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Using prediction markets for decision support

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Using Prediction Markets for Decision Support

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Submitted in fulfilment of the requirements for the degree of Doctor of
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Abstract

Organisations have always faced the challenge of making decisions in the context of large, dynamic, complex environments. The information technology revolution has increased by several orders of magnitude the information available to decision makers. However, information technology offers the promise of not just improving the information available to the decision making process, but also transforming the decision making process itself. This dissertation focuses on a relatively novel form of group decision making called a prediction market. Prediction markets use a market mechanism to aggregate the information held individually by a large, geographically and temporally separate group. Prediction markets are proposed as useful tools in a wide variety of organisational decision making situations. They are optimally deployed using information technology, which allows the defining characteristics of prediction markets such as scalability to be utilized to maximum effect.

This dissertation investigates prediction markets as group decision making tools, and evaluates their effectiveness and utility as organisational decision making tools. To this end, the literature on prediction markets and group decision making has been reviewed in depth, with a particular focus on integrating these two domains. A synthesis of these knowledge domains allows several novel insights to emerge. The literature review also drives the empirical data collection phase of the research project. Methodologically, the research strategy was a longitudinal study of a prediction market operating in a realistic context. A variety of research methods, including observation of trading behaviours and tests of behavioural traits were used to gather data to answer the research questions which emerged from the literature review.

The theoretical and empirical work detailed in this dissertation makes two contributions. First, the empirical work presented in this dissertation explores the effect of prediction market participation on individuals. It demonstrates how individual's skills and behaviours are affected by prediction market participation. Second, the empirical work presented also examines the impact that individual's personality traits have on prediction market participation and performance.

This dissertation provides empirical data supporting the contention that prediction markets are valid decision support systems. It shows that they are a valuable tool in the decision making armoury of the modern organisation. By demonstrating that prediction markets have a positive effect on the behaviours of individuals, it provides a further rationale for their deployment in modern organisations. It demonstrates that personality traits do not overwhelm other considerations mediating the performance and participation of individuals in prediction markets, and thus emphasises both their general utility and the importance of the careful design of incentives in optimizing prediction market performance.

Declaration

This dissertation is my own work and has not been submitted to any other university or higher education institution, or for any other academic award. Citations of secondary works have been fully referenced. The research presented has been approved by the Kemmy Business School Research Ethics Committee.

Patrick Buckley

Acknowledgements

For Mam and Dad.

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List of Abbreviations

IEM	Iowa Electronic Markets
PAM	Policy Analysis Market
MSR	Market Scoring Rule
DPM	Dynamic Pari-Mutuel
CDA	Continuous Double Auction
AMM	Automated Market Maker
LMSR	Logarithmic Market Scoring Rule
ILM	Insurance Loss Market
IPIP	International Personality Item Pool
REAL	Rich Environment for Active Learning

1. Introduction

1.1. Introduction

Organizations of all types and sizes have always faced the challenge of making decisions which are based in part upon the outcome of large scale, uncertain and complex systems. For example, the decisions a manufacturing organization makes regarding production prioritization and scheduling will be based in part upon expected future demand for its products. Making an accurate estimation of future demand for a product in turn depends upon estimating a further, larger set of variables. Factors such as the value of the product to the consumer, the relative merits of competing products, and economic conditions will all impact upon future demand for products.

Other organizations face similar decision making scenarios. Governments have to create and implement policies which are aimed at achieving social, political and economic objectives. Charitable organizations have to determine how and where to spend limited resources. In these situations, the variables which influence the decisions made are linked in a virtually infinitely complicated web of cause and effect.

The cornerstone of any research topic is inquiry. A research topic should be of interest to and excite the imagination of the researcher (Saunders et al. 2003). The researcher's inherent curiosity about the world and why it is the way it is prompts research and provides the motivation that is necessary to pursue what can be a long and arduous process. This research project was inspired by the researcher's contemplation of a seeming paradox. The rise of to virtual omnipresence of information technology in the modern world means that individuals, groups and organizations have access to information at a level that would have seemed fantastical even 20 years ago. Instant

access to factual information, virtually free instantaneous communication and the computational power to analyse terabytes of data are all examples of relatively common features of the modern world which would have seemed miraculous even a generation ago. Yet despite high speed, accurate access to factual information, decision makers still err. Decision making as an applied science has not kept pace with advances in other realms of information processing. An obvious example is the failure of risk decision making that occurred across the global banking sector over the last number of years. Some of the factors negatively impacting upon decision making are embedded in the human condition. Ultimately, decisions are still the domain of human beings, who have inherent cognitive, psychological and physiological limitations. In a very real sense, these limitations are a fundamental fact of human nature. Nonetheless, information has always been seen as being an input into decision making processes. Intuitively, it would seem logical that improving the information component of decision making should improve decision making overall, all other things being equal.

Fundamentally, this threshold where information technology mixes with decision making excites the researcher's curiosity. From this potent combination of ideas and concepts, it is easy to tease out macro-level questions that speak to the concerns of individuals and organisations in the 21st century. Has the quality of decision making really remained static despite the rise of information technology, or are improvements masked by prominent failures? How does information technology and the availability of enormous amounts of information impact upon decision making contexts, at an individual, group and organisational level? Is the impact of information technology on decision making limited to providing faster, cheaper ways of performing the same processes, or can information technology fundamentally change how, when, where and why individuals and organisations reach decisions. Can information technology be used

to improve decision making, absolutely and relatively? These questions are vast. If research is defined by inquiry, then these questions define the area and scope of a large research agenda. The sharpening of this research agenda into a concrete research programme led to the creation of this thesis.

At the broadest level, two macro level methodologies can be used to aid decision making in complex situations (Armstrong 2001). The first approach is to develop a mathematical model of the system of interest. This approach has had obvious success in many domains, particularly in the hard sciences. However, when dealing with the complex systems studied in the social sciences, mathematical models are often beset by a number of difficulties.

First, it can be impossible to accurately measure variables without creating models that are as complicated as the original system. Second, many variables of interest defy measurement. For example, a variable like customer satisfaction can be approximated, but never measured to arbitrary accurateness. Third, the number of variables that must be measured when modelling complex systems is often computationally prohibitive. Fourth, it is often the case that relationships between variables cannot be accurately defined. Finally, the model maker may be completely unaware of important variables to include. These issues place fundamental limitations on the usefulness and accuracy of mathematical models in the social sciences.

The other macro level approach identified by Armstrong (2001) is judgement. Judgement based decision making methods use an expert or a group of experts to make decisions about complex systems. Individuals use internal models called heuristics, as well as experience, wisdom and intuition to make decisions. However, these heuristics are limited by a number of factors. Individual decision making is limited by bounded

rationality and bounded awareness which places fundamental limits on the accuracy and reliability of these heuristics. These heuristics are usually tacit, which means they cannot be evaluated, transferred or made explicit.

Group decision making can ameliorate some of the problems associated with individual decision making. In group decision making, individuals come together to exchange information and arrive at a decision. This form of decision making can reduce the problems of bounded rationality and bounded awareness. However, group decision making structures suffer from their own inherent limitations. Power relationships and social interaction within groups can lead to issues such as groupthink, information cascades and group polarization.

The advent of phenomena such as globalization has only increased the need for rapid, accurate decision making in organisations. The ongoing information technology revolution has seen an enormous increase in the availability, accuracy and speed of information available to decision makers at all levels of the organisational hierarchy. However, this improvement in information quality has not engendered a commensurate improvement in decision making. The economic crisis of 2008 can be seen as a systemic failure of decision making on multiple levels, despite the ready availability of information that could have forestalled or mitigated the effects of its occurrence. Indeed, information technology is often blamed for the rise of phenomena such as information overload, which adversely affect the decision making process within organisations (Edmunds & Morris 2000).

In order to improve decision making within organisations, researchers need to move beyond the common perception that improving information quality alone is sufficient to improve decision making (Raghunathan 1999). Equal attention must be paid to

examining how the process of decision making can be improved by the judicious application of information technology. Organisations need to begin to leverage the global networks of knowledge workers that have been created by the information technology revolution and understand how they can be utilised to improve organisational decision making.

In the context of the above discussion, this dissertation focuses on a new form of structured group decision making called a prediction market. A prediction market is a relatively novel form of the more familiar financial markets. *“Prediction markets are defined as markets that are designed and run for the primary purpose of mining and aggregating information scattered among traders and subsequently using this information in the form of market values in order to make predictions about specific future events.”* (Tziralis & Tatsiopoulos 2007, p.75). This dissertation contends that prediction markets can be used to enable group decision making. When deployed over networks, prediction markets can scale efficiently to very large groups, potentially allowing organisations to access communities of practice on a global scale. As such, they can mediate decision making and leverage the power of information technology in a manner that is radically different from existing decision making methodologies. Prediction markets have strengths and weaknesses as decision making tools. The utility of prediction markets will vary depending upon the nature of the decision space under consideration, but this dissertation argues that they are a valuable weapon in the armoury of the modern manager seeking to deal with a complex, rapidly changing world.

1.2. Dissertation Layout

This section describes the structure of this dissertation and outlines the content of each of the following chapters.

Chapter 2 is primarily concerned with an examination of the literature pertinent to this study. Two broad domains of interest are identified. First the literature on prediction markets is presented. A section providing a primer on prediction markets is followed by an elucidation of the actual and proposed applications of prediction markets. An in-depth analysis of the choices and tradeoffs involved in designing prediction markets is offered in section 2.2.2. The second domain of knowledge examined in detail is decision making, with a particular emphasis on group decision making. The focus of this section is examining the intrinsic advantages and disadvantages of group decision making. Prediction markets are clearly positioned as a group decision making tools. The synthesis of two distinct literatures exposes the research questions which drive the remainder of the research process. These research questions are discussed in section 2.5.

Chapter 3 is the research methodology chapter. It presents a complete description of the research strategy used in this research project. It begins by providing a chronological description of the research process as it occurred. Moving on from this, the research questions investigated are described. Specific detail on how these questions emerged and how they were operationalised is provided. Finally, the data collection process is described in detail. This chapter explains the decisions that were made throughout the design of this specific research programme and where necessary rationalises the trade-offs that were made. This chapter concludes by examining the limitations of the research.

Chapter 4 presents the data collected by the research programme in order to answer the queries posed in section 2.5. It analyses this data so as to draw conclusions regarding the research questions which drove the data collection phase of this research project.

Chapter 5 concludes the dissertation by presenting a summary of the two major contributions made by this dissertation. Moving on from that it identifies areas for further research, which are suggested by the limitations of the research presented in this dissertation or by the results and contributions of this dissertation.

2. Literature Review

2.1. Introduction

This chapter reviews the literature relevant to the current study. Two specific knowledge domains are examined. First, the literature on prediction markets is explored in section 2.2. The nature and evolution of the concept of prediction markets is described. The reader is familiarised with the core concepts associated with prediction markets through the use of a simple example. An in-depth discussion of the issues that mediate the design of prediction markets is presented. These issues inform the design of the research strategy and data collection later in the research process. The current and proposed applications of prediction markets are discussed. Finally some issues which are specific to the prediction markets, namely market failure and market manipulation are investigated.

This dissertation positions prediction markets as group decision making tools, which can be used by organisations to access the tacit knowledge of employees, customers and other stakeholders. Positioning prediction markets thusly necessitates an examination of the literature on decision making, which is the second knowledge domain reviewed in this dissertation in section 2.3. The theory of decision making is first explored, before group decision making is examined in-depth. A model of group decision making is presented, and then used to examine the strengths and weaknesses of prediction markets as group decision making tools.

After the relevant literature has been examined and synthesized, a brief description of existing research themes in the area of prediction markets is presented in section 2.4.

This serves to identify gaps and shortcomings in the current literature. These gaps are explored in more detail in the concluding section of this chapter, section 2.5, which clearly identifies the research questions which emerge from the literature and drive the subsequent research programme which is described in the following chapters.

2.2. Prediction Markets

Tziralis & Tatsiopoulos offer a definition of a prediction market as: “*Prediction markets are defined as markets that are designed and run for the primary purpose of mining and aggregating information scattered among traders and subsequently using this information in the form of market values in order to make predictions about specific future events.*” (Tziralis & Tatsiopoulos 2007, p.75). This definition of a prediction market is the one used throughout this dissertation. Section 2.2 serves as an introduction to the extant literature on prediction markets. It consists of four main sections. Section 2.2.1 serves as a basic introduction to prediction markets. A brief example is presented to describe how prediction markets operate. The history of prediction markets is examined. Moving on from this, prediction markets are usually designed for a specific purpose. Designing prediction market is a challenging and involved task with an emerging, but already large, literature which is examined in section 2.2.2. Section 2.2.3 focuses on describing the current real-world applications of prediction markets. Where relevant, it also identifies potential applications which have been theorised in the literature. Unlike some forms of markets, prediction markets do not emerge organically. Section 2.2.4 concludes by fulfilling the purpose of this section from a research perspective. It focuses on identifying the gaps in our knowledge of prediction markets which are acknowledged in the literature. These gaps are used later to formulate the research questions which drive this research project.

2.2.1. Fundamentals of Prediction Markets

Most researchers accept that the term prediction market is not as yet universally accepted in the literature (Luckner 2008). This confusion has two causes. First, there have been a number of terms used in the literature to describe the phenomena referred to in this dissertation as prediction markets. They have been variously referred to in the literature as “*information markets*”, “*decision markets*”, “*electronic markets*”, “*virtual markets*”, “*political stock markets*”, “*election stock markets*”, “*artificial stock markets*” and “*ideas futures*” (Hanson 1995). Second, no single universally accepted definition of a prediction market has emerged. In addition to the definition offered at the beginning of section 2.2, which is the one accepted for the purposes of this dissertation, various leading researchers offer different definitions. One definition is that “*Prediction markets are designed and conducted for the primary purpose of aggregating information so that market prices forecast future events.*” (J. E. Berg, F. D. Nelson, et al. 2008, p.286). Another definition regularly cited in the literature is that “... *these are markets where participants trade in contracts whose payoff depends on unknown future events*” (Wolfers & Zitzewitz 2004, p.108). In a similar vein, it is proposed that “*A prediction market offers contracts whose future payoff is tied to outcomes of an event of particular interest and attracts participants to trade the contract.*” (Y. Chen & Pennock 2010, p.42).

While differing in detail, the various definitions proffered emphasise two points which are important to note. First, prediction markets operate by enabling participants to trade contracts. These contracts share a common property. Their value is dependent upon the outcome of a future uncertain event. These contracts are referred to variously as assets, securities or options in the literature. This dissertation will use the term contract throughout.

The second major point that emerges from these definitions is that the distinguishing characteristic of a prediction market is that its primary concern is the elicitation of information (T. W. Bell 2009). In the modern world, many markets exist that allow participants to trade assets whose value is dependent upon uncertain future events. While these markets can be viewed as prediction markets from a certain perspective, in general this dissertation will follow the guidelines proposed by Wolfers and Zitewitz (2004). This dissertation steers away from markets where the primary role is enhancing the enjoyment of an external event through taking on risk. Similarly, markets whose primary rationale for existence is that they enable the hedging of financial risk will not be considered prediction markets. While valuable lessons and insights can be drawn from these markets, this dissertation will focus on markets which have the distinguishing characteristics described above.

One important concern to address at the outset is the issue of gambling. One common objection raised to prediction markets is that they are a form of gambling (Wolfers & Zitewitz 2006). However, most researchers would argue that prediction market participation is not gambling. In order for an activity to be considered gambling, three conditions must hold (T. W. Bell 2009). First, the activity must offer a prize. Second the activity must involve chance. Third, the activity must involve consideration for the participant, which is to say that the activity must require the participant to stake a valuable consideration on the outcome of the transaction. Later sections will describe how the elements of prize and consideration can be manipulated through the design of prediction markets. In order for an activity to be considered gambling, “*chance must in theory predominate over skill*” (T. W. Bell 2002; T. W. Bell 2009). Precisely because they focus on future events which are at least theoretically amenable forecasting,

prediction market participation is not considered to be gambling by most researchers in the field.

This section aims to provide a general introduction to the field of prediction markets and is divided into four sections. First, in section 2.2.1.1 the theoretical roots of prediction markets are examined. Moving on, section 2.2.1.2 offers an example of how a prediction market operates in practice. In section 2.2.1.3 a description of the proposed benefits of prediction markets is presented. Particular attention is paid to the accuracy of prediction markets, both absolutely and relative to other comparable mechanisms. This reflects the emphasis that can be found on this topic in the literature. Finally, section 2.2.1.4 presents a brief discussion of the history of prediction markets.

2.2.1.1. Nature of a Prediction Market

“A market is a set of arrangements by which buyers and sellers are in contact to exchange goods or services” (Begg 1987, p.43). This conception of a market implicitly contains the notion of an equilibrium price, which is the price at which the quantity of a good supplied equals the quantity of the good demanded. At any particular moment in time, the price in the market may not be at the equilibrium price. The price may be either too high or too low, leading to excess supply or excess demand. However, these pressures will act to drive the price in the market towards the equilibrium price.

In a liquid market of the form described above, a number of processes of interest can be identified. Information exchange is clearly evident. By signifying willingness to purchase or sell a contract, market participants indicate information to other participants in the market. The indication of these preferences leads to the pressures that allow the formation of an equilibrium price. Since a market allows for multiple buyers and sellers,

one can say that information aggregation occurs. The equilibrium price is a value created from aggregated information from a large number of buyers and sellers.

Seizing upon these observations, Hayek (1945) proposed that markets operate as near perfect transmitters of information. Hayek proposed that decentralised planning is superior to central planning. He makes this argument by distinguishing between types of knowledge, referred to as explicit knowledge and tacit knowledge. Efficient planning requires knowledge. He then points out that aggregating tacit knowledge is by definition impossible. This implies decentralised planning is necessary to achieve efficiency. Decentralised planning in turn requires the exchange of information between decentralised planners. A market fills this role, by transmitting information to decentralised planners. Events cause a price change which rapidly propagates through the market to all the participants.

This perspective on market operation led to the development of what is known as the efficient market hypothesis. The efficient market hypothesis formulated by Eugene Fama states that stock *“prices at any time ‘fully reflect’ all available information”* (Fama 1970, p.383) .

The efficient market hypothesis is expressed in a number of forms, which reflect the strength of the claim being made. The weak form of the efficient market hypothesis claims that prices in a market fully reflect all the information contained in the history and volume of price movements. The semi-strong version of the hypothesis claims that market prices fully reflect all publicly held information, while the strong version of the efficient market hypothesis states that market prices reflect all information, whether public or private (Kamp & Koen 2009; Kolb 1997).

Questions are continuously being raised about the efficient markets hypothesis. Events such as the technology bubble of the early 2000's or the sub-prime mortgage crash in 2008 are presented as obvious examples that markets do not aggregate all information correctly and instantaneously. However, other researchers have shown that managed funds do not perform any better than simple index linked funds (Malkiel 2005). If markets did not efficiently assimilate information, then it is reasonable to assume that professional fund managers would be consistently able to beat simple indexes (Malkiel 2003). The inability of professional fund managers to consistently beat index linked funds is a clear indication of information aggregation at a relatively high level of efficiency.

The other important point to note is that an efficient market isn't necessarily correct in hindsight. To use the example of the technology bubble again, the financial markets at the time aggregated the beliefs of a large number of investors regarding the expected future value of the stock of internet firms. Ultimately these beliefs were proved incorrect. However, this does not undermine the ability of markets to aggregate information. A mechanism that successfully aggregates incorrect information is still an efficient information aggregation mechanism (Malkiel 2003).

As such, speculative markets such as those in stocks, commodities and future options do a credible, if imperfect job of aggregating relevant information into market prices (Hanson 2007a). This insight into the operation of traditional markets led researchers to begin to view markets as tools for communicating and aggregating information. The fundamental difference between a prediction market and a traditional financial market is that prediction markets focus directly on the event under consideration. For example, the prices of orange juice futures are statistically a very good predictor of the weather in Florida (Roll 1984). However, orange juice futures are affected by a large number of

independent variables such as fuel costs, seasonal demand, etc. This would make it difficult to use the price of orange futures to forecast the weather. Prediction markets seek to alleviate this difficulty by facilitating the trade of contracts that are linked directly to the event of interest (C. Hall 2010). This approach facilitated the establishment of the Iowa Electronic Market (IEM) in 1988, which is often seen as the first implementation of a prediction market. (Joyce Berg et al. 2008a). Since then academic and practitioner interest in prediction markets has continued to grow (Tziralis & Tatsiopoulos 2007).

2.2.1.2. Description of a Prediction Market in Practice

In this section, a brief description of how a prediction market operates is presented. As an example, consider an American presidential election. Assuming for the sake of simplicity that third party candidates are ignored, the winner of an American Presidential election will either be the Republican or the Democrat candidate.

There are a wide variety of methods available for estimating the probability of either the Democrat or Republican candidate winning the election. Traditional methods would include fielding an opinion poll or asking an individual or a group of experts. To use a prediction market to create a probability estimate, the following procedure is used. First, a contract is created. For the purposes of this example the contract will be referred to as DEM. A market participant who holds 1 unit of the contract DEM after the election has been decided will receive €1 if a Democrat is elected and €0 if a Republican has been elected. Likewise, a contract called REP is created, which has similar properties to DEM, except the payout is reversed, so the holder receives €1 if a Republican is elected and €0 if a Democrat is elected.

A central institution, usually referred to as the market sponsor is available to sell a pair of DEM, REP contracts to an individual for €1. The market sponsor will also buy back a pair of DEM, REP contracts for €1. Individual participants can interact with each other and the market sponsor to create a market. First, consider a rational trader called John who arrives on the market and buys a pair of contracts from the market sponsor.

