn, family and enterprise's issues affect individuals. They are human and hence potentially subject to cognitive distortions, affecting family business management and bringing sub-optimal decisions and outcome. Through reinforcement learning techniques (i.e., learning by trial and errors through models and simulations) these cognitive distortions can be (partially or even totally) avoided. This brings to value maximization, seen as a (local) optimum. In the next paragraphs, a formalism based on RL is introduced and discussed, in order to be used in computational simulation models.

Table 1
Examples of Biases and Their Potential Effects on FBM

Psychological phenomenon	Examples of cognitive distortion in FBM	Consequences for the FB (sub-optimums)
(1) Biases • Excessive optimism • Overconfidence • Confirmation bias • Control illusion	Postponing the decision regarding succession and/or enterprise transfer. Not planning the succession. Having an excessive trust in own capabilities and thinking of knowing more than it really is. Ignoring information in contrast with own opinion and considering only those that confirm it. Believing that what is good for the family is good also for the FB. Overestimating control level, forgetting that each decision depends on ability and luck.	Augmented risk. Underestimated risk. Value loss. Profit loss. Latency for adaptation to changes. Higher costs.
(2) Heuristics • Representativeness • Availability • Anchoring • Affect reaction	Taking decisions simplifying complexity, e.g., when choosing a successor, human or financial resources. Being excessively conservative when taking decisions (due to risk aversion and emotional components). Being emotionally and a-critically anchored to old family values and traditions. Judging as correct only what is "felt" at an emotional level (not rationally proven).	Value loss. Increased WACC. Wrong identification of priorities. Low propensity to growth. Survival at risk.
(3) Framing effects • Aversion to loss • Aversion to certain loss	Perception of control loss on FB higher than the benefit derived from opening to external subjects (negative tradeoff). Investing a part or all the family capital (directly or as a warranty for financing) to keep the FB alive (even when the choice is not objectively rational).	Renounce to the benefits derived from external HR and K. Renounce to development strategies (i.e., international growth). Value loss.

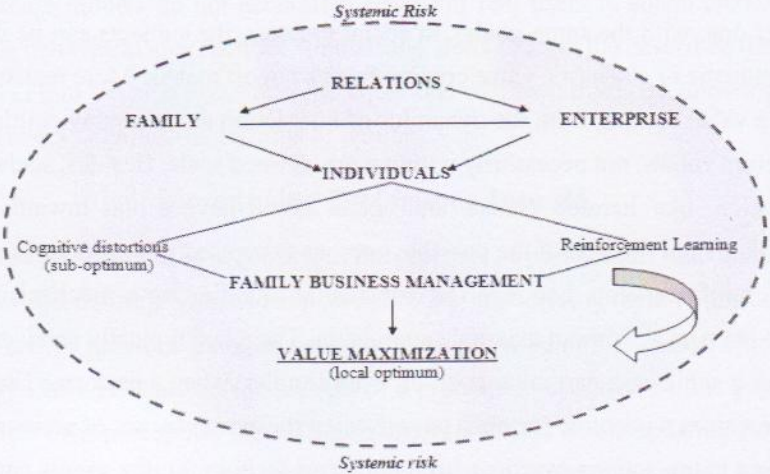

Figure 2. Influences of distortions and reinforcement learning, within systemic risk frame.

Agents and Reinforcement Learning

When dealing with the problem of action selection, in a computational model, reactive or cognitive agents can be employed. Reactive agents feature a wired behavior, deriving from some conditional embedded rules that cannot be changed by the circumstances, and must be foreseen and wired into them by the model designer. This can be deterministic or stochastic, but won't change based on the experience. Reactive agents are good for simulations, since the results obtained by employing them are usually easily readable and comparable (especially for ceteris paribus analysis). Besides, when the agent's behavior is not the primary focus, reactive agents, if their rules are properly chosen, give very interesting aggregate results, often letting emergent system properties emerge at a macro level. Though, in situations in which, for example, learning coordination is important, or the focus is on exploring different behaviors in order to dynamically choose the best one for a given state, or simply agent's behavior is the principal topic of the research, cognitive agents can be employed, embedded with some learning technique. Besides, if the rules of a reactive agent are not chosen properly, they could bias the results, which in fact, are chosen by the designer and thus reflect her own opinions about the modeled system. Since many computational models of social systems are formulated as stage games with simultaneous moves made by the agents, some learning techniques derived from this field can be embedded into them, in order to create more realistic response to the external stimuli, by endowing the agents with a self-adapting ability.