In the above situation, the total liability faced by the market sponsor is €1, since either the DEM contract will be worth €1 or the REP contract will be worth €1 after the election. Since the market sponsor collected €1 for the pair of DEM, REP contracts, the market sponsor's liabilities are covered by its cash. Provided it buys and sells pairs of contracts, the market sponsor carries no risk. Similarly, in this situation, John will receive €1 after the election, since in either event one of his contracts will pay out.

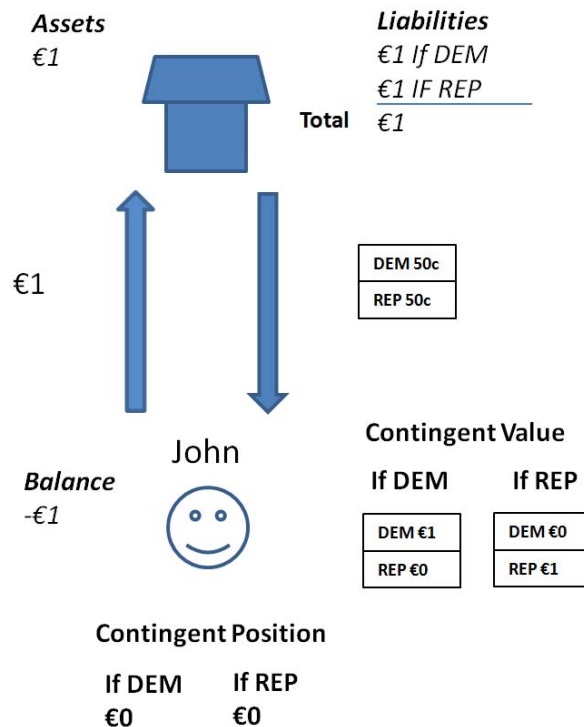


Figure 1. Market Position after John purchases contracts

Now, suppose John believes that the Democrats have a 70% chance of winning the election. Based on this belief, John will then be prepared to interact with other participants in a number of ways. He will be prepared to sell his DEM contract to any individual who is prepared to pay more than 70c. Alternatively, he will sell the REP contract, for any price greater than 30c.

Now, assume another trader Mary arrives to participate in the market. Mary believes there is a 50% chance that the Republicans will win the election. To operationalise this belief, she has two choices. Firstly, she can buy a pair of DEM, REP contracts from the market sponsor. In this situation, there are now two DEM contracts and two REP contracts outstanding. Regardless of the outcome of the election, the market sponsors liabilities are covered, and both Mary and John will receive €1.

Mary's other option is to buy the REP contract from John. If Mary is a rational trader, she should be prepared to pay anything up to 50c for the REP contract, while John should sell it for anything more than 30c. In this situation, it is reasonable to assume that Mary and John will agree on a price for the REP contract. They may agree on a price of 40c.

Now, the final valuation of the participants' portfolios depends on the outcome of the event. In this case, there is still only 1 DEM and 1 REP contract outstanding. Only one of these contracts will pay out, so the market sponsors' liabilities are still covered by the cash it originally received from selling the pair of contracts.

However, John and Mary's financial position is now dependent upon the outcome of the election. John has spent €1 to buy the pair of contracts DEM, REP. He then received 40c for the REP contract, meaning that his outlay is reduced to 60c. Mary has spent 40c to buy one REP contract. Now, if the Democrats win the election, John will receive €1

from the bank, meaning he makes a profit of 40c. In contrast, Mary will receive nothing for her REP contract, and so has made a loss of 40c. The situation is inverted in the case of a Republican win. Mary will receive €1 for her REP contract and make a profit of 60c, while John will receive nothing for his DEM contract from the market sponsor and will make a loss of 60c.

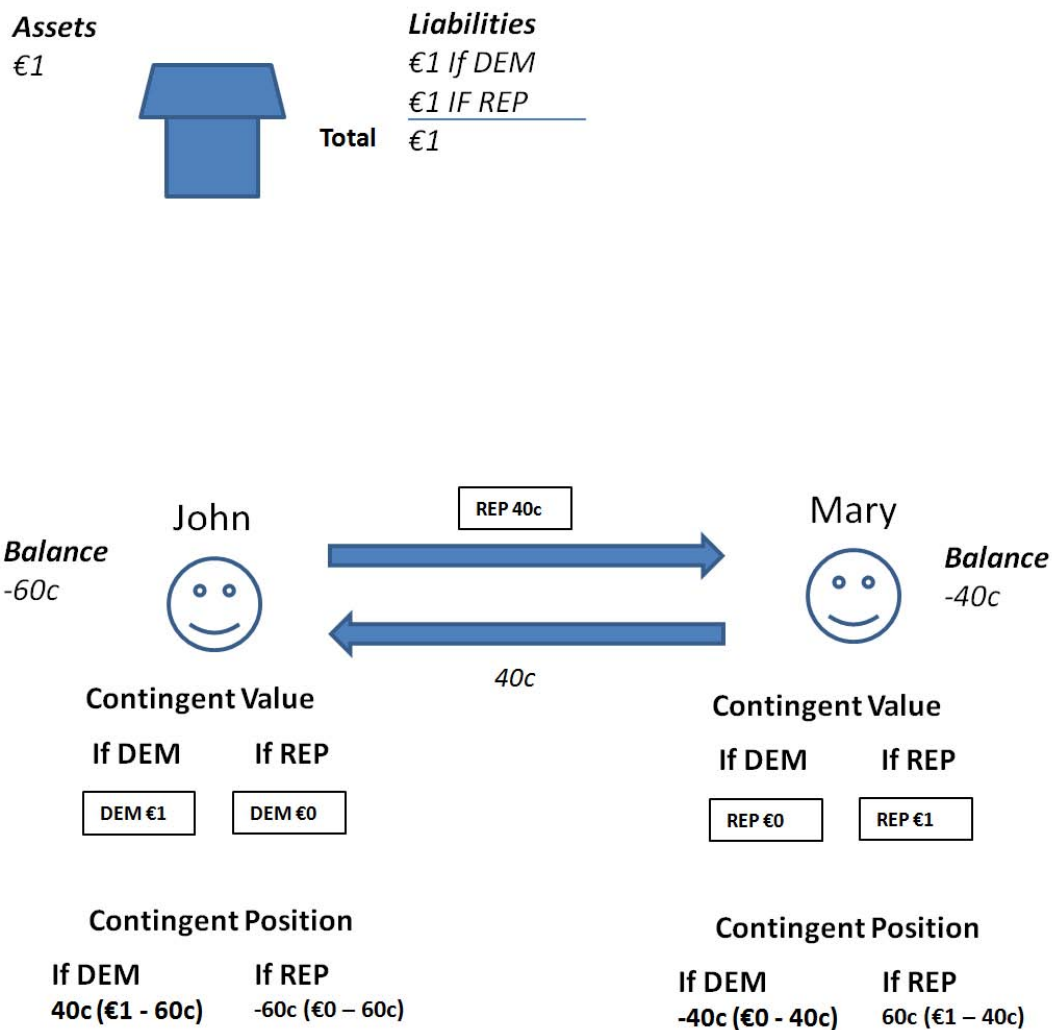


Figure 2. Market position after exchange between John and Mary

This simple example demonstrates the basic principles that underpin the operation of a prediction market. On the basis of theoretical, experimental and empirical evidence, the

equilibrium price of a contract can be treated as the evaluation of the probability of a Democrat or a Republican winning the election, based upon the information available to all the participants in the market (Ledyard 2006). This simple model, with a few modifications, describes how the original IEM operated. Since then much research has been conducted on how to better structure prediction markets in order to improve information aggregation and information revelation. The mechanisms used to facilitate trading, the structure of the contracts used and the incentives provided to participants are amongst the issues examined in detail in the literature.

2.2.1.3. Theoretical Benefits of Prediction Markets

Researchers have identified a number of theoretical benefits of prediction markets over comparable information aggregation mechanisms such as polls or expert groups (Servan-Schreiber et al. 2004). Prediction markets provide incentives for truthful information revelation. They provide an algorithm for automatically aggregating information. Finally, the specific attributes of prediction markets means they have certain structural advantages over other comparable mechanisms.

Prediction markets are instantiated by offering contracts for trade whose value is dependent upon the outcome of a future event. Contracts are specified in the format, “*Pay €X if event Y occurs*”. Individual participants buy and sell these contracts. Since these contracts are held by an individual, the reward if the event occurs accrues to said individual. This individualisation of reward creates an incentive for individuals to hold contracts in events they believe are likely to occur (Hahn & Tetlock 2006c). By providing an individualised incentive some of the challenges associated with information revelation in other domains can be ameliorated (C. Hall 2010). In a deliberative group, individuals may have little incentive to reveal private information, since any benefits will accrue to the group as whole. By providing information to

others, they bestow benefits on others without any reward to themselves, and possibly facing high private costs (Sunstein 2006b). The provision of a direct financial incentive to an individual can serve as a counter weight to the emotional, political and professional factors that may inhibit truthful information revelation. Since participants are rewarded for accurate decisions, and the accuracy of decision making depends in part upon the information available to the participant, all other things being equal, the provision of individualised incentives should promote information search (J. E. Berg & T. A. Rietz 2003; Hahn & Tetlock 2006b; Sunstein 2006a).

The second characteristic of prediction markets is that they implicitly contain an algorithm for information aggregation. The operation of the market in contracts, and the trading it facilitates automatically creates the equilibrium price which is used as a proxy for estimates about the event of interest (C. Hall 2010). It is this ability of markets that has captured the attention of many researchers. When considering a complex system, no one expert is likely to have all the information and knowledge required to make an estimate of the probabilities of uncertain future events (Hahn & Tetlock 2006a). The idea that experts working together can improve upon individual forecasts has fascinated academics and also permeated popular culture, most notably through the book "*The Wisdom of Crowds*" by James Surowiecki (2004) . By allowing experts to trade with each other, prediction markets allow disparate opinions and beliefs to be aggregated into a coherent, consistent whole (Hahn & Tetlock 2006b). As well as providing a mechanism for aggregating the private beliefs of individuals, prediction markets can also enable individual participants to extract information from observing market estimates (Kálovcová & Ortmann 2009), and correct biases in publicly available information (Gruca & J. E. Berg 2007).

The literature identifies a number of other benefits of prediction markets, which can be loosely described as advantages which derive from the structure and nature of prediction markets. Several authors point out that prediction markets implicitly weight the information supplied by participants (J. E. Berg & T. A. Rietz 2006; Graefe & Weinhardt 2008; Hahn & Tetlock 2006b). If participants are more confident of their beliefs in a particular topic, then they will be willing to buy more of the relevant contracts, and vice versa. The ability of participants to choose the level of their investment allows them to indicate their confidence in their information in a manner which is automatically accommodated by the aggregation algorithm. The nature of the market structure also means that prediction markets can scale to very large groups (Hahn & Tetlock 2006c). When considering a market that utilises information technology to enable trading, the only real limits on the number of participants are computational. This also means that prediction markets potentially have lower running costs, particular if they are in operation over a period of time (Polgreen et al. 2006). Most of the overheads in deploying prediction markets are involved in setting up the market and attracting participants. Prediction markets can operate in real-time (C. Hall 2010; Polgreen et al. 2006). This gives them a significant advantage over other comparable information aggregation methods such as polls. Finally, prediction markets can be designed in such a way as to allow trader anonymity (Remidez & Joslin 2007). The utility of this attribute can vary, but the ability to enable it emphasises the flexibility of prediction markets.

2.2.1.4. Evolution of Prediction Markets

Markets which share the same defining characteristic as a prediction market, which is say that they enable the trade of contracts on uncertain future events have been found in a wide variety of jurisdictions and times. Financial futures markets have existed in the

major trading exchanges for hundreds of years. Specific examples from the literature include markets on Papal elections in 16th century Italy, and parliamentary elections in 18th and 19th century Britain (Rhode & K. S. Strumpf 2008). Betting exchanges on the outcome of presidential elections in the United States have existed since at least 1868 (Rhode & K. S. Strumpf 2004). A number of factors are seen as having led to the demise of these markets, including the rise of scientific polling methodologies and the legalization of other forms of hedging, risk management and gambling (Rhode & K. S. Strumpf 2008).

Modern interest in prediction markets can be traced back to the creation of the IEM by academics at the University of Iowa in 1988 (Forsythe et al. 1992). The IEM is a real money, internet based prediction market which allows participants to buy and sell contracts whose value is dependent upon the outcome of uncertain future events (Joyce Berg et al. 2008a). The IEM commenced operation in April 1988, and offers a wide range of contracts in political events, such as American Presidential and Congressional Elections (Forsythe et al. 1992). Since then, the IEM has branched out into offering markets in other domains. One of the notable characteristics of the IEM is its success in predicting the outcome of American presidential elections. This success has led to increased academic and practitioner interest in prediction markets. Around the same time, Robin Hanson published a number of articles proposing that markets could be used as forecasting and decision making tools (Hanson 1990; Hanson 1991).

The use of prediction markets in business environments also became significantly more noticeable in the early to mid 2000's. First, companies such as Betfair and Intrade began to emerge, whose business model revolved around offering prediction markets to the general public (Siegel 2009). A related class of prediction markets such as the Hollywood Stock Exchange also began operating at this time. Rather than allowing

participants to trade using real money, and taking a percentage of the money being traded, these markets relied on using the general public to create predictions (for example, what would the opening weekend box office take be for a particular movie) and selling these predictions to interested parties.

Other companies began to offer prediction market platforms, which organizations could use to deploy prediction markets themselves. Notable examples of these companies include Inkling Markets and QMarkets.

No discussion of the history of prediction markets would be complete without mentioning the Policy Analysis Market (PAM). The PAM was a project announced by the Pentagon in 2003. One of the many intelligence gathering projects initiated in the aftermath of the September 11th terrorist attacks in New York, the PAM was conceived of as a market where participants could trade contracts on geopolitical events, such as the likelihood of a coup in Saudi Arabia (de los Reyes & Raifman 2008). However, the PAM quickly became politically sensitive, with both Republican and Democrat senators and congressmen condemning it as a project that would lead to betting on terrorist attacks (C. Hall 2010). In the face of a concerted political attack, the PAM was quickly cancelled (Hanson 2007b; Polk et al. 2003).

The current state of prediction market deployment could be summarised as follows. Public prediction markets such as Intrade, Betfair, etc. continue to perform well. However, business use of prediction markets has yet to reach the levels that were expected by early proponents. Gartner refers to prediction markets as being in the “*Trough of Disillusionment*” in their Hype Cycle. This is usually seen as being a precursor to widespread deployment. Commentators point to a number of issues which are slowing the adoption of prediction markets in organisations, including a lack of

awareness of prediction markets, a lack of information as to what are suitable problems domains for prediction markets and lack of case studies clearly demonstrating the benefits of prediction markets (K. Strumpf 2009)

2.2.2. Design Challenges in Prediction Markets

Prediction markets do not emerge spontaneously. The defining characteristic of a prediction market is that the value of the contract being traded on the market is contingent upon an uncertain future event. This characteristic means that a market does not arise spontaneously between buyers and sellers, as would be the case in more familiar markets. The market must be created by an individual or set of individuals. The person or persons who create the market is referred to hereafter as the market sponsor. We can identify three tasks the market sponsor must undertake. First, the market sponsor must define the market. Second, the market sponsor must define the outcome. Finally, the market sponsor must design the market. The fulfilment of these tasks is crucial in enabling a successful prediction market.

First, the market sponsor defines the market. In other words, the market sponsor specifies what future event is the concern of the market. For example, the market sponsor may create a market that will enable the trade of contracts whose value is contingent upon the outcome of a political election. In a project management setting, the market sponsor may create a market on whether or not a project is completed on time. The definition of the market will depend in part upon the purpose of the market. For example, the market sponsor may be seeking to create a public market, in the hopes of gaining a financial reward by charging fees for participating in the prediction market. This is the model followed by Intrade and other public prediction markets. In this situation, the market sponsor will seek to define markets that will be of general interest, and attract a large number of participants. In other situations, the market sponsor may be

interested in gathering information that has organizational or personal utility. In either case, the point is that the definition of the market is determined by the desires of the sponsor.

Second, the market sponsor defines the outcome. In fulfilling this role, the market sponsor precisely defines what valuations will be assigned to what contracts on the market depending upon the outcome of the event under consideration. The market sponsor acts as an “honest broker”, allocating rewards to participants when the outcome of the event under consideration can be determined. This can be a contentious issue. To give an example, consider the case of a contract on whether or not the dictator of a particular country leaves by a certain date. The clear intent of this contract is that the dictator is deposed, or in some other way is forced to cede power and leave the country in question. Now, consider the situation where the dictator leaves the country for medical attention abroad, with the clear intent of returning on completion of the medical procedure. In the strictest sense of the word, the dictator can be said to have left the country. Should the contract be terminated and participants paid off? This simple example demonstrates some of the complexities that can arise when resolving contracts (Wolfers & Zitzewitz 2006). The market sponsor must take great care to be precise in the definition of the outcome at the commencement of the market. Even so, it will often be the case that judgement will be required. Since participants are unlikely to trade in a market that is perceived to be unfair, exercising this judgement in a balanced and transparent manner is often of critical important to the long term success of a prediction market.

There are a wide variety of ways that a prediction market can be structured. The market mechanism used, the structure and value of the incentives offered, and the population participating in the prediction market are just some of the ways individual prediction

markets can vary. Since these markets do not emerge spontaneously, in many cases, the market sponsor must design the prediction market. They must decide, for example, which market mechanism to use when deploying the prediction market. Shaping the design of the prediction market is the third task of the sponsor of the prediction market.

The literature identifies a number of different design choices that are within the purview of the market sponsor (Luckner 2008; Spears et al. 2009; Wolfers & Zitzewitz 2004). First, the market sponsor can choose between a variety of market mechanisms. The market mechanism in a prediction market is the underlying process or algorithm that allows participants to trade contracts between each other. Second, the market sponsor can choose from a variety of contract types. The type of contract chosen affects the type of information returned by the prediction market. Third, the market sponsor chooses how to structure incentives in the prediction market. The incentives are simply the rewards participants receive for trading successfully in the prediction market. Fourth, it is within the domain of competency of the market sponsor to select the audience of the prediction market. In this context, the audience means the participants who are allowed to trade on the prediction market. In addition to these design choices, a number of other decisions made by the sponsor will affect the operation of the prediction market. Two obvious concerns are how long the market will run for, and will traders be allowed to participate anonymously in the prediction market (Spears et al. 2009). The decisions taken by the market sponsor will affect the aggregation, liquidity and ultimately the performance of the prediction market as a group decision making system.

2.2.2.1. Market Mechanisms

In order to enable the information aggregation which is at the heart of their power, prediction markets need to be able to execute trades. A mechanism must exist that allows for participants in the market to buy and sell contracts on the outcome of the

event being evaluated by the market. This is usually referred to in the literature as the market mechanism.

It is possible to identify a number of desirable attributes that a market mechanism should have. First, the market mechanism should enhance liquidity. Liquidity in markets can be considered an example of a chicken-and-egg problem. Traders are attracted to liquid markets that offer numerous opportunities to trade. However, liquid markets require large numbers of traders (Pennock 2004). Enhancing liquidity is a major concern in prediction market design (C. Hall 2010).

Prediction markets are often set up by market sponsors who are interested in the outcome of the market itself in terms of the price of the contract. This may mean that the market sponsor will have to invest resources in supporting the market. This support may include providing a reward for participants. In this situation, it is important that the market sponsor can calculate in advance how much the prediction market is likely to cost them. Thus, a second desirable characteristic of a market mechanism is that it limits the risk carried by the market sponsor and allows for prior calculation of that risk in monetary terms (H. Berg & Proebsting 2009).

A third desirable attribute of a market mechanism is that it rewards early information revelation. Some market mechanisms do not reward the early revelation of information. For example, a pari-mutuel market mechanism does not encourage early information revelation. A rational participant in a pari-mutuel market will wait until the very last moment before the market closes to reveal their information (Pennock 2004). Where a primary concern is to encourage the early, truthful revelation of information, this is not a desirable characteristic.

Finally, market mechanisms suitable for use in prediction markets should provide a fixed pay-off. It should be possible for a participant to calculate at the moment of executing a trade what their expected pay-off will be, for each of the possible outcomes of the event being evaluated.

The market mechanisms that are used in prediction markets can be divided into three major classifications (Luckner 2008). First, there is the Continuous Double Auction (CDA) market mechanism. This is very similar in form and function to the market mechanisms used in familiar financial markets. The second major type of market mechanism is a Market Scoring Rule. Market Scoring Rules (MSR) were originally developed by Hanson (Hanson 2003; Hanson 2007a). The third major category is the Dynamic Pari-Mutuel (DPM) market mechanism, which is a modification of the pari-mutuel markets found in sports betting. The DPM market mechanism was developed by David Pennock (2004).

Each of these market mechanisms is described below. Their strengths and weaknesses with respect to the characteristics required of market mechanisms are also examined.

A Continuous Double Auction (CDA) is the market mechanism that is used by most familiar financial markets. Conceptually, the mechanism is simple. Buyers who wish to purchase a contract indicate on a bid queue how much they are willing to pay. In parallel, sellers post on an ask queue the price they are willing to sell for. These queues are ordered, and once the highest bid exceeds the lowest ask, a trade is executed (Madhavan 1992).

CDA markets depend upon large numbers of traders for liquidity (Y. Chen & Pennock 2010). In thinly traded markets, the spread between the lowest ask and highest bid may be quite large (H. Berg & Proebsting 2009). If the spread between the bid and ask is too

large, then trading will never occur, meaning in turn that information aggregation can never occur (Hanson 2003).