Though, multi-agent learning is more challenging than single-agent, because of two complementary reasons. Treating the multiple agents as a single agent increases the state and action spaces exponentially and is thus unusable in multi agent simulation, where so many entities act at the same time. On the other hand, treating the other agents as part of the environment makes the environment non-stationary and non-Markovian (Mataric, 1997). In particular, models are non-Markovian systems if seen from the point of view of the agents (since the new state is not only function of the individual agent's action, but of the aggregate actions of all the agents) and thus traditional Q-learning algorithms (Sutton & Barto, 1998) cannot be used effectively. The actors involved in real social systems have a local vision and usually can only see their own actions or neighbors' ones (bounded rationality) and, above all, the resulting state is function of the aggregate behaviors, and not of the individual ones. While, as discussed in Sutton and Barto (1998), in iterated games learning is derived from facing the same opponent (or another one, with the same goals), in social systems, the subjects can be different and the payoff could not be a deterministic or stochastic value coming from a payoff matrix. More realistically, in social systems, the payoff could be a value coming from the dynamics of interaction among many entities and the environment, and could have different values, not necessarily within a pre-defined scale. Besides, social models are not all and only about coordination, like iterated games, and agents could have a bias towards a particular behavior, preferring it even if that's not the best of the possible ones, as expressed in the previous paragraphs.

Learning from reinforcements has received substantial attention as a mechanism for robots and other computer systems to learn tasks without external supervision. The agent typically receives a positive payoff from the environment after it achieves a particular goal, or, even simpler, when a performed action gives good results. In the same way, it receives a negative (or null) payoff when the action (or set of actions) performed brings to a failure. By performing many actions overtime (trial and error technique), the agents can compute the expected values (EV) for each action. According to Sutton and Barto (1998) this paradigm turns values into behavioural patterns. In fact, each time an action will need to be performed, its EV, will be considered and compared with the EVs of other possible actions, thus determining the agent's behavior, which is not wired into the agent itself, but self adapting to the system in which it operates. Most RL algorithms are about coordination in multi agents systems, defined as the ability of two or more agents to jointly reach a consensus over which actions to perform in an environment. In these cases, an algorithm derived from the classic Q-learning technique can be used. The EV for an action, EV(a), is simply updated every time the action is performed, according to equation (1), reported by Kapetanakis and Kundenko (2004):

$$EV(a_t) \leftarrow EV(a_{t-1}) + \lambda(p - EV(a_{t-1})) \quad (1)$$

where λ is the learning rate, and p is the payoff received every time action a is performed. The aforementioned RL algorithm analytically evaluates the best action based on historical data, i.e., the EV of the action itself, over time.

Biasing the Learning Algorithms

Simulation applied to social system is not necessarily about coordination among agents and convergence to the optimal behavior, especially when focusing on the aggregate level. It's often more important to have a realistic behavior for the agents, in this sense that it should replicate, as much as possible, that of real individuals. The aforementioned RL algorithm analytically evaluates the best action based on historical data, i.e., the EV of the action itself, over time. This makes the agent perfectly rational, since it will evaluate, every time she has to perform it, the best possible action found till then. If this is very useful for computational problems where convergence to an optimal behavior is important, it's not realistic when applied to a simulation of a social system. In these kind of systems, learning should take into account the human factor, in the shape of perception biases, preferences, prejudice, and external influences and so on. When a human (or an organization driven by humans) faces an alternative, the past results, though important for evaluation, are just one of the many components behind the action selection process and the distortions analyzed in previous paragraphs should be kept into account for the individual agents, in order to create more realistic models of financial markets. Traditional learning models can't represent individualities in a social system, or else they represented all of them in the same way, i.e., as focused and rational agents, since they ignore many other aspects of behavior that influence how humans make decisions in real life, these models do not accurately represent real users in social contexts. This is the main reason for proposing the behavioral approach for simulations, derived from the described theoretical frameworks. Starting from equation (1), in the next section, some equations will be introduced, showing how RL algorithms can be changed, so to reflect cognitive distortions of humans.