In terms of the other desirable characteristics of a market mechanism, CDA fare better. A CDA poses no financial risk for the market sponsor (Spann & Skiera 2003). CDA encourages early information revelation. If a participant has information that leads them to believe that a contract on the market is mispriced, then they are incentivised to correct the price of that contract through buying or selling as appropriate. CDA also allows for fixed pay-offs. It is comparatively simple to assign a fixed pay-off to the contracts being traded.

Continuous Double Auction market mechanisms have a long history of being used to implement prediction markets. With minor modifications, a CDA was used to implement the original IEM in 1988 (J. E. Berg & T. A. Rietz 2006). It is still used in prediction markets where promoting liquidity is a lesser concern. For example Intrade uses a CDA market mechanism. However, many researchers have pointed out that the limitations of CDA for promoting liquidity means that other market mechanisms are becoming increasingly popular (C. Hall 2010; Wolfers & Zitzewitz 2004; Hanson 2007a; Hanson 2009).

Traditional financial markets depend upon having a large number of traders to maintain the liquidity that leads to market efficiency. Familiar financial markets such as the New York Stock Exchange exist to perform economic functions such as the allocation of capital or the hedging of risk. The utility of such markets leads them to having large numbers of traders. However prediction markets will not have such a large number of participants for a variety of reasons (Christiansen 2007; C. Hall 2010; Hanson 2003). First, the events that prediction markets are used to evaluate may be of limited interest,

particularly in an organizational setting. Issues such as whether a project within an organization will be completed on time will only be of relevance to a small number of participants when compared to issues such as stock price movements. Second, prediction markets tend to involve far less funds when compared to traditional financial markets, reducing their attractiveness to investors and utility to those seeking to hedge risk.

The comparative paucity of traders in a prediction market can mean that it is difficult for buyers and sellers to synchronize their bids and asks, leading to a situation where few or no trades occur in the market. Since trading is what drives information aggregation, which is at the heart of the promise of prediction markets, such a situation poses a major challenge to prediction markets.

One way of ensuring that trading does occur is to use a market maker. A market maker is a person or other entity which stands ready to buy or sell contracts from traders (H. Berg & Proebsting 2009). A market maker ensures that trading occurs by filling buy or sell orders from traders as they occur, and adjusting the price of the contract accordingly.

While markets may use a person to fill the role of a market maker, most modern prediction markets use an Automated Market Maker (AMM) to fill that role. An AMM is an algorithm that automatically fills buy and sell orders as they occur (Hanson 2009). The Logarithmic Market Scoring Rules (LMSR) is an AMM (Hanson 2003; Hanson 2007a). According to Hanson “*Market scoring rules are scoring rules where anyone can change the current report, and be paid according to their new report, as long as he or she agrees to pay the last person reporting according to that last person’s report.*”(Hanson 2007a, p.4). A probability distribution is shared by all participants in

the market, in the form of the prices associated with the contracts being traded on the market. When a trader arrives, they can update the probability distribution if they believe it is incorrect. They pay the previous estimator off, and in turn will be paid by either the next estimator or the market sponsor when the market expires (Y. Chen & Pennock 2010). This model of sequential information release is a natural fit for a market, since the sequential ordering of updates encourages information revelation (Abramowicz 2006).

The LMSR is the one most commonly used in prediction market platforms today. It fulfils all the desirable characteristics of an AMM. It enhances liquidity, encourages early information revelation and provides a fixed pay-off to participants. While the market sponsor does carry some risk when the LMSR is used, the total liability can be calculated before the market commences. The use of the LMSR is particularly common amongst organizations who deal with situations where thin markets may be problem. Vendors who provide prediction markets to customers commonly use Hanson's Logarithmic Market Scoring Rule (Y. Chen & Pennock 2010).

Pari-mutuel markets are often used as mechanisms to enabling wagering on horse racing and other sports events. Individuals participate in the market through buying one or more contracts. Contracts in a pari-mutuel market have a fixed price. All the money received from individual participants is put into a central pool. The pay-off is determined after the event being evaluated has occurred. The pool of money collected from the participants is distributed amongst all the contracts backing the winning event. The losing contracts receive nothing (Kálovcová & Ortmann 2009).

A pari-mutuel market effectively has infinite liquidity (Luckner 2008). Any participant can bet on any outcome at anytime, without the need for any matching offer.

Additionally, pari-mutuel markets involve no risk for the market sponsor, since they only act to redistribute money received from participants (Pennock 2004).

However, pari-mutuel markets also have serious drawbacks when considered as market mechanisms for prediction markets. First, pari-mutuel markets do not offer a fixed pay-off. Since the final pay-off for a contract is determined by the total amount invested in the market, it is impossible to determine in advance of the market closing what the pay-off for a contract will be (Y. Chen & Pennock 2010). A second and more serious problem is that the evidence of pari-mutuel markets enabling information aggregation is mixed. While some experimental evidence suggests that pari-mutuel markets can aggregate information (Plott et al. 2003), other authors have published results contradicting this (Bullen & McKenzie 2010). A rational participant in a pari-mutuel market has no incentive to reveal information until just before the market closes (Y. Chen & Pennock 2010; Luckner 2008; Pennock 2004).

In order to ameliorate some of the shortcomings of pari-mutuel markets as market mechanisms for prediction markets, David Pennock has offered the Dynamic Pari-Mutuel Market (DPM) as a possible alternative (Pennock 2004). He proposed modifying a pari-mutuel market so that the price of the contract changes throughout the execution of the market. This is in contrast to a traditional pari-mutuel market, where the price of contract is constant. As with a traditional pari-mutuel market, each contract receives the same pay-off on the conclusion of the market.

This modification to the basic structure of a pari-mutuel market means that some of the drawbacks associated with pari-mutuel markets are ameliorated. A rational investor now has the incentive to reveal their information early in order to buy contracts at a lower price. Investors can also lock in profits on the movement of a contracts price by selling

them to other investors. It is important to note however that while DPM guarantees liquidity for buyers, it does not guarantee it for sellers. The mechanism does not guarantee that a buyer will be available to match an ask.

As a market mechanism for implementing prediction markets, the DPM has a number of advantageous properties. It offers guaranteed liquidity and no risk for the market institution. Unlike the more limited pari-mutuel market mechanism, it promotes continuous incorporation of information. It allows participants to close out positions by selling back previously bought contracts, although the liquidity of this market is not guaranteed. However, when compared to other market mechanisms DPM is disadvantaged by the fact that the pay-off cannot be calculated until the end of the market.

While regularly cited in the literature as being a plausible alternative market mechanism for prediction markets, DPM has not been deployed on many occasions. Most of the literature refers to experimental work on DPM (Lin & Y. Chen 2009). An implementation of DPM used to manage the Yahoo Tech Buzz Game is the most prominent example in the literature of an actual implementation of DPM as a market mechanism (Y. Chen et al. 2008).

2.2.2.2. Contract Design

The market sponsor faces a number of decisions when designing the contracts that are to be traded in a prediction market. The most obvious choices are the basic terms of the contract, namely the topic, outcome, time horizon and payment structure of the question under consideration (C. Hall 2010). Often these parameters will be framed by the larger concerns of the market sponsor. For example, consider a market sponsor who wishes to estimate the result of a political election with three candidates. In the case, the topic is

the election under consideration. The three possible outcomes are Candidate A wins, Candidate B wins or Candidate C wins. The time horizon will be determined by the how far in advance of the election that the market sponsor wishes to generate an estimate. If the market sponsor wishes to generate an estimate 1 month in advance of the election, then the market sponsor will terminate trading on the market at that time. Participants in the market will be paid off when the actual results of the election are known. The most simple payment structure, usually referred to as a winner-takes-all contract is one in which the owner of a contract in the event that occurs receives €1, while all other participants receive no compensation.

One important issue when creating contracts in prediction markets is ensuring the contractibility of the underlying event (Wolfers & Zitzewitz 2006). Two types of contractibility issues can arise. The first contractibility issue revolves around the nature of the underlying event. Prediction markets reward participants for holding contracts in events that do or do not occur. In order for this reward function to operate, it is necessary that the event being considered can be determined to have definitely occurred or not occurred at some point in time. What this means in practice is that prediction markets are of limited utility in situations where a definitive answer is not possible. A prediction market is a tool for answering questions of the form “*What will sales of product X be?*”, rather than questions of the form “*Should our company invest in product X?*” As the question being considered becomes more subjective, the utility of prediction markets diminishes.

The second issue that must be handled with care by the market sponsor is the precise definition of the outcome in question. Market sponsors must be extremely clear as to what precisely will lead to a contract being considered fulfilled, and what will lead to it not being fulfilled. One example demonstrating the problems that can arise is the case of

the Tradesports contract on Yassir Arafat offered in 2004. This contract would be held to be fulfilled if Yassir Arafat departed the Palestinian state by the end of 2005. In late 2004, Yassir Arafat become ill, and left Palestine for medical treatment. This led to controversy amongst Tradesports participants, many of whom held the opinion that the clear intent of the contract was that Arafat would leave Palestine under duress (Wolfers & Zitzewitz 2006). This example highlights the importance of precisely defining contracts, since traders are likely to turn away from a prediction market that is not seen as being fair and transparent.

When defining the pay-off function that is used to reward participants holding a validated contract, the market sponsor also faces design decisions. The two most common pay-off mechanisms are winner-takes-all and index contracts (Christiansen 2007; Wolfers & Zitzewitz 2004).

Contract	Result (% Share of Vote)	Pay-off	
		Winner-Takes-All	Index Contract
Candidate A	27%	€0	27c
Candidate B	53% (Winner)	€1	53c
Candidate C	20%	€0	20c

Table 1. Pay-offs in different contract types

Winner-takes-all contracts operate as step functions across the probability distribution reported by the market (J. E. Berg & T. A. Rietz 2006). To illustrate with a simple example, consider the aforementioned 3 candidate election, between candidate A, B and C. If the market is structured in such a way as to sell A, B, and C contracts on one market, then the normalised prices of Contract A, Contract B and Contract C will sum to 1 at any point in time, assuming no arbitrage. If we assume that Candidate B wins the election, then participants holding Contract B will receive €1 for every contract they

hold. Participants holding Contracts A or C will receive nothing. The reward can be any fixed monetary value. The structure of a winner-takes-all contract means that the prices in a market can be interpreted as the traders aggregated expectation of the probability of that event occurring in the future (Luckner 2008).

The other common pay-off function used in prediction markets is an index or linear contract (J. E. Berg & T. A. Rietz 2006). The pay-off in an index contract is a linear function of the associated event. Again, to illustrate with the simple example of an election between candidate A, B and C, each contract pays off according to the formula €1 times the percentage of the votes each candidate received in the election. The pay-off based on the results achieved by the candidate are detailed in the fourth column of Table 1. This pay-off structure means that the price of the contract can be interpreted as the mean value the market assigns to the outcome (Luckner 2008).

The two types of pay-off function described are those most commonly used in prediction markets. They reveal different information about the aggregated expectations of all the traders on the market regarding the underlying event. It is this distinction in information revealed that is most commonly used by market sponsors when determining the correct type of contract to use in a particular prediction market setting. However, a number of other factors can influence this decision.

First, winner-takes-all contracts are described in the literature as being simpler to understand, particularly for participants who are not versed in the intricacies of financial markets (Christiansen 2007; Wolfers & Zitzewitz 2004). Individuals find it easier to deliver a verdict on a question phrased in the form “*Will Candidate A win?*” than in the form “*What share of the vote will Candidate A receive?*” Reducing the knowledge barriers faced by participants is seen as being key to enhancing liquidity in markets, and

thereby improving their accuracy (Christiansen 2007). This would initially suggest that winner-takes-all contracts are more suitable for prediction market deployment than index contracts.

A second point in favour of winner-takes-all contracts is that the literature suggests that they are less vulnerable to the “long-shot bias”, a well known psychological phenomenon which affects human beings when estimating probabilities. For the moment it will suffice to point out that the literature suggests that winner-takes-all contracts are less affected by this bias (Berlemann & Schmidt 2001; Borghesi 2009b).

However, index contracts are superior to winner-takes-all contracts in other situations. Consider for example the case of market sponsor who wishes to estimate the percentage vote share received by Candidate A in an election. In order to gather this information using winner-takes-all contracts, the market sponsor could create one market, with 100 separate contracts. Contract 1% would pay €1 if Candidate A received 1% of the vote, Contract 2% would pay €1 if Candidate A received 2% of the vote, and so on. The literature suggests that as the number of contracts on a market rises, the number of trades, and hence the liquidity of the market will fall (Ledyard 2006; Wolfers & Zitzewitz 2004). In thin markets, this can often affect the accuracy of the market. In this situation, the 100 individual contracts required to estimate the vote share could be reduced to 1 index contract, which would reveal the information required by the market sponsor.

2.2.2.3. Incentive Design

Many of the advantages attributed to prediction markets are theorised to arise from the provision of individualised incentives to participants. (A. Hall 2009; Siegel 2009). The literature suggests that the provision of individualised incentives is at least partly

responsible for engendering three distinct behaviours in participants which improve the performance of prediction markets as decision making tools. First, incentives motivate traders to participate in the market. The best designed market will fail without providing a motivation to trade (Wolfers & Zitzewitz 2004). Information aggregation is enabled and mediated by participants in the market signalling their information by trading contracts. Without trading, no information exchange between participants can occur and so no information aggregation can occur. Second, incentives promote truthful information revelation. Prediction markets create personalised incentives, where the benefits of truthfully signalling information accrue to the individual who provides the information rather than to the group as a whole. This means the information that is aggregated by the market mechanism is accurate and relevant (Wolfers & Zitzewitz 2004). Finally, several authors suggest that incentives will promote information search. Participants may be motivated to seek out new information that may be relevant to the problem being considered (Christiansen 2007; Hanson 1990; Wolfers & Zitzewitz 2004).

In terms of choosing the incentive structure, a clear distinction can be drawn between public real money prediction markets such as Intrade or Betfair, and private prediction markets ran by organizations to create forecasts or gather information. Turning first to public real money prediction markets, many of the incentive design choices are simplified by their nature. First, these prediction markets use real currency. Second, participants invest their own money. Market sponsors in these situations finance their activities by taking a fee to facilitate transactions, but other than that take on no risk. The design of incentives is also simplified by the relatively straightforward nature of the activity. Participants are engaging in the prediction market because they believe they

have superior insights and information to others, and hope to turn this into a financial reward.

In other environments where prediction markets may be deployed, the situation is complicated by a number of factors. First, the market sponsor is running the prediction market because of an interest in the event being considered by the prediction market. Individuals who have relevant information may not be sufficiently interested in participating to actually invest their own money in the market. In order to engender motivation, the market sponsor may have to provide participants with an endowment, which can only be used to trade on the market. The provision of this endowment entails the market sponsor taking on risk. In order to manage this risk, the market sponsor must in turn evaluate the value of the information gathered by the prediction market, so they can calculate a suitable endowment to participants. While this activity can be simplified by the use of certain market mechanisms as described in section 2.2.2.1, it still entails the determination of the value of unknown information.

Second, the market sponsor must consider regulatory challenges that may be raised by the provision of incentives (C. Hall 2010). In some jurisdictions, prediction markets may run afoul of laws governing gambling, securities trading or futures contracts (Gruca et al. 2008). These challenges can be exacerbated where participants in a prediction market are operating in a number of different jurisdictions, for example when a large multinational organization is running an internal prediction market.

The provision of incentives linked to performance can raise organizational questions. Should an organization reward employees on the basis of performance, if such a reward structure does not already exist within the organization? Should an organization enable

a market structure which will implicitly create winners and losers? These questions require careful consideration on the part of the market sponsor.

The nature of a prediction market requires the use of some form of currency to enable trading. The concerns raised by utilising real currency in organizational prediction markets has led to some organizations and prediction market companies to create markets that use virtual currency rather than real currency. The principle used is straightforward. Rather than being provided an endowment in real currency, participants are given a virtual endowment, similar in principle to, for example, the Linden dollars used in Second Life. In the simplest form, these virtual dollars are completely divorced from real currencies. There is no exchange mechanism that permits transferring virtual balances to real currency or vice versa. The virtual currency is a purely notional conceit used to enable trading in the prediction market.

When implementing prediction markets the objections noted in terms of market sponsor risk, regulatory concerns and the organizational risks of using real currency can be sidestepped or ameliorated by using virtual currency (Servan-Schreiber et al. 2004). The merits of real money versus virtual money have been explored in the literature. From a theoretical perspective, most researchers hold the position that in order to properly motivate traders, the possibility of real financial rewards and losses is necessary (Luckner & Weinhardt 2007). The removal of the risk of loss and the possibility of gain may mean that participants do not take their decisions seriously. Additionally, the use of real currency, particularly when the funds are provided by participants, creates a Darwinian aspect to prediction market participation. Unsuccessful traders who make bad decisions will suffer financial losses, and eventually withdraw from the market (Rosenbloom & Notz 2006).

Empirical research comparing the performance of real money prediction markets to play money prediction markets is limited. In the most commonly cited research from the literature Emile Servan-Schreiber et al (2004) conducted a large scale comparison between the accuracy of Tradesports real money markets in NFL games in the United States, and the play money prediction market ran by News Futures in the same sporting events. Their conclusion was that there was “..no significant difference in predictive accuracy” (Servan-Schreiber et al. 2004, p.250). Another study compared the real money markets in the IEM on movie box office receipts with those operated by the Hollywood Stock Exchange (HSX) and again found no significant differences (Gruca et al. 2008). Other research has provided more mixed results. A study by Rosebloom and Notz (2006) found that real money markets were significantly more accurate than virtual currency markets in predicting movements of the Dow Jones Industrial Average, although the same work also found no difference in accuracy when the subject was team sports in North America. In summary, the empirical research to date suggests that whether or not virtual currency affects the performance of prediction markets is dependent upon the characteristics of the event being considered although given the paucity of empirical data no definitive conclusions can be drawn.

One reason suggested in the literature as to why this might be case is that participants will have different motivations when considering different problem domains. Participants may have intrinsic motivations associated with the event being considered as well as the extrinsic motivation of financial reward (Luckner & Weinhardt 2007). A number of intrinsic motivations are suggested in the literature. Traders may be motivated to acquiring “bragging rights” through demonstrating superior knowledge of the topic in question (Servan-Schreiber et al. 2004). Such motivations may be particularly important in domains such as sports, which are emotionally resonant with

many individuals (Hanson 2003). March (2009) points out that competition for reputation in decision making situations often prompts the production and sharing of information far beyond what is required to resolve uncertainties, and prediction markets are no different from other decision making systems in that regard. Prediction markets offer a way of creating and interacting with a community of individuals who share an interest in the topic being considered (Christiansen 2007). The benefits of gaining membership of this community may be a significant factor motivating prediction market participation. Participants may be enticed by the “thrill of a gamble”, and participate in prediction markets purely for the utility of taking a risky position (Wolfers & Zitzewitz 2004).

The importance of ensuring liquidity by promoting trading is continually emphasised in the literature. For this reason, incentive schemes are often put in place that move away from rewarding purely for performance, and towards rewarding both participation and performance. A number of schemes of this sort have been suggested in the literature. A scheme which rewards purely on participation is relatively easy to imagine. Participants receive a fixed sum provided they make a predefined number of trades (Luckner & Weinhardt 2007). Such a scheme encourages participation, but does not encourage careful decision making. Participants are merely encouraged to make the predefined number of trades. A more subtle method of implementing the same idea is to use the number of trades made as a threshold. If a participant makes more than the predefined number of trades, they are paid as normal for the positions that they hold. If they make less than the predefined number of trades, then they receive no reward, regardless of their performance. Such a mechanism balances the need to promote trading with the need to incentivise superior decision making.

Another approach which can be used to balance the competing requirements of promoting trade and rewarding performance is to use an ordinal reward structure (Luckner & Weinhardt 2007). Such an incentive scheme is again relatively simple to describe. Consider a prediction market where participants are paid in virtual currency. At the end of the prediction market, all the participants are ranked from first to last in terms of the value of their portfolio in virtual currency. This ranking produces an ordered list of all the participants in the market. Participants are rewarded on the basis of their standing in the ordinal list, rather than their absolute performance in the prediction market. This incentive structure can be easily adapted to suit the requirements of the market sponsor. It has the property of diminishing the effects of outliers. One performer may end up with an extremely large portfolio value by investing all their endowment on an extremely risky proposition which comes off. In a pure performance based market, they will receive an extremely large reward for what was essentially a lucky guess. By using an ordinal structure, the reward received, while still being large, will be closer to the reward received by an individual who carefully considered the decision, and invested in a number of outcomes. This dampening effect is often useful in prediction market design. The ordinal incentive structure also has the advantage that it provides a straightforward mechanism to allow individuals to compare performance, and so can be used to heighten the effect of the intrinsic motivations mentioned earlier.

In summary, there are a wide variety of incentive mechanisms and structures that can be selected by the market sponsor. The market sponsor will use two criteria to choose the most suitable incentive structure for their purposes. First, the market sponsor will seek to balance the information being revealed with the need to promote trading. Increasing the number and complexity of contracts in a market reveals more information, but risks

reducing liquidity and thereby the performance of the prediction market. Second, the market sponsor will seek to use an incentive structure that rewards participation and performance. The precise details of the incentive structure chosen will depend on balancing these demands, as well as the specific nature of the problem being considered.

2.2.2.4. Audience Structure

The nature of a prediction market is such that the participants are most often viewed in the literature as being rational or semi-rational individuals pursuing their own goals. Such a focus on the individual is often useful in analysing prediction markets. However, it is also often useful to look at the characteristics of all the participants. For the purpose of this dissertation, the term audience is used to refer to the group of all the participants in the prediction market. A number of attributes of the audience are suggested by the literature to have a major impact on the performance of the prediction market.

First, a prediction market can only be expected to aggregate information that is in the possession of at least one of the participants in the market (C. Hall 2010). Even given that a prediction market may encourage participants to search out new information, that information must be integrated into the market through the trading behaviour of an individual participant. This is particularly the case when the topic under consideration is technical, requires specialist knowledge, or advanced training. For example, making an accurate forecast of the price of oil requires knowledge of topics such as the risk of political instability in the Persian Gulf, the risk of Somali pirate attacks, and a myriad of other socio-economic factors. When designing a prediction market, the market sponsor must ensure that the prediction market is attractive to an audience of individuals who have the information, skill and knowledge to make an accurate estimate of the question at hand (Ho & K.-Y. Chen 2007). If such an audience cannot be identified, then the suitability of a prediction market as a decision making tool must be drawn into question.

Second, the size of the audience is a variable determining prediction market performance. One of the main strengths of prediction markets is their scalability. A prediction market can easily allow hundreds or thousands of participants to engage in a decision making scenario simultaneously. However, most researchers suggest that a certain minimum audience size is necessary before prediction markets can operate effectively (Sunstein 2006a). Below a certain minimum size, there are too few participants to allow trading to occur. Liquidity is limited or non-existent, and information aggregation fails to occur. Empirical work in this area is limited. Christiansen's (2007) work on prediction markets in rowing races suggests that 15 or more traders are required in order to create a viable prediction market. Below this number, reliability drops off quickly. This suggestion is echoed by other researchers (Rajakovich & Vladimirov 2009), but as yet the evidence is too limited to draw a definitive answer as to what is the lower limit of audience size that will deliver acceptable prediction market performance. From the perspective of the market sponsor, the point to bear in mind when designing a prediction market is that the audience needs to be of a sufficient size to enable trading. Obviously, the motivation of participants plays a role in determining the required number of traders. A prediction market can operate effectively with fewer traders who are highly motivated (Wolfers & Zitzewitz 2004). The issue of inducing trading in participants through the provision of incentives has already been discussed in section 2.2.2.3.

2.2.2.5. Other Design Considerations

In addition to the design choice enumerated above, a number of other decisions made by the sponsor will affect the operation of the prediction market. Two obvious decisions are how long the market will run for, and will traders be allowed to participate

anonymously in the prediction market (Spears et al. 2009). In addition to these operational decisions, two other factors shape the choices that a market sponsor makes. These are legal and regulatory issues and the issue of knowledge barriers, and are discussed below in more detail.

Legal restrictions and governmental controls impact upon the operation of prediction markets (Cherry & Rogers 2006). Depending upon the subject of the prediction market and the jurisdiction it is operating in, a real money prediction market may be considered a form of gambling, a form of securities trading or a form of futures trading (Gruca et al. 2008). This confusion is increased by internet technology, which allows a prediction market sponsor to recruit participants from all over the world, and thus from a wide variety of different jurisdictions, which often have conflicting rules and regulations. An in-depth analysis of the legal issues involved is beyond the scope of this dissertation. For the purposes of this work, it will suffice to echo Hanson (2007b) when he suggests that much of the problem here stems from the lack of clarity at both a national and global level on precisely what the function of a prediction markets is. As discussed in section 2.2.1, many researchers hold the position that prediction markets are not a form of gambling, and should not be treated as such.

Existing public prediction markets have sidestepped legal and regulatory issues by following one of three main strategies (C. Hall 2010). First, they may restrict themselves to using play money, perhaps offering financial rewards or prizes which are not directly linked to performance. An example of this would be a prediction market like the Hollywood Stock Exchange. Second, they may locate themselves in a jurisdiction that is favourable to the operation of prediction markets. For example, Intrade, a real money prediction market, operates from the Republic of Ireland. Much of the literature examining this subject discusses prediction market operation from the

perspective of the United States, where is it fair to say that that the legal situation is uncertain. The regulatory framework in other countries may present little difficulty to operating prediction markets. Finally, prediction market operators may lobby the government not to intervene on a case-by-case basis. This is the model followed by the IEM, which has obtained a “No-Action” letter from the Federal Trading Commission, which allows them to operate in the United States of America, subject to certain conditions.

The strategies followed by public prediction markets offer models which can be used by organisations when implementing private prediction markets. Most case studies discussing the deployment of prediction markets in the literature specify that these implementations use play money allied with some form of ancillary reward indirectly linked to performance. This model is probably the most suitable for organisational deployment, as it sidesteps any legal concerns, while at the same time allowing for the flexible design of incentives.

The other major design issue in prediction markets revolves around what is referred to as knowledge barriers (Christiansen 2007). While the basic principle of buying and selling contract is relatively trivial for most individuals to grasp, more complex structures such as combinatorial contracts can be difficult for participants to understand. The market mechanism that provides the information aggregation function is often difficult to understand for laypeople (Gruca & J. E. Berg 2007). The precise sequence of steps and decisions that leads to the formulation of a price is not visible and cannot be watched. It is often conceptualised as a “black box” (Seemann et al. 2009). This attribute of prediction markets can often led to a sense of uncertainty in individuals participating in a prediction market. Finally, the user interface itself is often an important factor. The portrayal of price changes and the nature of the interface that

allow participants to make a trade has an influence on individuals perception of the prediction market.

Knowledge barriers influence the design of prediction markets in an organisational setting in three ways. First, the existence of knowledge barriers means it is important to provide training to individuals, explaining how prediction markets work and the principles behind their operation. Second, the effect of knowledge barriers can be mitigated by reducing the number of contracts offered, and simplifying the structure of contracts where possible. This incitement to simplification must be balanced with the requirement that the prediction market provide useful information. Finally, the possibility of knowledge barriers emphasises the importance of careful user interface design in prediction markets, a characteristic shared by most information systems.

2.2.3. Applications of Prediction Markets

Prediction markets are still relatively novel, but have already been deployed in a number of contexts and at a variety of different scales. Various authors have suggested categorization schemes for the various applications of prediction markets. Luckner (2008) divides prediction market deployments into political stock markets, sports prediction markets and other applications. Other authors suggest experiments, political stock markets, sports markets and other applications (Tziralis & Tatsiopoulos 2007). This dissertation divides prediction markets applications by access, and then examines specific applications within each domain. Broadly speaking, prediction markets can be described as being public or private. A public prediction market is one which invites participation from the general public. A private prediction market is one created by a sponsor which seeks to recruit participants from a specific, albeit potentially very large population.

Public prediction markets generally operate using real currency. Participants transfer funds into an account which is then used to finance trades on the market. These markets make a profit by charging a fee for each trade. The fee may be fixed, or linked to the value of the transaction. Public prediction markets can be broken up into two further sub categories, namely sports prediction markets, and general interest prediction markets. Sports prediction markets are closest in nature to traditional betting forums. They allow participants to predict the outcome of sports events. The most prominent example of a sports prediction market is Betfair (<http://www.betfair.com/>). General interest prediction markets are distinguished from sports prediction markets by offering a wider range of questions. Prominent examples described in the literature include Intrade (www.intrade.com), the IEM (<http://tippie.uiowa.edu/iem/index.cfm>) and the Hollywood Stock Exchange (<http://www.hsx.com>). Some of these public prediction markets allow participants to use real currency (Intrade), some limit the amount of funds participants can invest (IEM), and some only use virtual currency (The Hollywood Stock Exchange).

Type	Example
Public (Real Currency)	Intrade (http://www.intrade.com) Betfair (http://www.betfair.com) Iowa Electronic Market (http://tippie.uiowa.edu/iem/index.cfm)
Public (Virtual Currency)	The Hollywood Stock Exchange (http://www.hsx.com) Huddub (http://www.hubdub.com) Newsfutures (http://hwww.lumenogic.com) Foresight Exchange (http://www.ideosphere.com)
Private	Qmarkets (http://www.qmarkets.com) Inkling Markets (http://www.inkling.com) Crowdcast (http://www.crowdcast.com) Prokons (http://www.prokons.com)
Ideas Markets	Spigit (http://www.spigit.com) Nosco (http://www.nos.co)

Table 2. Non Exhaustive List of Operational Prediction Markets

Private prediction markets are designed by market sponsors with the goal of targeting a specific population. This is the form of prediction market deployment which is most commonly used in organisational settings, when organisations are interested in tapping the potentially valuable private information held by employees and other stakeholders in the organisation (Gruca & J. E. Berg 2007). Academic references and analyses on the use of prediction markets as internal decision support tools for various organisational functions is still relatively limited, although increasing all the time. Ortner (1997) describes the use of prediction markets in a project management process in Siemens in Austria, with another example of prediction markets use in project management offered by Remidez and Joslin (2007). A number of papers discuss the use of prediction markets as sales forecasting tools in HP (K.-Y. Chen & Plott 2002; K.-Y. Chen et al. 2003). A similar case study, forecasting market share in the Austrian mobile phone market is described by Waitz and Mild (2009). Hopman (2007) describes the use of prediction markets for demand forecasting in Intel, with other authors offering examples from the medical domain (Rajakovich & Vladimirov 2009; Polgreen et al. 2006). Hahn and Tetlock report Eli Lilly have used prediction markets to evaluate what drugs will be successful, while Microsoft have used them to forecast sales of software (Hahn & Tetlock 2006b). Other organisations that are reported to have used prediction markets include Motorola, Qualcomm, Infoworld, MGM, Chiron, TNT, Yahoo, Corning, Masterfoods, Pfizers, Abbott, Chrysler, General Mills, O'Reilly and TNT (Tziralis et al. 2009).

Other authors have focussed on providing theoretical descriptions of the applications of prediction markets in organisations. Passmore et al. (2005) describe how prediction markets can be used to support the Human Resource function in organisations. Other authors have suggested prediction markets can have applications in the domain of risk

management (Bergfjord 2008; Berlemann & Schmidt 2001; Bruggelambert 2004). Sunstein (2006b) offers another list of possible applications of prediction markets, while other authors point out the power of prediction markets as communication tools in an organisational setting (Gebauer & Glienke 2007).

One specific form of prediction markets has recently emerged which is exciting interest in the academic and practitioner community. These are variously referred to in the literature as “*opinion markets*” (Raban & Geifman 2010), “*preference markets*” (Kamp & Koen 2009) or “*idea markets*” (Hanson 1995). Idea markets share many conceptual similarities with prediction markets. Participants are encouraged to trade contracts on a market, using real or virtual currency. The distinction is that rather than the contracts being linked to a future event of interest, the contracts represent a more intangible artefact, such a proposed new product, or an idea for process improvement. The hope is that the market mechanism will ensure that the idea that is regarded as most valuable by the most participants will receive the highest share price (Kamp & Koen 2009). A number of authors report of the deployment of idea markets (Spears et al. 2009; Lavoie 2009; Dahan & Hauser 2002; K. Strumpf 2009; Ho & K.-Y. Chen 2007). However, the lack of an objective standard by which to measure the success or failure of such markets means that their utility is still the subject of intense debate in the academic community (Kamp & Koen 2009).

2.2.4. Current Challenges Facing Prediction Markets

Two specific classifications of concerns, unique to prediction markets can be identified. First, there is the issue of what is referred to as market failure (Wolfers & Zitzewitz 2006). Markets of any type can be vulnerable to failures such as bubbles or crashes. Such events do not preclude the utilization of prediction markets as a group decision

making tool. Most forms of group decision making are vulnerable to various types of failures, for example, information cascades. The possibility of these failures does not make group decision making useless for organizational decision making. A similar logic holds for the deployment of prediction markets.

The second concern often raised in the literature is the issue of market manipulation (Wolfers & Zitzewitz 2006). This is where a trader or group of traders participate in the market with a motive other than truthful information revelation (C. Hall 2010). This is often mentioned as being a concern when organizational decisions are to be based in part or whole upon the outcome of a prediction market (Sunstein 2006a; Wolfers & Zitzewitz 2006). In a similar manner to market failure, the possibility of market manipulation does not preclude the use of prediction markets as an organizational decision making tool. Participants in a Delphi process who have a vested interest in the decision reached by the group are just as likely to attempt to manipulate the decision arrived at to further their own ends as participants in a prediction market would be.

The possibility of market failures or attempts at market manipulation places further constraints on the design decisions that the market sponsor makes. As well as making choices that seek to improve the aggregation and liquidity of the prediction market, the market sponsor will also attempt to lessen the likelihood and effect of these eventualities. This literature review of prediction markets concludes with an examination of these issues and how they are affected by the design choices made by the market sponsor.

The concept of market failure is not unfamiliar to anyone who has lived through the market convulsions of the last number of years. This dissertation does not take the position that markets are infallible aggregators of information. Similarly, no claim is

made that prediction markets are infallible aggregators of information. In the same way that individuals and groups can make incorrect decisions, prediction markets can generate faulty decisions. The benchmark for prediction market performance should not be infallible perfection (Hanson 2006). Instead, prediction markets should be evaluated contextually versus methods with similar functionality. This point should be kept in mind when reviewing the phenomenon of market failure.

Prediction markets suffer from some of the same problems that appear in other financial markets (Wolfers & Zitzewitz 2004). These problems lead to the prediction market failing to aggregate the information held by participants correctly. Four major psychological biases that affect individual's trading behaviours are noted in the literature.

The first major bias is the well known long-shot bias. *"The favourite long-shot bias is when agents place more bets on the long-shot than their frequency of winning commands and less bets on the favourite than is optimal"* (Bullen & McKenzie 2010, p.36). Put simply, participants are likely to overestimate the chances of an unlikely event occurring, and underestimate the chances of a likely event occurring. The long shot bias is *"..the most longstanding empirical regularity in the literature concerning decision making under uncertainty"* (Metsola 2010, p.59). The long-shot bias has been demonstrated affecting most forms of decision making, and prediction markets are no different, with empirical evidence reported in a number of cases (Berlemann & Schmidt 2001; Kálovcová & Ortmann 2009).

A second source of market inefficiency is trading according to sentiment. For example IEM traders naturally have political preferences, and studies have shown that these preferences affect their trading decisions and portfolio choices (J. E. Berg & T. A. Rietz

2006). Other examples are documented by Wolfers and Zitzewitz (2004). This market failing is also discussed by Durham and Perry (2008). It is important to note here that trading according to sentiment does not imply that individuals are attempting to manipulate the market. Participants in the IEM are not attempting to create a positive prediction for their favoured candidate. Instead, their decision making processes are subconsciously affected by their preference for a particular outcome or candidate.

Momentum trading is a well known phenomenon which affects most market structures to a degree. Momentum trading is caused by participants basing their trading decisions in part upon the most recent trend in the contract or stock being considered (Malkiel 2005). As such, this is a failure of decision making which is specific to prediction markets, since momentum does not exist in such an easily examined form in other methods of decision making. The effect of momentum trading is that it leads to participants undervaluing the importance of newly revealed information (Malkiel 2005; Durham & Santhanakrishnan 2008). This in turn damages the information aggregation from which much of the power of prediction markets is derived.

Finally, the phrasing of contracts has been shown to have a demonstrable effect on the behaviour of participants in prediction markets (Borghesi et al. 2010). In sports prediction markets, participants are more likely to trade in contracts which are specified in the form "*Team X will win*" than contracts which are worded "*Team Y will lose*", even if these contract are binary and mutually exclusive. They suggest that participants have a psychological bias which predisposes them to cheer on "winners".

In many cases, these psychological biases have little or no effect, and are ameliorated to insignificance by the presence of large number of traders. However, it is also easy to see how in certain circumstances, extreme incidents of these effects can lead to catastrophic

market failure. Momentum trading can lead to the formation of bubbles (Sunstein 2006a). That prediction markets are vulnerable to these market failures is suggested by the literature (Spann & Skiera 2003; Wolfers & Zitzewitz 2006; Sunstein 2006b). However, this does not invalidate the use of prediction markets as decision making tools, any more than human fallibility invalidates individual decision making. Instead, it emphasises that prediction market sponsors must be aware of the fallibility of prediction markets, and should in so far as possible design markets in such a way as to reduce the likelihood of these failures occurring.

Both market failures and market manipulation lead to a situation where the price of contracts traded on the prediction market are not a true reflection of the aggregated opinion of all the participants in the market. The distinction between market manipulation and market failure is intent. Market failures occur because of the ingrained psychological biases and responses of individual participants. Market manipulation occurs when one or more participants knowingly attempt to alter the outcome of the prediction market for their own benefit (J. E. Berg & T. A. Rietz 2006). The possibility of market manipulation has been identified as being a possible block to the adoption of prediction markets in organisations (Wolfers & Zitzewitz 2004; Hanson 2006).

Hall (2010) provides a useful taxonomy which can be used to categorise the types of manipulation that prediction markets are theoretically vulnerable to. The first type of manipulation that can occur in a market is when a participant trades against their beliefs in order to create a trading pattern which they hope to profit from later (C. Hall 2010). Two specific examples of this type of manipulation can be conceived. First, a participant may refuse to trade, in order to avoid revealing information that they possess. In this case, the participant is hoping that other, less informed participants will move the price of the contract in such a way as to allow him or her to take greater

profits in the future. Second, a participant may actively trade against their information. A participant may have information that suggests a certain outcome. In order to profit from this information, the participant trades in a manner that suggests this outcome will not occur. In this scenario, the participant hopes that others will follow this trade, driving the price of the contract lower still and allowing the manipulator to take even larger profits when they reverse their position. It is essentially an attempt to capitalise on momentum trading, discussed previously in section 2.2.2.5.

A second type of manipulation that can occur in a prediction market is when a trader or group of traders has the ability to influence the underlying event being considered by the market (C. Hall 2010). In this case the participant may have an incentive to select a particular outcome on the market, and then ensure that outcome in fact occurs. For example, an individual may indicate on a prediction market that a project will not be completed on time, and then actively work to sabotage said project, creating a self-fulfilling prophecy (Hanson 2006).

The third type of manipulation is closely related to the second, but is differentiated by the motives of the manipulator. This type of manipulation occurs when a participant has a vested interest in seeing a particular outcome occurring. The utility of the outcome occurring outweighs the potential gains for the manipulator in the market and so they are happy to trade at a loss in order to have the prediction market indicate the preferred outcome. A good example of this type of manipulation is that which has been observed on the IEM. Since opinion polls, and by extension prediction markets have been demonstrated to affect individual's voting behaviours, partisans have a vested interest in skewing the results of the prediction markets so as to indicate their preferred candidate is a winner. They may be prepared to suffer a financial loss from participating in the prediction market, if the underlying outcome is favourable to them.

The possibility of the manipulation of prediction markets, particularly markets which directly or indirectly drive policy creation at an organisational level can be a stumbling block to adoption of prediction markets. The Policy Analysis Market (PAM), discussed in section 2.2.1.4 was doomed by the perception that individuals would undertake terrorist attacks in order to make a profit on the PAM.

Proponents of prediction markets counter the fear of manipulation with three main points. First, they point out that much of the incentive for manipulation can be reduced by the careful design and selection of incentives (Ho & K.-Y. Chen 2007). For example, one is unlikely to risk ones career by sabotaging a work project for the sake of a relatively trivial financial gain on a prediction market. The correct calibration of incentives reduces much of the risk of manipulation. Second, they point out that traditional forms of decision making are as much at risk of these types of manipulations as prediction markets (Hanson 2007b; Abramowicz 1999). The spectre of these types of manipulations prescribes the careful selection of participants in prediction markets, and an awareness of the possibility of conflicting desires on the part of the market sponsor.

Finally, the literature points out that most observed attempts at the manipulation of prediction markets have failed (Hanson 2006; Sunstein 2006b). Several attempts at manipulating the IEM have been quickly arbitrated away (J. E. Berg, Forsythe, et al. 2008). Historical studies of price manipulation attempts find that these efforts are unsuccessful (Rhode & K. S. Strumpf 2004). Wolfers and Zitzewitz (2004) conclude that efforts to manipulate prices on a prediction market do not have anything other than a transitory effect. While empirical research on this issue is limited, it does suggest that within the specific parameters prediction markets operate in, the possibility and effect of manipulation are not so great as to preclude the use of prediction markets as organisational decision making tools.

2.3. Decision Making

In this section an overview of the literature on decision making is presented. Its purpose is to introduce the models and concepts used in section 2.3.4, which presents a fully realised analysis of prediction markets as group decision making tools. The conceptual nature of decisions and decision making is examined. A model of individual decision making and the psychological and physiological limitations which undermine this model is presented. Following that, a more evolved descriptive theory of decision making called bounded rationality is presented.

Group decision making is examined in section 2.3.2. A description of the advantages and disadvantages of group decision making is presented. The nature of decision spaces which suit group decision making are described.

Section 2.3.3 examines group decision making in more details. Using Ellis and Fischer's (1994) model of group decision making, it examines the individual elements that affect group decision making. This discussion of group decision making is presented in order to contextualise the discussion of prediction markets in section 2.3.4.

Finally, section 2.3.4 uses Ellis and Fischer's (1994) model of group decision making to synthesize the literature on group decision making and prediction markets. By examining prediction markets using the provided framework, prediction markets are firmly positioned as group decision making tools. Additionally, this synthesis allows for the identification of gaps in the literature on prediction markets, which drives the identification of research questions in section 2.5.