Introducing Distortions Into RL

Even if preferences can be modified according to the outcome of past actions (and this is well represented by the RL algorithms described before), humans keep an emotional part driving them to prefer a certain action over another one, as described in previous paragraphs. That's the point behind learning: Human aren't machines, which are able to analytically evaluate all the aspects of a problem and, above all, the payoff deriving from an action is filtered by their own perception bias. There's more than just a self-updating function for evaluating actions and in the following a formal reinforcement learning method is presented which keeps into consideration a possible bias towards a particular action, which, to some extents, make it preferable to another one that has analytically proven better through the trial and error period. As a very first step towards that direction, "ego biased learning", introduced by Marco Remondino, allows to keep personal fact or into consideration, when applying a RL paradigm, by modeling two perception errors described in previous paragraphs: anchoring and affect heuristics. In the first formulation, a dualistic action selection is considered, i.e., $A(a_1, a_2)$. By applying the formal reinforcement learning technique described in equation (1) an agent is able to have the expected value for the action it performed. We imagine two different categories of agents (α_1, α_2): one biased towards action a_1 and the other one biased towards action a_2. For each category, a constant is introduced $(0 < K_1, K_2 < 1)$, defining the propensity for the given action, used to evaluate $\overline{EV(a_1)}$ and $\overline{EV(a_2)}$ which is the expected value of actions, corrected by the bias. For the category of agents biased towards action a_1 we have:

$$\alpha_1: \begin{cases} \overline{EV(a_1)} = EV(a_1) + (|EV(a_1)| * K_1) \\ \overline{EV(a_2)} = EV(a_2) - (|EV(a_2)| * K_1) \end{cases} \tag{2}$$

In this way, K_1 represents the propensity for the first category of agents towards action a_1 and acts as a percentage increasing the analytically computed $EV(a_1)$ and decreasing $EV(a_2)$. At the same way, K_2 represents the propensity for the second category of agents towards action a_2 and acts on the expected value of the two possible actions as before:

$$\alpha_2: \begin{cases} \overline{EV(a_1)} = EV(a_1) - (|EV(a_1)| * K_2) \\ \overline{EV(a_2)} = EV(a_2) + (|EV(a_2)| * K_2) \end{cases} \tag{3}$$

The constant K acts like a "friction" for the EV function; after calculating the objective $EV(a_i)$ it increments it of a percentage, if a_i is the action for which the agent has a positive bias, or decrements it, if a_i is the action for which the agent has a negative bias. In this way, the agent α_1 will perform action a_1 (instead of a_2) even if $EV(a_1) < EV(a_2)$, as long as $\overline{EV(a_1)}$ is not less than $\overline{EV(a_2)}$. In particular, by analytically solving the following:

$$EV(a_1) + (|EV(a_1)| * K_1) \geq EV(a_2) - (|EV(a_2)| * K_1) \tag{4}$$

We have that agent α_1(biased towards a_1) will perform a_1 as long as:

$$EV(a_1) \geq EV(a_2) * \frac{1-K_1}{1+K_1} \tag{5}$$

Equation (5) applies when both $EV(a_1)$ and $EV(a_2)$ are positive values. If $EV(a_1)$ is positive and $EV(a_2)$ is negative, then a_1 will obviously be performed (being this a sub-case of equation (5)), while if $EV(a_2)$ is positive and $EV(a_1)$ is negative, then a_2 will be performed, since even if biased, it wouldn't make any sense for an agent to perform an action that proved even harmful (that's why it went down to a negative value). If $\overline{EV(a_1)} = \overline{EV(a_2)}$, by definition, the performed action will be the favorite one, i.e., the one towards which the agent has a positive bias.

In order to give a numeric example, if $EV(a_1) = 50$ and $K_1 = 0.2$ then a_1 will be performed by agent α_1 till $EV(a_2) > 75$. This friction gets even stronger for higher K values; for example, with a $K_1 = 0.5$, a_1 will be performed till $EV(a_2) > 150$ and so on. By increasing the value of K_1, the positive values of $EV(a_1)$ turns into higher and higher values of $\overline{EV(a_1)}$. At the same time, a negative value of $EV(a_1)$ gets less and less negative by increasing K_1, while never turning into a positive value (at most, when $K_1, \overline{EV(a_1)}$ gets equal to 0 for every $EV(a_1) < 0$). For example, with $K_1 = 0.1$, $\overline{EV(a_1)}$ is 10% higher than $EV(a_1)$. Since a_2 is the action towards which the agent α_1 has a negative bias, it's possible to notice that the resulting $\overline{EV(a_2)}$ is always lower (or equal, in case they are both 0) than the original $EV(a_2)$ calculated according to equation (1). In particular, higher K_1 corresponds to more bias (larger distance among the objective expected value), exactly opposite as it was before for action a_2. Note that for a $K_1 = 1$ (i.e., maximum bias) $\overline{EV(a_2)}$ never gets past zero, so that a_2 is performed if and only if $EV(a_1)$, and hence $\overline{EV(a_1)}$, is less than zero. The first general case (more than two possible actions and more than two categories of agents) is actually a strict super-case of the one already formalized. Each agent is endowed with an evaluation biased function derived from equation (2) and equation (3).