2.3.1. The Theory of Decision Making

A decision is when an actor selects one action to enact from a variety of possible actions (Simon 1997). The selection process posited in this description does not imply rationality or even consciousness. When presented with an obstacle, an insect may decide to turn left or right. While it can be said to have made a decision, the act of selection that the insect undertakes is not usually taken as an indication of intelligence. In a similar manner, a human being will instinctively remove their hand from a hot plate. This can be portrayed as a decision, even though no conscious thought will have occurred to select the action. While recognising that the definition of a decision offered above does not presuppose rationality or consciousness, this dissertation will generally concentrate on decisions that do involve conscious selection of actions.

The nature of decisions can be examined in a number of ways. Decisions can be categorized in terms of their familiarity to the decision maker. Some decisions are described as being programmed or structured (Hitt et al. 2005; Cooke & Slack 1991; Jennings & Wattam 1998). A programmed decision is one undertaken in a well understood environment. It occurs routinely and is unsurprising in both content and context (Hitt et al. 2005). An example of a programmed decision is a driver's response to a red traffic light. The meaning of the red traffic light is clear to the driver, as is the recommended action to take. In an organizational context, many decisions are programmed. A manufacturing organization will decide to order more supplies in response to dwindling stocks. Managers will hire more employees in response to staff shortages.

Other decisions are described as being non-programmed or unstructured (Cooke & Slack 1991; Jennings & Wattam 1998). Non-programmed decisions are novel to the

decision maker, and involve considerable uncertainty (Simon 1997). To continue with the automotive example, a decision maker would be faced with a non-programmed decision space if they encounter a traffic accident. A wide variety of possible actions are available to the driver. They may continue on their way, contact the authorities, or stop and offer assistance. The driver must choose between these alternatives. In a similar manner organizations will often have to make non-programmed decisions. If an organization is faced with falling demand for a product, many actions may be considered. Alternatives include decreasing the cost of the product, increasing marketing spend, or terminating the product line entirely.

Programmed and non-programmed decisions represent extreme ends of a continuum. In reality, very few decisions are programmed or non-programmed. Most decisions fall somewhere between these two poles. Individuals and organizations will respond to these differing types of decisions in different way. Default behaviours are often developed to deal with more programmed decision spaces. Individuals develop habits. Organizations use Standard Operating Procedures (SOP) or similar guidelines to define responses to programmed decisions. Little or no conscious thought or effort is required to make the decision. On the other hand, non-programmed decisions often require analysis, thought and reflection at both the individual and organizational level.

Decisions can be examined from the perspective of their ends. Some decisions involve factual statements. A factual statement is one that can take the value true or false. Organizations will often take decisions that are essentially making factual statements about the future. As an example, a firm may need to decide what sales of a product will be in the next financial quarter. The evaluation of this figure is a decision, in the sense that the decision making actor evaluates all the possible sales figures for the next quarter, and selects the one they believe is most likely to occur. At the end of the next

quarter, the actual sales figures can be compared to the previously reached decision, and can be determined to have been true or false.

Conversely, many decisions may have an imperative quality (Simon 1997). Actors select one action from the myriad of possible actions with a view to enacting a particular future state of affairs that is beneficial to them. Organizations may decide to increase marketing spend in order to boost sales in the future, or invest in new technology in order to boost productivity.

As with familiarity, categorizing decisions as factual or imperative is a false dichotomy. Most decisions fall in between the spectrum defined by these extreme endpoints, and have both a factual and imperative component.

Another important characteristic of decisions is that they tend to be dependent (Cooke & Slack 1991; Simon 1997) Two types of dependencies can be clearly identified. First, decisions tend to be linked to other decisions within the organizational structure. As Simon (1997) points out, organizations tend to be hierarchical, meaning that decisions at higher levels in the organization affect decisions at the lower levels. A strategic decision to focus on a particular market segment will impact upon the operational plans of the marketing department. Equally, a decision made in one division of an organization affects other divisions within that organization. If the operations department decides to terminate the manufacture of a product because maintaining the machinery has become prohibitively expensive, the sales department will no longer be able to offer that product to customers.

Decisions may also have temporal dependencies. Past decisions can constrain current decisions. If a large investment has been made in a new manufacturing plant, then an organization may feel constrained to complete the plant and claw back some of the

investment, even if changing market conditions mean the investment is no longer likely to be profitable. The same example can be turned on its head and used to demonstrate that current decisions can also be affected by considerations of future decisions. An organization faced with the decision on whether or not to invest in a new manufacturing plant must factor into its deliberations the constraints that investment will place on its future decisions.

2.3.1.1. Individual Decision Making

Decision making can be thought of as an act or a process. (March 2009). When decision making is thought of as an act, it is the act of selection between alternatives as outlined previously. (Simon 1997). However, this limited definition leaves out several important features of decision making in an organizational setting. A more useful definition is that *“Decision making is the process of specifying the nature of a particular problem or opportunity and selecting among the available alternatives to solve a problem or capture an opportunity”* (Hitt et al. 2005, p.301). This definition of decision making includes the selection process which has been identified as the act of decision making, but also implicitly includes other activities. The nature of the problem to be solved must be specified. A list of alternative actions that could possibly be chosen must be identified.

The atomic unit of decision making is generally seen to be the individual human being. The conception of human beings as entities capable of using free will to make decisions is a cornerstone of many disciplines, including Economics, Political Science and most of the social sciences (March 1999b). There are two fundamental models describing how individuals make decisions. The rational model stresses the logic of consequence (March 2009). It views decision makers as forward looking individuals, who evaluate

possible actions in terms of consequences, and select from the alternatives available based upon these consequences (Simon 1997). In contrast, the rule following model follows the logic of appropriateness (March 2009). The rule based model conceives of decision makers as evaluating a situation and selecting an appropriate behaviour based on past experience.

This dissertation will focus in detail on the rational model of decision making. There are a number of reasons for this. First, the rational model of decision making that is used most commonly in the relevant literature. Particularly in the fields of management and economics, the rational model is used both as a descriptive and normative model of decision making. The rule following model is more commonly found in the literature on psychology and to a lesser degree education. Since this dissertation rests primarily upon the literature in the areas of management and decision science, it is appropriate to follow the conventions of the extant literature.

Second, the behaviour of individuals and groups in administrative organizations is primarily forward looking, and orientated towards goals and objectives (Simon 1997). The forward looking rational decision model with its emphasis on expected consequences provides a neat theoretical fit with this perspective on individual and organizational behaviour.

In any case, it is important to note that these are not mutually exclusive models. Indeed, depending upon one's perspective either is a subset of the other (March 2009). Rational models of decision making accept the existence of rule based behaviour, but theorise that the creation and use of these rules is in fact the result of a higher-order rational decision. Likewise, the rule based model of decision making views rational decision making as another rule. In certain situations, it makes sense to weigh the consequences

of one's actions, and choose accordingly. From this perspective the rule following decision maker instantiates an identity by choosing to engage in rational decision making.

The rational decision making model as described by Simon has three main stages (Simon 1997). While these stages are sometimes assigned different titles by different authors, they retain their distinctive characteristics throughout the literature. For the sake of clarity Simon's terminology is used throughout this discussion. Simon identified three stages in the decision making process, namely Intelligence, Design and Choice. In conjunction with other authors, he later added a fourth stage, most commonly referred to as Implementation (Turban et al. 2007). While other authors sometimes add other stages to the decision making process, such as Monitoring (Turban et al. 2007), or Sensing (Boddy 2005), the four stages identified above are common across most models of rational decision making, and this discussion will be restricted to them for that reason.

In the rational model the first stage of the decision making process is called Intelligence. The Intelligence stage is primarily concerned with the collection and analysis of information. Two primary activities can be identified (Turban et al. 2007). First, the decision maker needs to examine the environment in order to determine the current situation (Cooke & Slack 1991; Jennings & Wattam 1998). The decision maker is said to establish the state of the world (March & Simon 1993). Second, the decision maker needs to identify that the state of the world requires a decision be made. This activity is sometime identified as a separate Sensing stage, but is more usually subsumed into the Intelligence stage.

The second stage is most commonly called Design. Again, Design contains two major activities. First, the decision maker identifies the alternatives that are available given the state of the world (Laudon 2006). Second, for each alternative, the decision maker establishes the consequences of selecting that alternative (March 2009). In this framework a consequence is seen to be a new state of the world. This state of the world is hypothetical, but will be instantiated if the decision maker chooses the relevant alternative.

The third stage is most usually referred to as Choice. It is in this stage that the act of decision making occurs (Laudon 2006). A decision maker is assumed to have a consistent set of preferences. Preferences allow the decision maker to calculate the utility of a consequence. In the Choice stage, a decision rule is invoked to select a single alternative from all the alternatives available (March 1999b). In the rational model the decision rule is assumed to be that the alternative that invokes the consequence with the highest utility is selected (Simon 1997). In this way, rational decision making is seen as being forward looking. The selection of alternatives is prompted by the utility of the expected consequence. In this way it is conceptually very different from rule based decision making, where selection occurs through the instantiation of a behaviour that is selected by virtue of the decision making situations similarity with a previous situation.

At this point in the rational decision making process, the act of decision making has occurred. However, most models of rational decision making include an Implementation stage. This reflects the idea that the act of selecting an alternative does not enact that alternative. The actions associated with the chosen alternative must be performed (Laudon 2006). The implementation stage is seen as consisting of the actions and behaviours that change the current state of the world into the state of world described as the consequence of the alternative chosen.

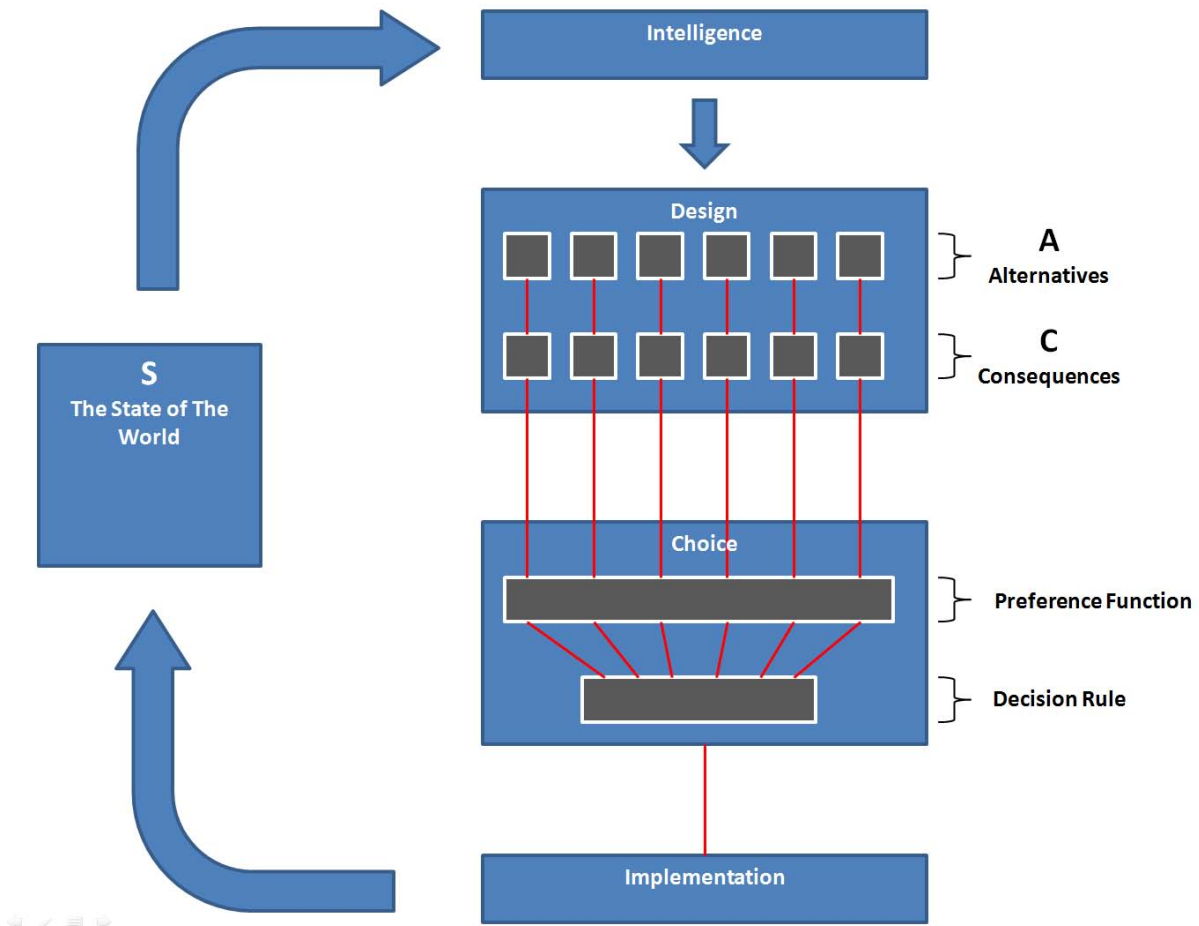


Figure 3. Model of Rational Decision Making

A model of the four stages described above is shown in Figure 3. In the rational model, decision making is seen as a process that runs from Intelligence to Design to Choice to Implementation in that order. Before examining the weaknesses of the rational model, it makes sense to examine the assumptions it is based upon. In its purest form, as described above, the rational model contains four assumptions. First, it assumes the decision maker has complete knowledge, both of the state of the world, and of all the alternatives available. Second, the decision maker has complete knowledge of all the

consequences of each alternative, at least up the level of being able to calculate a probability distribution for the consequences that will arise upon selection of an alternative. Third, the decision maker has consistent preferences that allow them to assign a value to every consequence. Fourth, a decision maker has a consistent decision rule that is used to select alternatives based upon their preferences for each consequence (March 1999b).

These assumptions are far too onerous to form the basis of a realistic model of how decision making actually occurs. However, the framework supplied by the rational model is commonly used as a normative model for decision making (Jennings & Wattam 1998). Its assumptions underpin much of Economics and its associated disciplines. In much of the management and decision making literature it is presented as a meta-level construct to describe how decision making should occur, both at an individual and a group level. Most researchers also agree that decision makers are “intendedly rational” (Simon 1997). While actual decision making may not be rational in the strict sense of the word, most decision makers aspire to rationality (March 2009).

2.3.1.2. Critique of Rational Decision Making Theory

Rational decision making is a normative theory of decision making (Jennings & Wattam 1998). However, the most ardent proponents of the rational theory of decision making admit its limitations as a realistic description of how decision making actually occurs. A descriptive theory of decision making should explain how human decision makers actually make decisions. As such, many of the findings that demonstrate the limitations of the descriptive power of the rational theory of decision making come from the field of psychology (Thaler 2000). Before examining a widely accepted descriptive theory of

decision making called bounded rationality in the next section, a critique of rational decision making is elucidated in this section.

The cognitive and intellectual limitations of the human brain impact upon decision making (Bazerman & Chugh 2006; Simon 1997; Thaler 2000). Drawing upon work from a range of disciplines, most notably psychology and sociology, researchers in decision making have identified a number of psychological and physiological factors that undermine the rational model of decision making as a descriptive theory.

Psychological/Physiological Limitation	Effect
Bias	<ul style="list-style-type: none"> • Framing • Incorrect Categorization
Selective Perception	<ul style="list-style-type: none"> • Bounded Awareness • Information Filtering • Uncertainty Absorption
Stereotyping	<ul style="list-style-type: none"> • Negative Stereotyping • Positive Stereotyping
Cognitive Complexity	<ul style="list-style-type: none"> • Simplification
Attention	<ul style="list-style-type: none"> • Increases Simplification
Memory	<ul style="list-style-type: none"> • Failure to Recall Information • Recall Incorrect Information
Emotion	<ul style="list-style-type: none"> • Emotional Responses to Decisions

Table 3. Psychological/Physiological Limitations on Decision Making

One psychological factor that researchers have found affects decision making is bias, sometime referred to as information bias (Hitt et al. 2005). Bias is usually linked with words such as prejudice and discrimination in common usage. However, in the context of decision making, bias occurs when the decision maker subconsciously filters information in order to fit existing preconceptions and mental models. Consider a firm

facing a situation of declining profits. The marketing manager in the organization is likely to see the problem as a marketing issue. They will consider alternatives such as increasing marketing spend, or targeting marketing campaigns at more profitable market segments. The finance manager will be inclined to see it as a cost issue. They are likely to consider alternatives such as cutting costs, or reducing staff. Both actors in the situation are framing the problem. They place the decision in a frame of reference that they are familiar with (Jennings & Wattam 1998). Bias is closely linked to the notion of categorizing (Cooke & Slack 1991). Decision makers seek to deal with non-programmed decisions by relating them to previous decisions they have encountered. Categorizing is often essential in rendering abstract decision making situations manageable, given the limitations of the human intellect. However, the process has inefficiencies. The assumptions of similarity and familiarity which drive categorizing are often misguided. Decision makers may seek to “put a square peg in a round hole” by assuming similarities where none exists. This in turns impedes the efficient operation of the decision making process.

Closely related to bias is the phenomenon of selective perception. Selective perception is when decision makers screen out information which does not fit the decision makers world view (Cooke & Slack 1991). In developing their concept of bounded awareness Bazerman and Chugh (2006) point out that decision maker’s often fail to see relevant information, even when it is readily available. They point to Neissers (1979) work on perception, where a video of two teams playing basketball is shown to participants, who are asked to count the number of passes made in the video. In the middle of the video, a woman walks through the scene holding an umbrella. Despite the incongruousness of this event, less than 21% of participants notice this (Neisser 1979). Decision makers have also been shown to be uncomfortable dealing with ambiguous information. They

deal with ambiguity in a number of ways such as filtering this information out (Cooke & Slack 1991). Alternatively decision makers may engage in uncertainty absorption (Hitt et al. 2005). This is where the uncertainty inherent in information is reduced as a way of simplifying its analysis. Decision makers may take a piece of information like “There is a 5% chance that house prices will remain the same or fall”, and subconsciously process this as meaning house prices will not fall. Uncertainty absorption is a particular problem when information is passed from person to person (Hitt et al. 2005).

Bias in decision making often affects decision maker’s perception of other people (Jennings & Wattam 1998) . This specific form of bias is often referred to as stereotyping (Hitt et al. 2005). A stereotype is a “*broad generalisation about what characteristics are held by a particular group or category of people*” (Jennings & Wattam 1998, p.68). Categorization is usually a two step process. Individuals have a set of attributes which they associated with a category. For example, an individual may assume that a person who is over the age of 65 is in the category of elderly. In parallel, the individual has a set of characteristics which they associate with the term elderly. Possible examples here might include “slow”, or “set in their ways”. Following on from this, it is easy to see how stereotyping impacts upon decision making. Decision makers evaluate a person based on their presented attributes, and then consciously or subconsciously assign to them the characteristics they associate with this stereotype (Cooke & Slack 1991). It is important to note that stereotyping can be positive or negative. A decision maker may see a person who graduated from a university such as Yale or Harvard as having superior intellectual skills to other persons. Stereotyping most obviously affects the selection and recruitment processes involved in human resources (Hitt et al. 2005; Jennings & Wattam 1998). However, it also can affect other

decision making situations. Decision makers may assign more or less weight to information provided by other actors depending upon the stereotype that they apply to that informant.

The cognitive complexities of many decisions pose problems to decision makers. At its simplest, cognitive complexity is a function of the information processing limits of the human brain (Hitt et al. 2005). Any individual can only store so much information at one time. Similarly, an individual can only process so much information at any one time. Cognitive complexity places fundamental limits on the problems that can be handled by an individual human being. This can be exacerbated by a number of factors. First, a decision maker may not have skills or abilities which would be applicable to the decision at hand. For example, a decision maker may not have the required background in civil engineering and planning to determine whether a new road is required or not. Second, a decision maker may not have access to relevant information about the decision making situation. For example, the decision maker may not have information regarding the current and expected volume of traffic on this new road. Third, a decision maker may not know that they do not have access to relevant information. For example, the new road may be planned to cope with a surge of traffic expected to occur due to the opening of a new airport. However, the decision maker may be unaware of this planned development, in what can be seen as a failure to seek information (Bazerman & Chugh 2006). The general response to cognitive complexity is to utilise a simplification strategy, such as editing, framing, heuristics or decomposition. These strategies are discussed in more detail later.

Perception is generally seen as “*the active psychological process in which stimuli are selected and organised into meaningful patterns*” (Jennings & Wattam 1998, p.66). The concept of attention thus is seen as being central to meaningful perception. Decision

makers choose to attend to some stimuli and ignore others. The act of attending is choosing from all the possible stimuli presented by the world which ones to consider in more detail, and which to ignore (Simon 1997). This is usually a subconscious process. Attention is governed by what Simon calls the “*startle pattern*” (Simon 1997, p.101). Stimuli which are unexpected are more likely to attract decision maker’s attention. Conversely, small incremental changes are less likely to attract decision maker’s attention. These psychological reflexes affect what information is considered, and obviously impacts upon decision making. Attention is also important in understanding how decision makers deal with cognitive complexity. Cognitive complexity generally leads to decision makers simplifying the problem being considered, using various psychological processes which will be discussed in the following section. If the decision maker faces time constraints they will devote less attention to the problem, leading to increased simplification. Decision makers may feel pressurised to take a decision quickly, leading to sub-optimal consideration of the problem, and therefore a suboptimal solution (Simon 1997). This can lead to stress which also adversely affects the decision making process (Hitt et al. 2005). Increased stress can lead to suboptimal decision making, which in turn leads to more stress and so on.

The importance of memory in rational decision making is obvious. Decision makers use memory to recall facts and the experience of past similar situations when making decisions. However human memory is notoriously fallible. Humans may simply forget facts (Jennings & Wattam 1998). More corrosively, humans often remember past experiences incorrectly, usually in a way that allows them to positively portray themselves or the consequences that arose from those situations. An additional complication arises from the way it is generally accepted that memories are stored in the human brain. Memory is seen as being associative (March 2009). For example, a certain

smell will evoke a childhood memory. However, this often means that a relevant memory is not recalled because the decision making situation does not contain a suitable associative prompt to enable recall.

The final psychological attribute that plays a role in decision making is emotion. Emotions are generally seen as providing the urge to action that prompts human behaviour and decision making. A famous example of the role of emotions in decision makers is provided by the case of Phineas Gage, a railway construction worker whose pre-frontal cortex was damaged in a construction accident. This accident damaged the part of his brain which governed emotions. His peers and colleagues described this accident as radically changing Gages behaviour, to such a degree that he was described as being a different man (Damasio 1996). Whereas as previously Gage was seen as hard-working and industrious by his peers, he came to be viewed as lazy and unreliable after his accident. The decisions he made subsequent to his accident were clearly influenced by the damage to the part of his brain governing emotions.

Other empirical work also demonstrates the role of emotion in the decision making process. The ultimatum game is a well known psychological study where one player, known as the proposer, is given a sum of money, say \$10. They offer a portion of the money, A , to the other player known as the responder. The responder can accept the portion offered, in which case the responder gets A , and the proposer gets $10 - A$, or reject the offer in which case both players get nothing. In this case, a rational responder will accept any offer, regardless of how small it is. In practice, however, if A becomes too small, the responder will reject the offer. This is seen as being an emotional response where the responder seeks to punish the proposer for what is seen as being an unfair offer (Thaler 2000). More generally, it is fair to say that decision makers are affected by the emotional impact of the decision on them. A politician is less likely to

vote for health cuts if a person close to them will be affected by said cuts. If the consequences of the decision can be personalised, then this will also affect the decision maker.

This literature review has demonstrated the limits of rationality in individual decision makers. As such, these limitations are part of the psychological and physiological make up of human being, and can only be ameliorated. In order to create a descriptive theory of decision making, which accounts for these limitations, the theory of bounded rationality was developed, which is discussed in the next section.

2.3.1.3. Bounded Rationality

The psychological and physiological limitations that are a part of the human condition mean that the rational model of decision making can only ever be a normative model of decision making. The failings of rational decision making as a model which describes how decisions are actually made has been recognised (Thaler 2000). This has led to the development of bounded rationality as a descriptive theory of decision making, propounded most notably by Simon (Simon 1997).

Before moving to examine the bounded rationality theory of decision making, it is important to make a number of points about the rational theory of decision making. First, while most researchers recognise that rational decision making is an unreachable goal, many academics and practitioners still use it to describe how decision making should occur. It is frequently used as a normative framework both at an individual and a group level to understand how decision making can be improved. Second, most researchers recognise that while individuals cannot be wholly rational, they are “intendedly rational” (March 2009). Finally, experimental data suggests that the rationality of decision making improves in groups (March 2009). Various processes that

occur at a group level can ameliorate the effect of the psychological and physiological limitations of individuals. These processes will be examined later.

Simon's theory of bounded rationality takes as its starting point the rational model of decision making. This model is then modified in order to bring it closer to a realistic description of how decision making occurs. He introduces three major concepts which alter the model (Hitt et al. 2005). These concepts are iterative alternative evaluation, simplification, and satisficing.

The rational model proposes that decision makers generate and examine all the alternatives that are possible in a given situation, and further proposes that decision makers then estimate the consequences that will arise from taking an alternative in the current situation. However, generating and evaluating all possible alternative-consequence pairs is impossible given the problems associated with cognitive complexity, attention and memory discussed earlier (March 2009). Instead, bounded rationality proposes that decision makers generate one alternative, then identify the likely consequence of taking that action and finally use their personal preferences to apply a decision rule to see if that alternative is suitable (Hitt et al. 2005). If the expected consequence is acceptable, then the decision maker chooses that action. If it is not acceptable, then the decision maker generates a new alternative, and begins the procedure again. Rather than generating all possible alternatives, the decision maker is envisaged as engaging in an iterative process where alternatives and consequences are evaluated sequentially, until such time as an acceptable consequence is found. At that point search terminates, and the chosen alternative is selected.

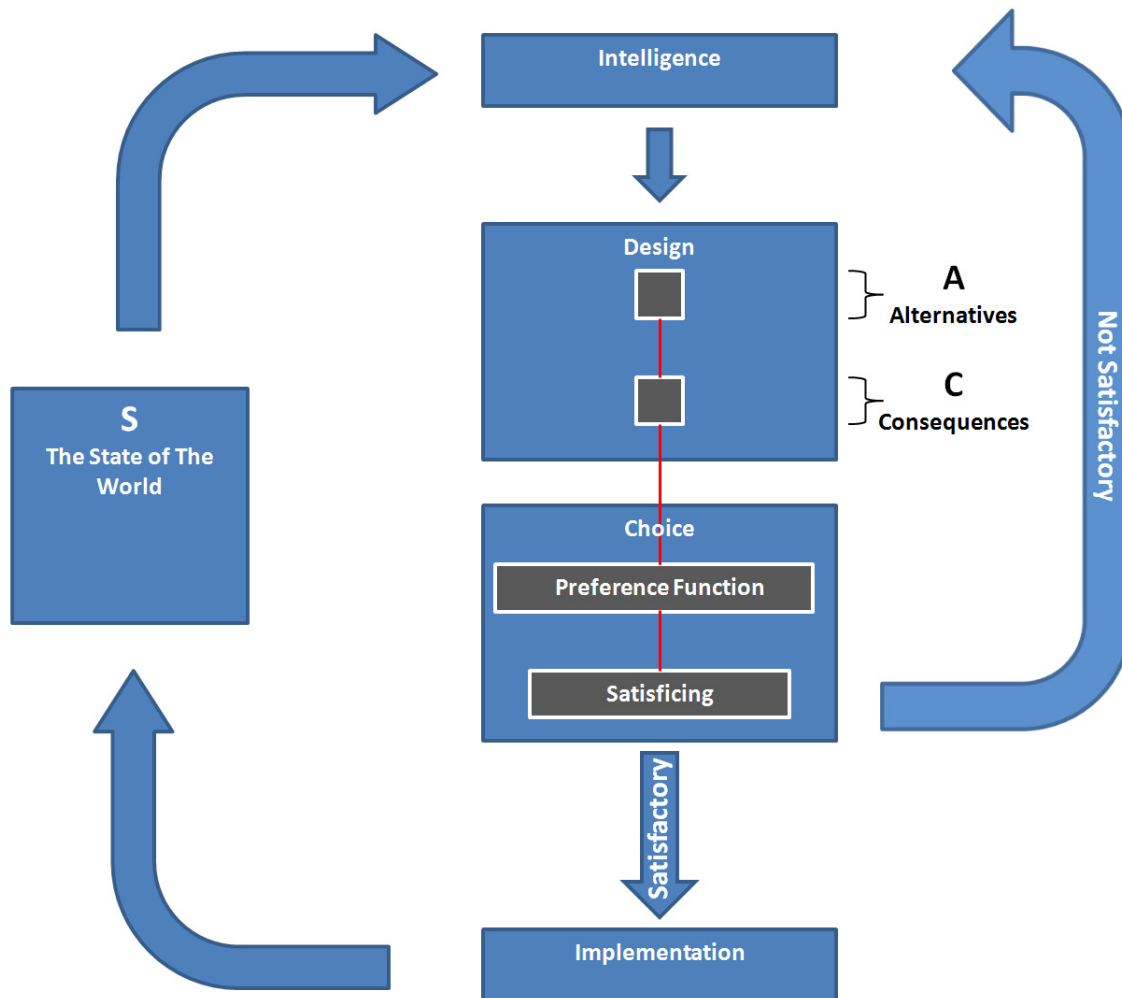


Figure 4. Decision Making Under Bounded Rationality

The bounded rationality model of decision making recognises that the information processing and problem solving abilities implied by the rational model are beyond the individual human (March 2009). Instead of the exhaustive search and rigorous calculations implied by rational decision making, decision makers use simplifications to make decision spaces tractable. March identifies four major classes of simplifications which occur in the decision making process, namely editing, decomposition, heuristics and framing.

Editing is a process where a decision is simplified before entering the choice stage of decision making, by winnowing the alternatives available using a simple cues (March

2009). A given decision making situation may have a number of dimensions to be considered. For example, an engineer charged with selecting a suitable location for a hydro-electric dam may have to consider a number of different criteria when judging the suitability of a site. The cost of the construction, the power generation potential of the dam, and the impact of construction on the environment may all be considerations that have to be balanced in choosing the final site. Rather than optimizing for all these variables simultaneously, editing conceives of the engineer optimizing sequentially. The engineer will first select from the alternatives based on cost. From the acceptable alternatives remaining, the decision maker will then filter based on power generation potential and so on (Simon 1997). Often, this process is subconscious and opaque to the decision maker. Editing is used to reduce the infinite number of alternatives available in any situation to a computationally tractable number. However it runs the risk of settling on a suboptimal solution. Additionally, the final result is sensitive to the order in which the filtering occurs. To use the example above, filtering first by power generation capacity, then by cost can lead to a different result from filtering by cost then power generation.

Decomposition is reducing a large problem into component sub problems which are more tractable (March 2009). The assumption is that by solving the smaller individual problems, a solution will emerge for the large problem. For example, a sales executive may approach the problem of allocating advertising resources in a global market by first decomposing the market into regional sub markets, and then allocating resources to each of these sub markets.

The effectiveness of decomposition as a methodology for reducing complexity is dependent to a large degree on the nature of the problem being considered. Decomposition has a long and successful history as a problem solving methodology,

particularly in the physical sciences. Complex real world systems are decomposed until it eventually becomes possible to run controlled experiments to verify hypotheses regarding physical laws.

However, in the same way that understanding evaporation does not allow prediction of the weather, problem decomposition often runs afoul of the interrelatedness of systems. A system is a set of elements or components that interact. A system is composed of subsystems (Stair et al. 2008). However, a system is more than the sum of the subsystems of which it is composed. The attributes and characteristics of the system as a whole are formed not just by the subsystems, but also by the interactions of those subsystems. When there are relatively few interactions between subsystems, the subsystems are referred to as being loosely coupled. When there are many interactions between subsystems, they are considered tightly coupled.

Problem decomposition works when the subsystems identified as part of the larger system are loosely coupled. However, if the subsystems identified are tightly coupled, then problem decomposition essentially ignores the effect of these interactions, which are in fact vital to understanding and solving the larger problem (March 2009). It is characteristic of many non-programmed decision making situations that the problem being considered is tightly coupled.

The third major class of simplification is heuristics. Jennings and Wattam offer the following definition of heuristics : “*Heuristics are simple generalisations or guidelines that individuals use to reduce mental efforts in processing information*” (Jennings & Wattam 1998, p.67). A simple example of a heuristic is the well known phrase “*Red sky at night, Sheppard’s delight*”. This simple rule of thumb allows the user to make a very quick forecast as to the likely weather conditions tomorrow, at least in geographical

locations like the British Isles where the predominant weather patterns are westerly in origin. While this heuristic is obviously not as accurate or as scientifically rigorous as a properly compiled meteorological forecast, it does have certain advantages. It can be applied extremely rapidly. It does not require the acquisition, recall or application of advanced scientific concepts and models. In some situations, these advantages can outweigh the loss of predictive accuracy. Decision makers use heuristics to make complex problems cognitively tractable (March 2009). Heuristics are used to guide the search for alternatives (Hitt et al. 2005). Heuristics are often applied in order to forecast the consequences that will arise as a result of selecting a particular alternative (Cooke & Slack 1991).

The fourth simplification methodology identified by Marsh is framing (March 2009). Decisions are framed by the beliefs and paradigms used by decision makers when evaluating problems. Consider the situation where an organization faces declining sales of a particular product. This problem can be framed as being about maintaining profits, or maintaining market share. The frame chosen affects the alternatives considered. Under the first frame, alternatives likely to increase the margin on the product will be considered. Under the second frame, alternatives likely to decrease the cost of the product will be viewed more favourably. Similarly the framing of the decision affects the evaluation of consequences. Increased sales at the cost of declining profits may be viewed as a favourable outcome in the second frame, but rejected in the first frame.

These four simplifications are used by decision makers both consciously and subconsciously. While the preceding paragraphs have illustrated particular applications of these simplifications to particular stages in decision making, it should be noted that all of these simplifications are applied to a greater or lesser degree in all stages of the

decision making process. They are the inbuilt mechanisms used by the human brain to deal with a complex world, and are essentially unavoidable.

The third major modification of the rational model of decision making is the introduction of the concept of satisficing. Satisficing is the “*selection of the minimally acceptable solution rather than pushing further for an alternative that produces the best results*” (Hitt et al. 2005, p.309). The pure form of rational decision making assumes that the decision maker is attempting to make the best possible decision, as defined by the expected consequences and their personal preferences. Under bounded rationality, this decision rule is altered. Iterative alternative evaluation conceives of alternative and consequences being evaluated sequentially by the decision maker. Satisficing implies that the decision maker has a set of criteria for evaluating the expected consequences of a decision. Consequences are not evaluated against each other in order to establish the best vis-à-vis the decision maker’s preferences. Instead, they are evaluated against criteria held by the decision maker. If the utility of the consequence under consideration exceeds the criteria of the decision maker, then the alternative that leads to that consequence is selected. Decision making terminates and the process moves onto the implementation of the decision.

Bounded rationality is a descriptive model of how decision making occurs. In response to the psychological and physiological limitations of the human brain, decision makers’ actual behaviour moves away from that of a hyper-rational homo economicus, and towards the more limited rationality of Simons’ administrative man. Fundamentally, the limitations of information processing and problem solving that are inherent in individual humans mean that such a divergence is unavoidable. Creative alternatives are ignored, or not even conceived of. Expected consequences of alternatives are incorrectly calculated. Optimal solutions are ignored because of previously reached satisfactory

solutions. The result of bounded rationality is that individual decision making is necessarily sub-optimal.

2.3.2. Principles of Group Decision Making

This section introduces group decision making. It begins in section 2.3.2.1 by examining the advantages of group decision making over individuals decision making. By its nature, group decision making is a social activity, which involved the interaction of a group of individuals. These interactions affect group decision making and are in part responsible for some of the advantages of group decision making. However these interactions can also have negative effects on the group decision making process, which are explored in section 2.3.2.2. Finally, in section 2.3.2.3, an analysis is presented which explores the attributes of decisions from the perspective of their suitability for group decision making.

2.3.2.1. Advantages of Group Decision Making

The core advantage of group decision making over individual decision making is intuitively obvious, and is summarised by the well worn adage “Two heads are better than one” (Jennings & Wattam 1998). The psychological and physiological limitations of an individual are part of the human conditions, and cannot be sidestepped or avoided. An individual can only store so much information in memory. An individual can only consider so many alternatives, and so on. It is intuitively obvious that two individuals can store a greater amount of information than one person. Two people can consider more alternatives than one, and so on.

As well as having at least the potential to process more information than any one individual, group decision making enables the assembly effect. “*An assembly effect*

occurs when the group is able to achieve collectively something which could not have been achieved by any member working alone or by a combination of individual efforts” (Collins & Guetzkow 1964, p.58). The assembly effect is what prompts, for example, the generation of alternatives that no individual within the group would have developed, if they did not have other members of the group to “bounce off”. Five specific advantages of group decision making can be identified from the literature. The advantages are addressed in turn, particularly with reference to how the group decision making dynamic allows the amelioration of the psychological and physiological limitations described in section 2.3.1.2.

Advantage	Reasons
Increased Information	<ul style="list-style-type: none"> • Overcomes limitations of memory • Reduces the effect of bias and selective perception • Improves information search by ameliorating attention limitations
Improved Alternative Generation	<ul style="list-style-type: none"> • Reduces the effects of bias and selective perception • Greater number of alternatives considered • Enables the assembly effect
Improved Judgement	<ul style="list-style-type: none"> • Normalization of emotions effects • Normalization of risk propensity • Improved utilization of domain experts • Improved Information processing
Improved Legitimacy	<ul style="list-style-type: none"> • Decision inherits legitimacy from process
Individual Development	<ul style="list-style-type: none"> • Improved Knowledge • Improved Transferable Skills • Improved Morale

Table 4. Advantages of Group Decision Making over Individual Decision

Making

The position that group decision making increases the amount of information that is available to be applied to the decision space is widely accepted (Boddy 2005). Hitt et al tell us that “Groups can accumulate more knowledge and facts” (Hitt et al. 2005, p.317). This position intuitively gives group decision making an advantage over

individual decision making. As March points out, “*decision processes presume the exploitation of knowledge*” (March 2009, p.243). Groups are seen as being superior to individuals in capturing and storing information for a number of reasons.

One of the major constraints on the information available in the individual decision making context is the limitations of human memory. This limitation is overcome in group decision making by including more individuals. By drawing on the memories of more individuals, the total amount of information available to address and analyse the problem is increased.

Bias and selective perception play a major part in what is referred to as bounded awareness. Bounded awareness is the failure to seek, see, use or share information (Bazerman & Chugh 2006). Under bounded awareness, relevant information may not be used because an individual’s perceptual limitations mean they do not identify the information as being useful. However, in a group decision making situation, the uniqueness of each individual involved in the process implies that each individual will have separate and distinct biases and perceptual limitations. In this situation, if one individual ignores a relevant piece of information because of perceptual filters, another person may identify its relevance and bring it to the group’s attention. Of course, it is possible that biases that operate on a group, organizational or cultural level affect all the individuals in the group, but all other things being equal, group decision making offers the possibility of reducing the effect of these biases.

One important construct in bounded awareness is the failure to seek information (Chugh & Bazerman 2007). While this may occur because of selective perception, another factor which may cause this behaviour is attention. The amount of time that any one individual can devote to searching for information is limited. March tells us that “*In*

theories of limited rationality, attention is a scarce resource” (March 2009, p.23).

However, in a group situation the limitations of scarce attention can be ameliorated. The total amount of attention paid to searching for relevant information is increased in a group by virtue of the fact that more people are contributing their attention. The increased amount of time and effort spent searching in a group decision making environment does not guarantee that all relevant information is found, but it does increase the likelihood of it being found.

Group decision making is also thought to be superior to individual decision making in alternative generation. For similar reasons to those outlined above, the biases and selective perceptions that can lead to an individual ignoring possible alternatives are overcome by group decision making. By including many people in the decision making process, and assuming each person considers different alternatives, more alternatives are considered overall, meaning the total number to choose from increases. Alternative generation is also an activity where the assembly effect can be particularly powerful. Creativity is stimulated by interaction with others (Ellis & Fisher 1994). Groups have been shown to be significantly more prolific at generating novel alternatives than individuals (Hitt et al. 2005; Jennings & Wattam 1998).

Within any decision making process, judgements have to be made. An evaluation will have to be made as to what consequences will arise from choosing an action. Preferences are used to evaluate consequences. The distinction between fact orientated decisions and value orientated decisions means that in many cases an objective standard is not available to evaluate consequences. In these cases, judgement is required. Groups are seen as being better at performing these judgements than individuals (Ellis & Fisher 1994).

Groups can ameliorate the effect of emotions, which often cloud judgement. As mentioned previously, emotions can affect decision making in a number of ways. First, individuals have personality traits. By definition, a melancholic individual is likely to assign more negative consequences to alternatives than an optimistic person. Second, in the course of their life, individuals will experience positive and negative events, such as splitting up with a partner, or winning a sum of money. These events will have a temporary effect on an individual's emotional state, which can impact upon decision making. Group decision making can ameliorate the effect of emotions on the decision making process by smoothing out these differences. Some people in a group will be optimistic, and some will be pessimistic. Some individuals in the group will have recently experienced negative events, while some will have recently experienced positive events. As the group moves towards developing joint preferences from the disjoint preferences of individuals, the assumption is that the differences in preferences caused by emotional states are cancelled out.

Another important factor to be noted here is risk. In an uncertain world, any decision that involves the calculation of consequences is an exercise in risk calculation. Individual's attitudes to risk will vary. Some individuals are cautious, while some have a higher tolerance to risk. This attitude is referred to as risk propensity. However, as March points individuals with a higher risk propensity tend to rise up in the organization. "*Managers have a higher risk propensity, because they have engaged in risky, albeit successful behaviour to become managers*" (March 2009, p.46). One is reminded of Isaac Asimov's story where the protagonist wishes to present to the populace a man who always makes the right decision. Rather than attempting to develop the perfect decision maker through education, the protagonist simply started with a population of 100 million individuals at birth. Every time one of the individuals made a

mistake, they were dropped from the population. After 25 years had passed, only one individual remained from the original population. However, the protagonist was able to present this individual as a man who never made mistakes!

This tale, while obviously tongue in cheek, identifies the problem with administrative structures that reward risky behaviour. Managers have achieved their position by engaging in risky behaviour. This in turn encourages them to continue to engage in risky behaviour. However, to paraphrase the warning applied to financial products, past performance is no guide to future return. In situations where we wish to dampen risky behaviour, we should increase the number of people involved in decision making (March 2009).

The process of determining what consequences will arise from selecting a particular alternative when dealing with complex systems is a cognitively demanding task. Beyond a certain level of complexity, precise evaluation of likely consequence becomes computationally intractable. At this point, experts who can use heuristics, experience and intuition to estimate consequences become a necessity for effective decision making. By leveraging groups in decision making, individuals who have specialised skills and abilities can be included in the decision making process, increasing the ability of the group as a whole to deal with cognitively complex tasks (Ellis & Fisher 1994).