Be $\alpha(\alpha_1, \alpha_2, \ldots, \alpha_n)$ the set of agents, and $A(a_1, a_2, \ldots, a_m)$ the set of possible actions to be performed, then the specific agent α_k, with a positive bias for action a_h will feature such a biased evaluation function:

$$\alpha_k: \begin{cases} \overline{EV(a_1)} = EV(a_1) - (|EV(a_1)| * K_1) \\ \ldots \\ \overline{EV(a_{h-1})} = EV(a_{h-1}) - (|EV(a_{h-1})| * K_1) \\ \overline{EV(a_h)} = EV(a_h) + (|EV(a_h)| * K_1) \\ \overline{EV(a_{h+1})} = EV(a_{h+1}) - (|EV(a_{h+1})| * K_1) \\ \ldots \\ \overline{EV(a_m)} = EV(a_m) - (|EV(a_m)| * K_1) \end{cases} \tag{6}$$

This applies to each agent, of course by changing the specific equation corresponding to her specific positive bias. Even more general, an agent could have a positive bias towards more than one action; for example, if agent α_5 has a positive bias for actions a_1 and a_2 and a negative bias for all the others, the resulting formalism is equation (7) and, in the most general case, for each $\overline{EV(a_i)}$ we have the equation (8). In case that two or more $\overline{EV(a)}$ have the same value, the agent will perform the action towards which it has a positive bias. In the case explored by equation (7), in which the agent has the same positive bias towards more than one action, then the choice among which action to perform, under the same $\overline{EV(a)}$, is managed in various ways (e.g., randomly).

$$\alpha_5: \begin{cases} \overline{EV(a_1)} = EV(a_1) + (|EV(a_1)| * K_1) \\ \overline{EV(a_2)} = EV(a_2) + (|EV(a_2)| * K_1) \\ \overline{EV(a_3)} = EV(a_3) - (|EV(a_3)| * K_1) \\ \ldots \\ \overline{EV(a_m)} = EV(a_m) - (|EV(a_m)| * K_1) \end{cases} \tag{7}$$

$$\overline{EV(a_i)} = EV(a_i) \mp (|EV(a_i)| * K_j) \tag{8}$$

As a last general case, the agents could be a different positive/negative propensity towards different actions. In this case, the K variable to be used won't be the same for all the equations regarding an individual agent. For example, given a set of $K(K_1, K_2, \ldots, K_n)$ and a set of actions $A(a_1, a_2, \ldots, a_m)$, for each agent (α_k) we have:

$$\alpha_k: \begin{cases} \overline{EV(a_1)} = EV(a_1) \mp (|EV(a_1)| * K_1) \\ \ldots \\ \overline{EV(a_m)} = EV(a_m) \mp (|EV(a_m)| * K_n) \end{cases} \tag{9}$$

Being a fixed parameter, K could be a stochastic value, e.g., given a mean and a variance.

Conclusions

This paper uses a novel systemic and inter disciplinary approach to introduce the links among human cognitive distortions—derived from psychology and behavioural finance—and family business management. In particular, strategic choices of family firms are believed to depend on the way in which their owners and managers represent them. Much of the family business management is influenced by individual cognitive distortions that, sometimes, could harm the enterprise and, in general, lead to sub-optimal aggregate results.

In this context, the behavior and cognitive distortions of owners/managers can be formally represented, taking cues from the analytical representation of a rational agent, employing the paradigm of reinforcement learning. This technique, borrowed from the field of artificial intelligence, allows building computational models based on individual rational agents, in order to study and analyze the emergent aggregate behavior. In this work the equations are modified in order to introduce a bias, mimicking some of the cognitive distortions, typical in the family business management.

Through the link among cognitive distortions and reinforcement learning, it is possible to identify the "macro effects" produced by the model (in which the agents individually act at a micro level) which are equivalent to those, found in the real world, affecting the FBM. This brings to a formal and higher knowledge of systematic errors that, starting from sub-optimal results, pushes the individual to improve the way in which she manages her enterprise.

This novel analytical model moves from and extends the existing research in the family business field and is suitable for practical and empirical implementations.

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