Finally, judgement is improved by the greater access to information enabled by groups. The improved ability of groups to search for, store and recall information allows them to handle cognitively complex tasks more efficiently than individuals.

The previous three advantages of group decision making are related to the quality of the decision reached. Group decision making can ameliorate the psychological and physiological limitations of individual decision makers. This means that the decision

reached by a group is more likely to be the correct decision, in an objective sense. However, group decision making offers other advantages over individual decision making from an organizational perspective. Group decision making is seen as providing increased legitimacy for the decision reached. This is particularly the case for value decisions, where acceptance of the decision is a vital measure of success (Simon 1997). If a value decision is taken by an individual, then it may be seen as an autocratic act, and other individuals within the organization may reject it. The nature of the decision process means that they may feel they are not bound by it. Decisions reached by a group are seen as having greater legitimacy (Boddy 2005). Individuals involved in a group decision making situation report greater satisfaction with the decision, and greater commitment to the decision (Hitt et al. 2005). This is even the case where the individual disagrees with the decision reached. The fact that a group arrived at the decision lends it legitimacy (Jennings & Wattam 1998).

A final impact of group decision making can be observed at the level of the individual. Groups are composed of individuals, who engage in many activities within the organization. They acquire improved knowledge of the domain that is the subject of the decision, and develop transferable skills such as information literacy and interpersonal skills. Research shows that participation in the decision making process leads to greater employee satisfaction and improved performance (J. Black & Gregersen 1997). It is positively related to morale and job satisfaction, and negatively related to issues such as stress and career dissatisfaction (Jennings & Wattam 1998). This is another positive outcome of group decision making.

2.3.2.2. Disadvantages of Group Decision Making

The advantages of group decision making can be summarised as being derived from two factors. First, groups can leverage aggregation effects. Groups have more resources, in terms of information, skills, knowledge, abilities and attention than an individual. Second, the emergent properties of the group offer the promise of improved decision making. Groups have emergent properties, such as assembly effects, which positively impact upon decision making processes such as alternative generation, and judgements. Group contain multiple social interactions. This social dimension gives rise to the emergent property of cohesiveness, which has a positive impact on variables such as decision legitimacy and individual satisfaction. However, group decision making also has its own unique limitations. Many of these arise from the socialisation that is implicit in group decision making.

Reaching a decision involves selecting one from the many alternatives available. However, situations where groups are unable to agree on an alternative are common. Familiar examples include hung juries, failed labour negotiations or contested elections (Ellis & Fisher 1994). This can be particularly problematic when a decision making process that is unsuitable for the task at hand has been pre-selected. Consider a group that is formed on the basis that unanimity will be required in order to reach a decision. If it becomes apparent during the course of the groups deliberations that unanimity cannot be reached, it is very difficult to change to a more appropriate decision making process, without damaging the legitimacy of the process.

The problem of alternative selection can be exacerbated in a number of ways. First, the more individuals there are in the group, the harder it becomes to arrive at a decision. The literature suggests that in situations where unanimity or negotiation are seen as

being the appropriate decision process, it is important to keep the number of individuals in a group to between 7 and 12 (Hitt et al. 2005). Larger groups then this usually use voting as the decision process, as in for example political decision making processes such as electing representatives, or enacting laws through parliamentary structures.

The social nature of decision making can also make selecting an alternative more difficult. Boddy points out that “*a group is a political system which establishes the relative power of people and functions*” (Boddy 2005, p.212). Role conflict can prevent groups from selecting alternatives. Individuals or cliques within the group may refuse to accept an alternative, not because they fail to see the logic of the alternative, but because they are using their refusal as a tool to take or to hold a position in the social hierarchy (Hitt et al. 2005). This can become even more pronounced when individuals view the group decision making process as an extension of the larger organizational context, and use the group as a proxy war for role conflicts elsewhere in the organization.

The literature is in general agreement that groups are slower to reach decisions than individuals (Ellis & Fisher 1994; Boddy 2005; Hitt et al. 2005). Groups will require time to form. Moving through the group formation stages takes a certain amount of time, regardless of how well the individuals know each other (Tuckman & Jensen 1977). Even when decisions are to be made by a pre-existing group, the exchange of information, the debate of the pros and cons of the various alternatives and the synchronization of preferences requires communication between the individuals in the group, which takes a certain amount of time. It is usually necessary to arrange convenient times for groups to meet. Groups also have to engage in socialization activities to develop and maintain cohesiveness, which takes additional time.

Confidentiality is another issue that can affect group decision making (Jennings & Wattam 1998). Some decisions may be particularly sensitive. For example, decisions on downsizing and outsourcing are often emotional and contentious in an organizational setting. The disadvantages of using group decision making in this situation are obvious. The more individuals who are aware that these issues are being considered, the more likely it is the information will leak, with the attendant ramifications.

The allocation of responsibility is another factor that affects group decision making. In many situations, it is necessary that one person carry ultimate responsibility for a decision (Jennings & Wattam 1998). While an individual may take advice from a large number of advisors, one person makes the final decision. This is particularly characteristic of political systems. Civil servants may advise government ministers. However, since in most situations these individuals cannot be reprimanded by the general public, in order to ensure that accountability exists, it is an elected politician who makes the final decision. This structure ensures that someone in the system of government can be held accountable for the decisions reached.

The most obvious emergent property of a group decision making system is cohesiveness. To recap briefly, cohesiveness is the “*ability of groups to get along, the feeling of loyalty, pride and commitment of members towards the group*” (Ellis & Fisher 1994, p.23). Cohesiveness is the source of many of the advantages of group decision making. It motivates individuals to contribute information, propose alternatives and engage positively with the decision making process. It leads to improved satisfaction in individuals and increases the legitimacy of the decision. However, cohesiveness is not a purely positive phenomenon. When the effect of cohesiveness becomes too powerful, individuals subsume their own identity to that of the group. Consciously or subconsciously they alter their preferences to match those of the group as a whole. They

suspend their critical facilities in favour of agreeing with the group to bolster a sense of loyalty and self-esteem that is linked to group membership (Ellis & Fisher 1994). This can lead to a number of well known phenomena which can lead to sub-optimal decision making.

Possibly the best known of these phenomena is referred to as groupthink. Groupthink is defined by Hitt et al as *“a mode of thinking that people engage in when they are deeply involved in a cohesive group, when the members’ striving for unanimity overrides their motivation to realistically appraise alternative courses of action”* (Janis 1972, p.9). In a more earthy definition, Ellis and Fishers say *“Groupthink is what happens when a group avoids conflict and reaches consensus without criticizing and evaluating ideas”* (Ellis & Fisher 1994, p.133).

Janis identified eight symptoms of groupthink (Janis & Mann 1979). First, individuals in the group have an inherent belief in the morality of the group. Ascribing moral qualities such as “good” or “right” to the group means it becomes more difficult for individuals to argue with the group, since the argument is not about logic or fact, but about morality. Second, individuals begin to believe in the invulnerability of the group. Bolstered by the groups support, individuals begin to believe that they are always right. Third, individuals in a group will rationalise the risk of negative consequences associated with the group’s decision. Information or opinions which contradict the group’s opinions will be ignored, and parties outside the group who disagree will be stereotyped unfavourably. The group will begin to establish destructive norms in order to protect the cohesiveness of the group. Individuals will engage in self-censorship, and fail to report conflicting information or personal doubts to the group. Direct censorship will also occur, where group members will express to themselves and others in the group that dissent will not be welcome. Individuals will act as mindguards, and keep

facts or opinions that disagree with the group's position out of the discussion. These norms in turn lead to the illusion of unanimity. Since no individual in the group raises objections, each individual will assume that they are the only person who has doubts. Based upon this, they will seek to suppress their own doubts even more, leading to even more groupthink behaviour.

The negative effects of groupthink in group decision making are obvious. The group will fail to consider alternatives, particularly novel alternatives. Instead, the group will focus on a few alternatives. In extreme cases, even when an alternative can be demonstrated to be wrong, individuals will prefer to maintain the group's cohesiveness by selecting that alternative (Hitt et al. 2005). Valuable information that threatens the group's position will be ignored or devalued. Instead, individuals will focus on using information that is shared by all the members of the group, significantly reducing the advantage of the group over an individual in terms of information processing ability (Bazerman & Chugh 2006).

Another negative phenomenon that can arise from cohesiveness is referred to as group polarization. Group polarization is "*the tendency of groups to make decisions that are more extreme than the initial position of its members*" (Ellis & Fisher 1994, p.45). Group polarization can be seen in Churchill's quote regarding the British response to the German naval build up before World War 1. "The Admiralty demanded six Dreadnoughts, the Economists offered four. In the end, we compromised on eight."

Normalization theory holds that group decision making would generally reflect the average of all the individual's opinions. Group polarization contradicts this theory. Group polarization occurs when groups have a high level of cohesiveness. Any group will have individuals who hold extreme positions. It is often the case that extreme

positions are held more fervently than moderate positions. In a cohesive group that creates pressure to normalise preferences and opinions, individuals holding moderate positions will move more towards extreme positions than vice versa. This movement in turn encourages individuals holding extreme positions to hold even more extreme positions, and so on (Ellis & Fisher 1994). As an example of group polarization, Myers and Bishop found that groups composed of racists became more racist after discussion (Myers & Bishop 1971). Group polarization is far from a dominant behaviour in group decision making, but it demonstrates how too much cohesiveness can lead to sub-optimal decision making.

Escalation of commitment is defined as “*an increased commitment to a previous decision despite evidence it may have been wrong*” (Boddy 2005, p.211). Escalating commitment can often be observed in individual decision making. Decision makers fear losing face and so refuse to change a decision, insisting that it will be proved correct in the end. Escalating commitment can be a particularly pernicious problem in the group decision making setting (Hitt et al. 2005). Individual’s desire to save face is bolstered by the knowledge that a group has evaluated and made this decision. When combined with some of the symptoms of groupthink already mentioned such as a belief in the inherent morality of the group, and the illusion of invulnerability, it becomes very difficult for an individual or the group as a whole to consider re-evaluating the decision.

The nature of group decision making is that it is a social interaction. The socialization effects that occur in groups are advantageous in certain situations. When seeking commitment to the decision, or legitimacy for the decision, the development of the emergent attribute of cohesiveness is important. However, as the previous discussion has made clear, too much cohesion can impact negatively on the quality of the decision reached. Phenomena such as groupthink, escalating commitment and group polarization

can counteract the advantages group decision making has over individual decision making. Similarly, too little cohesion can lead to problems such as role conflict and power struggles within the group. Conventional, unrestricted, spoken communication is seen as being at the heart of these dysfunctions (Reagan-Cirincione 1994). This observation has led to the development of structured group decision making systems. There are innumerable forms of structured group decision making systems, but all share some common characteristics. First, they structure the communication that occurs in the group in some way. Second, they attempt to diminish the impact of role conflicts and power struggles in the organization, by methods such as prescribing roles rigidly, or allowing for anonymity. Well known structured group decision making mechanisms include Brainstorming, the Nominal Group Technique and the Delphi Method.

The crucial point to note is that these methods aim to modify the cohesiveness of the group. In certain situations, it may be desirable to increase the cohesiveness of a group. For example, a political party faced with making difficult budget decisions may seek to increase the cohesiveness of the group making the decision in order to ensure that the individuals making the decision remain loyal to the group and to the decision. Conversely, in other situations, it may be desirable to reduce the cohesiveness of the group, so that dissenting opinions and uncomfortable information is presented to the group. This can be summed up in three key points. First, the cohesiveness of a decision making group can be modified by the design of the communication and decision processes used by the group. Second, the cohesiveness of the group will affect how the group searches for, handles and utilises information and ultimately the quality of the decision reached by the group. Third, identifying the level of cohesiveness that is suitable for a decision making group is dependent in part upon the decision. Some decisions require cohesive groups to implement the decision and provide it with

legitimacy. In other situations, it is more important to get dissenting opinions and contrary voices.

2.3.2.3. Decision Spaces for Group Decision Making

The theoretical frameworks found in the literature on individual and group decision making have a number of practical applications. The insights provided by these models allow researchers and academics to begin to develop practical approaches to improve decision making. Some of the work in this area focuses on individual decision making. Such approaches usually use the rational model of decision making as a normative model. Working on the assumption that rationality is an ideal, they offer prescriptions on how individual decision makers can become more rational. Scholars of group decision making attempt to improve group decision making by offering suggestions on how to improve communication in groups, reduce role conflict, improve information collection and utilization and ameliorate the possible negative effects of cohesiveness.

One obvious application of the comparison of individual decision making to group decision making is that it provides the tools required to analyse which decision spaces are better handled by individuals, and which by groups. Since group decision making has both strengths and weaknesses vis-à-vis individual decision making, it is intuitively obvious that some types of decision are best handled by individuals, and some by groups. The models and frameworks discussed thus far allow practitioners to evaluate a decision space, and assign it to an appropriate decision making body.

Decision Characteristic	Favours
Urgent Decision	Favours Individual Decision Making
Confidentiality	Favours Individual Decision Making
Responsibility	Favours Individual Decision Making
Programmed versus Non-Programmed	Programmed favours individual, Non-Programmed favours Group
Fact Decision versus Value Decision	Value Decision Favours Group
Legitimacy	Legitimacy Favours Group

Table 5. Decision Characteristics versus Suitable Decision Making Model

It is characteristic of group decision making that it takes longer to reach a decision than individual decision making (Boddy 2005; Ellis & Fisher 1994; Hitt et al. 2005). The process of forming a group and the processes that allow a group to reach a decision all impose overheads. These overheads are linearly related to the size of the group. Thus, when time is an important factor in decision making, individual decision making has an advantage. If it is considered necessary to use group decision making in an urgent situation, it is advisable to keep the size of the group as small as possible.

Similarly, where confidentiality is a key concern, the more individuals involved in making the decision, the more likely it is that information will leak out of the decision making process (Jennings & Wattam 1998). Thus, confidentiality concerns in decision making means that the decision should be left to individuals or groups composed of as few members as possible.

If a decision requires that responsibility be taken for the decision, then it is considered appropriate to limit decision making to individuals, or groups that are as small as possible. In situations where groups make decisions, it is often the case that responsibility is diffused amongst the group (Ellis & Fisher 1994). Particularly in legal

and political situations, the legitimate use of power requires commensurate acceptance of responsibility. When responsibility is diffused, this can lead to reckless and possibly corrupt behaviour.

Decisions can be categorised as being programmed or non-programmed. A programmed decision is one that is undertaken in a well understood environment and is routine and well understood (Hitt et al. 2005). A non-programmed decision is novel to the decision maker, and involves considerable uncertainty (Simon 1997). By definition programmed decisions do not require the acquisition of large quantities of new information, or the generation of new alternatives. They are well understood situations, and even the more risky activities such as assigning consequences to alternatives are relatively well understood. In these situations, the advantages offered by group decision making in terms of seeking and utilising new information are marginal in most cases. Additionally, programmed decisions will often require specialised knowledge. For example, the decision on where to build a bridge requires specialised expert knowledge.

Conversely, non-programmed decisions are poorly understood. In these decision making situations, the advantages of groups come to the fore. Groups can access, store and utilize more information. Bounded awareness, described as the failure to seek, see, use or share information is often particularly problematic in non-programmed situations (Bazerman & Chugh 2006). However, the multiple perspectives, information sources, skills and knowledge offered by group decision making can ameliorate these effects. The ability of groups to evaluate larger numbers of alternatives, both by considering all the individuals alternatives and generating novel alternatives through the assembly effect, is a considerable advantage in non-programmed situations. In general, the greater creativity and information processing abilities of groups means they are superior to individuals in non-programmed decision making situations.

The merits of group versus individual decision making can be analysed in terms of the distinction Simon draws between fact decisions and value decisions (Simon 1997). Factual decision will eventually take a factual value, whereas as value decisions can only be validated by their acceptance (March 2009). In reality, factual decisions and value decisions form a continuum, with every decision having both a factual and value component to a degree. However, some decisions tend to be more factual, and others more value orientated.

Decisions that are predominantly factual can be programmed or non-programmed. For example, the decision whether or not a particular component of a nuclear plant is safe requires expert knowledge of physics and engineering. In these situations, the decision is best left in the hands of an expert, who has the knowledge, skill and experience to make an evaluation (Jennings & Wattam 1998). However, other factual decisions may be non-programmed. Relevant information may be spread amongst a large population. For example, relevant information on the likelihood of a project being completed on time is spread amongst the entire project team. In this case, the advantage of group decision making in terms of information capture, storage, retrieval and utilization means that it is superior to individual decision making.

Decisions which are largely value orientated in nature generally require judgement. Additionally, in order to gain the assent which is an important metric of decision process quality, they require legitimacy. Group decision making is seen as being superior to individual decision making when making judgement decisions (Ellis & Fisher 1994). Group decision making is also superior in providing a decision with legitimacy (Jennings & Wattam 1998). For this reason, groups are generally seen as being superior to individuals when decisions are value orientated.

In situations where ensuring the decision has legitimacy, utilizing group decision making can be more useful than individual decision making. Group decision making is perceived to have more legitimacy than individual decision making and this legitimacy is inherited by the decision reached.

This discussion provides guidelines that can be used by management to determine whether a decision is better handled by an individual, or by a group. It is a practical application of the theoretical frameworks that are used to describe how decision making should and does take place.

2.3.3. Fundamental Characteristics of Group Decision Making

In the vernacular, a group is a term used to describe a collection of people. A crowd on a street or in a shopping centre is referred to as a group. When used in the literature, the term group has a more precise meaning. Shaw offers a general definition of a group as being “*two or more people who are interacting with one another in such a manner that each person influences and is influenced by each other person*” (Shaw 1976, p.11). This definition captures one essential quality of groups from the perspective of the decision making literature, namely that individuals who are in a group interact with and influence each other. This definition eliminates from consideration collections of people who happen to be temporally or geographically close but have no relationship other than that.

Ellis and Fisher define a task orientated group as follows. “*Task-orientated group is a generic term that identifies any one of an enormous variety of groups whose existence depends on performing some task*” (Ellis & Fisher 1994, p.xiv). This definition of a task-orientated group contains the notion of purpose. A task orientated group exists for a reason. This distinguishes a task-orientated group from other groups such as a family.

Hereafter, the term group should be taken to mean a task-orientated group. It should be noted at this point that a decision making group is a specific type of group, which is created for the purpose of making decisions. Decision making groups will be examined in more detail later, but in order to ground that discussion, a brief overview of groups in general is presented.

Ellis and Fischer (1994) suggest that it is often useful to consider group decision making as having a social dimension and a task dimension. Similarly, Tuckman (1965) refers to the interpersonal activities, and the task activities. The task dimension “*refers to the relationship between group members and the work they are to perform*” (Ellis & Fisher 1994, p.22). The social dimension refers to “*the relationships of group members and with one another*” (Ellis & Fisher 1994, p.22). The metric that Ellis and Fischer suggest is most useful to use when considering the social dimension is cohesiveness. Cohesiveness is the “*ability of groups to get along, the feeling of loyalty, pride and commitment of members towards the group*” (Ellis & Fisher 1994, p.23). This dichotomy in group decision making has two important implications. First, all the elements of a group have both a social element and a task element. For example, the personalities of individuals involved in the group will affect how well the group fulfils its purpose, and also how well members of the group get on with each other. Second, this dichotomy means that a group will have at least two measurable outputs. One output will be related to the task dimension, while a second will be related to the social dimension.

Having developed a conceptual understanding of what a group is, it is now necessary to examine what factors affect group performance. Group performance is simply how well the group fulfils its purpose. In this case, the purpose of the group is to make decisions, hence group performance is a measure of how well a group makes decisions. Research

has shown that a myriad of variables affect group performance. For the purposes of analysis of groups, Ellis and Fisher (1994) offer a high level categorization scheme, which breaks these variables into three classifications.

Entry elements are inputs into the group (Ellis & Fisher 1994). These are the elements that are present when the group is first established. The most obvious example here is the individuals who are members of the group. Their skills, attributes and personalities will affect the group's performance. The size of the group will impact upon the groups performance (Boddy 2005). The resources that are available to the group is another important determinant of performance, as is establishment of a common purpose or a group charge (Ellis & Fisher 1994; Boddy 2005)

The second class of variables proposed by Ellis and Fischer (1994) is process elements. Based on the recognition that the fundamental property of a group is that individuals within a group influence each other, the most important group process is communication (Ellis & Fisher 1994). The communicative process within a group influences and is influenced by the creation and evolution of roles and norms within the group. The communication process is often mediated by procedures which aim to formalise and structure communication so as to improve efficiency.

Finally, Ellis and Fischer (1994) propose that the outcomes of groups represent an important set of variables to be considered when examining groups. The most obvious outcome of a group is the quality of its output, which should be measured by a metric related to the purpose of the group. This is a measurement of the task dimension of the group. In other words, sports teams should be measured in terms of victories or defeats, while the output of a team of tax practitioners might be the number of clients dealt with. Groups also have a social dimension. This implies the existence of outcomes which

arise from the interactions that occur as part of the groups deliberations. These interactions alter individual member’s relationships with other members of the group, and how individuals come to view their own identity in relation to the group. The metric that Ellis and Fischer suggest is most useful to use when considering the social dimension is cohesiveness (Ellis & Fisher 1994). It is important to note that cohesiveness does not take account of the effect group participation may have on individual members. Participants in a group may develop new skills as a result of participating in a group process. The effect group membership and participation has on individuals is identified as another important output of group decision making.

Classification	Variables
Input Elements	<ul style="list-style-type: none"> • Individual Skills • Individual Personalities • Size of Group • Resources • Common Purpose
Process Elements	<ul style="list-style-type: none"> • Group Roles • Group Norms • Communication Processes and Structures • Decision Processes and Structures
Outputs	<ul style="list-style-type: none"> • Decision Quality • Cohesiveness • Individual Development

Table 6. Variables Affecting Group Decision Making Performance.

The most obvious input element of group decision making is the individuals that comprise the group. Two characteristics of the individuals selected affect the performance of the group. The first characteristic is the skills and the abilities of the individual. The nature of the decision being made by the group may require specialist skills, abilities, information or knowledge (Cooke & Slack 1991). Different decision making scenarios will require different types of specialist knowledge. Strategic decision

for an airline will require individuals that have experience and knowledge of the air transport industry. In contrast, decision making in the banking sector will require information and knowledge about finance, international finance, banking regulations, etc.

The other important characteristic of individuals that affect group performance is their personality. It is generally accepted that different individuals fulfil different roles within groups (March 1999b). These roles may be task orientated roles, such as information collection, or social orientated roles, such as acting as a negotiator between other individuals within the group. Belbin identifies nine different types of roles within groups (Belbin 1996). The specific nature of these roles is not considered here. However, it is generally considered good practice to ensure that at all of these roles are filled (Boddy 2005; Cooke & Slack 1991; Hitt et al. 2005). An individual may fill more than one role. It is also the case that roles can evolve over time. For the moment, the important observation is that individuals may be suited to some roles then others. Shy, introverted individuals are unlikely to assume the role of leader of a group. Belbin suggests that creating an efficient team involves ensuring that the group roles are filled. He further suggests the selection of group members should in part involve evaluating group members on the basis of the congruence of their personality with their expected role (Belbin 1996). This idea is still quite controversial, but has been applied with some success (Cooke & Slack 1991).

The other input elements in group decision making are conceptually straightforward. The size of the group is seen as impacting upon the performance of the group (Boddy 2005). One of the reasons that group decision making can outperform individual decision making is because the group as a whole has more sources of information (Ellis & Fisher 1994). However, this argument for continually increasing the size of group is

tempered by research which shows groups that grow beyond a certain size tend to fracture (Jennings & Wattam 1998). The communication structures that enable cohesiveness and allow for consensus to emerge begin to break down (Boddy 2005).

The resources that the group has available to it will also have a major effect on the performance of the group. Decision making situations may require the collection or acquisition of large amounts of information, which may require considerable expenditure of time, money and other resources. If the group has the resources to allow it to access these resources, then it is logical that the group will perform better (Ellis & Fisher 1994).

Finally, the group's purpose is an important entry element. It provides a rationale for the existence of the group in the first place. Confusion about the group's purpose will obviously damage the effectiveness of the group (Ellis & Fisher 1994). Additionally, the group's purpose is a common element, shared by all the group's members. If group members internalise the group's purpose, it can provide a powerful unifying force that increases cohesiveness within the group.

Communication is defined by Ellis and Fisher as *“the process of people exchanging messages, which are formulated according to the principles of a code, in a context”* (Ellis & Fisher 1994, p.85). This definition highlights two points. First, communication involves the use of a code. The form of code that most readily springs to mind when discussing communication in a group decision making process is the spoken language. However, it is important to note that *“the medium is besides the point; what matters is the functional use of signs, any signs that could play a role corresponding to that of speech in humans”* (Vygotsky 1986, p.86). The spoken language is one form of code that allows the exchange of information between humans. However, other codes also

play a part in communication within groups, for example non-verbal gestures such as nodding, smiling, etc. Additionally, it is equally possible to imagine other codes replacing the function of spoken language in group decision making processes. For example, no theoretical objection can be raised to a group engaging in a decision making process using sign language (Ellis & Fisher 1994). Second, this definition highlights that communication occurs in a context. The messages that are conveyed by the particular code chosen to enable communication only acquire meaning in a specific context, and in relation to the messages that precede and follow it.

Communicative processes have a major impact upon the task dimension of the group decision making process. The process of communication allows for the exchange of information regarding the decision. It also allows for the signalling of assent to or dissent from the current decision proposal. In the language of bounded rationality, communication allows individuals to exchange information about the state of the world, possible alternatives and individuals expectations as to the consequences that will follow from selecting an alternative. By signalling assent or dissent, individuals communicate information about their preferences. In studies of communication in group decision making, messages are often categorised in terms of their contribution to the group reaching a decision (Boddy 2005; Ellis & Fisher 1994). While differing in detail, these schemes usually identify messages that prompt or enable the exchange of information, the proposal of decisions, and the expression of agreement or disagreement with the decision being currently proposed.

Communicative processes also have a major impact upon the social dimension of decision making. Simon (1997, p.10) says that "*It is a prevalent characteristic of human behaviour that members of an organized group tend to identify with that group*". Often, as people interact they become more favourably disposed to each other, particularly

when the messages exchanged are supportive of each other's views and opinions. Of course, the opposite can also be true. Unsupportive messages or unreasonable views can reduce an individual's opinion of other members of the group. In either case, communication affects individual's perceptions of each other. In general, this is referred to as the principle of reciprocity, which states that human beings tend to react to other humans in a manner similar to how those humans have treated them (Ellis & Fisher 1994). Communication also affects the emergent property of cohesiveness. Groups which have open and fair communication channels are more likely to develop a high level of cohesiveness.

Individuals enter a group decision making situation with their own behaviour patterns. These behaviour patterns are modified by participation in the group by two mechanisms, namely roles and norms. A definition offered of a role from the perspective of decision making is that "*a role is a set of communicative behaviours performed by an individual and that it involves the behaviours performed by one member in light of the expectations that other members hold toward those behaviours*" (Ellis & Fisher 1994, p.114). Roles have an essential nature to them. Consciously or subconsciously, people have predetermined expectations of the behaviour of individuals holding a particular role (March 2009). A leader is expected to inspire. A negotiator is expected to listen carefully to both parties in a dispute. The conception that roles impose expectations on behaviour leads to the notion of a role contract (March 2009). A role contract is the relinquishing of control or authority to one individual by other individuals, by virtue of the role they are perceived to hold. For example, disputing parties will accept the judgement of an individual perceived to be the negotiator within the group.

An important point brought up in the literature is that roles are not singular (March 2009). Individuals hold different roles in different aspects of their life. An individual may be a father at home, a manager in the organization, and a negotiator in a group decision making situation. Similarly in a group situation, an individual may fill a number of roles. For example, an individual may be both the leader of the group, and a negotiator who resolves conflicts between other members of the group. Additionally, even within the limited context of a group decision making situation, the role an individual fills may evolve over time (Ellis & Fisher 1994). While the group is considering a domain of knowledge which is the ken of one individual in the group, that person may act as a specialist. When the group moves on to consider a different knowledge domain, the person may release the specialist role to another individual in the group who is more qualified.

Role conflict occurs when one or more members of the groups dispute the role assumed by another individual within the group. There are a number of causes of role conflict. First, role conflicts can occur when a network of formal roles are imposed upon the group by an external source. For example, if a decision making group is established within an organization, then the obvious leader of the group is the person who is highest in the hierarchy of that organization. However, the dynamic of the group may mean that another individual is more suited to assuming the leadership role in the group, irrespective of the power relationships between individual members outside of the group. In this case, groups often evolve informal structures which pay lip service to the externally imposed roles, while tacitly recognising the power structure which has evolved in the group (Ellis & Fisher 1994).

Role conflict can occur when an individual holding a role is perceived to have violated the role contract by other members of the group (March 2009). For example, a

negotiator who is perceived to be systematically unfair will eventually lose support as a negotiator. Even favoured parties will eventually no longer see that individual as a negotiator. They may support them out of self interest, but will perceive them as a champion, rather than a negotiator. Since roles are to a great degree socially validated by others, the perception of others is important for an individual assuming and holding a role. If an individual breaches the implied role contract in the eyes of others, the group will eventually tacitly or explicitly appoint another member to fill that role.

The final cause of role conflict is interpersonal conflict. This is where two or more individual compete for the same role (Ellis & Fisher 1994). For example, multiple individuals may seek to assume the leadership role in the group. They may seek the position for the social capital that accrues from being perceived as a leader. Alternatively, they may be concerned with ensuring the group selects a particular alternative, and so seek a leadership position in the belief that it will provide them with power to influence the decision of the group. Interpersonal role conflicts of this nature are often the most difficult to resolve in group decision making situations. While the social nature of the group implicitly contains mechanisms to resolve the other types of role conflict, if the individuals contending for a particular role are sufficiently motivated to ignore the group pressure to resolve the conflict, this type of role conflict may linger on unresolved, and adversely affect the group's performance.

The other major social mechanism that alters individual's behaviours in groups is referred to as norms. Norms are "*rules and standards that are understood by members of a group, and that guide and/or constrain social behaviour without the force of law*" (Trost & Cialdini 1998, p.152). Norms are thought to share three characteristics (Hackman et al. 1983). First, norms apply only to behaviour, not private thoughts or feelings. Second, norms develop for what behaviour is seen as most important by the

group. Third, most group norms allow a variance in what is considered acceptable behaviour by individuals.

Norms for group behaviour can be formal or informal (Cooke & Slack 1991). Formal norms are explicit, and are intentionally adopted by the group. Such norms may cover issues such as dress code and acceptable behaviour in terms of time keeping. Other important examples of formal norms which may be adopted by groups include procedures for controlling meetings. Groups may choose to adapt formal standing orders, and may formalise the order of speaking or the maximum permitted length of contributions from individual members. These norms will impact upon the effectiveness of decision making. Groups may also formally adopt specific consensus mechanisms, which are discussed below.

Informal norms are tacit, and emerge as a product of the group's interaction (Ellis & Fisher 1994). Such norms may cover things such as, for example, the acceptability of humour in a meeting. Other informal norms may cover items such as the acceptability of reporting on the group's activities to individuals outside of the group, or tacit assumption of how much effort individuals are expected to make towards the completion of the groups task (Jennings & Wattam 1998). Informal norms are often harder to examine than formal norms (Ellis & Fisher 1994). Often, individual members are not consciously aware of these norms. They are also more mutable, since they are a product of the group member's interactions with each, and so are constantly evolving.

Decision making groups are differentiated from other types of group by the requirement that it reach a decision. The purpose of the group is usually defined in terms of making one or more decisions. Following the terminology of bounded rationality, this means that to fulfil its purpose the group must select one alternative from all the possible

alternatives presented to it. Given that there are individuals whose preferences are not aligned at the beginning of the process, decision making groups must include a mechanism for selecting the alternative. There are three main processes that groups can use to reach a decision. The first is unanimity, the second is negotiation and the third is voting (Ellis & Fisher 1994).

Unanimity occurs when all the members of the group agree on the alternative selected. From the perspective of the group, this is often the best case scenario. After evaluating the information presented, examining the alternatives available and considering the consequences, the group has reached a unanimous decision as to what is the best alternative. This outcome can imply that one alternative is clearly superior to all other alternatives. However, it is important to note here that other factors can lead to unanimity. Individual preferences can move towards those of the groups, not because the group's preferences are more rational, but because of social pressures inherent in groups. Individuals may support a proposed alternative, not because they agree with it, but because they fear violating group norms.

Negotiation is used in group decision making when the decision involves two or more parties in what is viewed as a zero-sum game. If one party gains, then the other suffers a corresponding loss (Cooke & Slack 1991). Negotiation involves parties agreeing to trade off losses and gains vis-à-vis each other until such time as an acceptable compromise is reached. An obvious example of the application of such a mechanism is decision making conducted between trade unions and employers. An important point to note here is that negotiations often involve a number of decisions, in order to enable the trading off process. A party gains in one decision, and loses in another, but accepts the entire package of alternatives, both for the sake of the gains it has made and for the sake of reaching an agreement.

The final form of group decision making is voting (Cooke & Slack 1991). Voting involves the establishment of some criteria. As an example, the group as a whole may accept that if 2/3 of the group select an alternative, then the group as a whole select that alternative. Voting is different from unanimity and negotiation in that it implicitly accepts that some individuals will agree with the decision, and some will not.

Closely linked to decision making processes is the notion of acceptance. In some decision making processes, consensus may emerge. Consensus implies “*not just agreement with the decision reached, but commitment to it*” (Ellis & Fisher 1994, p.141). Unanimity is a necessary, but not sufficient precondition for consensus. A group may reach a unanimous decision, but some members may not necessarily be committed to it. A similar pattern may hold for negotiation. In decision making processes that use voting, consensus is usually unobtainable.

This definition of consensus highlights the importance of acceptance. Acceptance of a decision is the agreement by the group to abide by the decision reached, irrespective of their personal opinion of that decision. As an example, an individual may vote against a law in a referendum, but if that law is passed, they will accept that law, and be bound by it. Acceptance is dependent upon group cohesiveness and on the individual agreeing to be bound by the decision process used to reach the decision.

The task orientated output of a group decision making process is a decision. However, evaluating decisions is problematic at best, for a number of reasons. In general, a decision is taken in order to attain an objective at some point in the future. In the language of rational decision making, an alternative is selected by determining which alternative leads to the optimum consequence at some point in the future. This implies a temporal lag between the selection of an alternative, and the consequences of that

decision occurring. In the intervening period, the preferences of the decision makers may have changed (March 1999b). Unexpected events may have intervened which means the expected consequences do not occur. There is the distinction between what Simon calls factual and value decisions (Simon 1997). Factual decisions will eventually be true or false. As such, they can be objectively evaluated as being correct or incorrect at some point in the future. In contrast, value decisions cannot. They can only be validated by human acceptance. Simon points out that *“The process of validating a factual proposition is quite distinct from the process of validating a value judgement. The former is validated by its agreement with the facts, the later by human fiat”* (Simon 1997, p.65).

These issues mean that there is a clear divide in the literature on how exactly decision quality should be measured in terms of a decision making process (Simon 1997). In a nutshell, the difficulty can be presented thusly. Should a decision making process be evaluated strictly in terms of the consequence that actually occurs, even if it is unexpected? Or, should a decision making process be evaluated in terms of how often the expected consequence occurs, even if it is suboptimal? One school of thought suggests that the only measurement of decision quality that matters is the consequences that occurs. The second suggests that it is the quality of the decision process itself that matters. To be sure, how often the decision process produces a correct or optimal answer is important, but other issues such as how quickly the decision is reached, how much information is brought to bear, and how much consensus the decision making process can create are also seen as being important metrics.

In general, the lack of resolution to the philosophical arguments outlined above means there is no accepted universal definition of decision quality. Different authors use different metrics. Some authors measure decision quality by evaluating it post-hoc.

Others measure decision quality by examining how closely a particular decision making process selects the same alternative as another decision making process. Other authors conclude that decision quality is a function of several other variables, and measure decision quality by measuring and amalgamating these variables. There is no agreement in the literature as to what variables should or should not be included.

For the purpose of this dissertation, a relatively limited definition of decision quality is taken. This dissertation assumes that decision quality is measured by how accurately the decision making process correctly estimates the probability of a consequence occurring. The use of this definition is not to be taken as a diminution of the importance of other factors involved in all decision making processes. In general, because most decisions contain both a factual and value component, the author would follow Cooke and Slack (1991) who suggest that decision quality is one factor contributing the more important overall metric of decision process quality.

Communication within a group establishes a group identity through the creation of roles and norms. Parallel to this, individuals who are a member of the group come to absorb that group identity. Fundamentally, this phenomenon arises as a result of a human behaviour pattern whereby members of a group come to identify with that group. This process has been given many different names, including satisfaction (Cooke & Slack 1991), partner consistency (March 2009) and group identification (Boddy 2005). In this dissertation, the preferred term is cohesiveness. Cohesiveness is defined as “*the ability of members to get along, the feeling of loyalty, pride and commitment of members towards the group*” (Ellis & Fisher 1994, p.23). Cohesiveness is an emergent property of the group. It exists because of the communication networks, the roles and the norms that are created by the group. It could not exist without these group processes, but at the same time is more than the sum of them.

Three important effects of cohesion can be identified. First, a certain level of cohesion is necessary for a group to function at all. Second, cohesiveness affects the decision making process in many ways. Cohesiveness can lead to improved decision quality, improved commitment to the decision and greater legitimacy for the decision reached. Third, cohesion is not a universal positive. Cohesion has both positive and negative effects. In particular, too much cohesion can lead to some well known problems in group decision making.

This analysis of group decision making has emphasised the systematic nature of group decision making. Group decision making must be analysed and understood in terms of the group as whole. Nonetheless, when considering the outcomes of group decision making, it is also important to recognise that the primary subsystem of group decision making, namely the individuals involved, have an existence distinct from the group. Individuals will participate in a particular group, but will also interact with a myriad of other groups. At the most basic level learning occurs from social interaction (Vygotsky 1986). Thus, it is reasonable to suggest that individuals who interact with a group may acquire new skills, abilities, knowledge and competencies from their interactions with the group. If these acquisitions are valuable to the individual, or to the organization then that represents a valuable output of the group decision making process.

It is possible to identify three main areas which individuals are likely to be positively affected by engaging in a group decision making process. First, individuals are likely to develop improved skills in the domain under consideration. Individuals have the chance to watch others grapple with decisions in the problem domain, and can take the opportunity to learn from this experience. Second, individuals are offered a chance to develop general purpose skills. Information literacy skills and interpersonal skills are likely to be sharpened by engaging in a group decision making process. Finally,

individuals are likely to develop a more positive view of the organization through being involved in a decision making process.

2.3.4. Prediction Markets as Group Decision Making Systems

When considering prediction markets as group decision making systems, it is important to consider the dependent and hierarchical nature of decision making (Cooke & Slack 1991; Simon 1997). Decisions are often dependent upon other decisions. To give an example, an organization may face a decision on whether or not to increase advertising or marketing expenditure to boost sales of a product. This decision will in part be based on a determination of what the expected sales of that product will be. If sales are expected to be high, then the organization may determine that increased expenditures are not necessary, whereas if sales are expected to be low, then the organization may attempt to boost future sales by increasing expenditure.

The crucial point to note here is that these linked problems can be viewed as two separate decisions. One decision space is in the area of determining expenditures for the organization. The second is a decision as to what sales in the future are likely to be. The two separate decisions are interrelated, but separate. They also have different constraints upon them. In the case of the first decision, issues of responsibility and confidentiality may be more important. In the second case, decision quality may be a more important criterion. The difference in these decision spaces implies that different decision making mechanisms may be more suitable for different decision making contexts.

This understanding of the ecology of decision making is important for understanding how prediction markets can be integrated into organizational and managerial decision making. Certain decisions have characteristics which mean that prediction markets are suitable for using them to reach decisions. Other decisions do not. By identifying these

characteristics, this dissertation provides a theoretical roadmap that allows organizations to improve overall decision making by identifying specific situations where prediction markets can improve the quality of sub-decisions, thereby improving decision making in an organization as a whole.

In the next section, the analysis is continued by examining the variables that affect group decision making systems, as listed in Table 6. This section has two purposes. First, the elements of prediction markets that match the variables are clearly enunciated. This enunciation clearly positions prediction markets as group decision making systems. Second, where relevant, areas where prediction market have unique characteristics vis-à-vis other group decision making systems are highlighted. This purpose of this analysis is to allow the creation of a framework in the following sections that allows for the comparison of prediction markets to other group decision making systems from a theoretical perspective.

The skill of an individual is the first input into group decision making (Cooke & Slack 1991). The skills, abilities, information and knowledge of individual participants are important factors affecting the quality of the decision reached by the group as a whole. A crucial component of any group decision making system is that it allows individuals to make a contribution to group.

The decision reached by a prediction market is represented by the contract price being traded on the market. This price represents the aggregated buy and sell orders of all the individual participants in the prediction market. Ultimately, individuals decide to buy or sell a contract by using their information, knowledge, experience, skills and judgement to evaluate the likelihood of the underlying event occurring or not. Thus, prediction markets provide a mechanism that enables individual skills to be aggregated together.

Individuals' personalities play in an important role in group decision making (March 1999b). Personality is seen as influencing the roles that people adopt in groups and the group norms that emerge as part of the group decision making process. Ultimately, the personalities of the individuals involved in the group determine the cohesion that is an emergent property of groups.

The literature suggests that the personality of participants influences prediction market performance. In particular, it is implied that risk propensity affects how individuals interact with the market. Risk propensity is an individual's comfort with risk. Individuals with a high risk propensity are more comfortable with risk. It is suggested they are more likely to participate in prediction markets and more likely to take risky positions in the market in the hopes of higher reward (Wolfers & Zitzewitz 2004). The inverse is true for individuals with low risk propensity.

The size of the group is an important determinant of the effectiveness of group decision making. From a theoretical perspective, the core advantage of group decision making over individual decision making is that the group as a whole has access to more information, knowledge and skill than any one individual. Based on this observation, it should follow that increasing the number of individuals involved increases the effectiveness of the group decision making process. In reality, this is generally not the case. After a certain point, the advantages of increasing the size of the group are overwhelmed by the difficulties associated with coordinating a large group. Administrative tasks such as arranging a time and location for all the individuals to meet can be problematic. Managing communication channels with a large number of individuals can become prohibitively difficult.

In common with other group decision making systems, prediction markets allow for a number of participants to engage in the group decision making process. By their very nature, markets enable multiple participants to buy and sell contracts. In a prediction market, the contract being traded is the expected future outcome of an event, rather than a physical asset, but nonetheless the essential structure of a market remains. The design of a prediction market implicitly enables group decision making.

One crucial distinction between prediction markets and other structured group decision making tools is that many of the challenges in managing large groups of participants are automatically resolved by the use of a market mechanism as the communication channel. Prediction markets can scale efficiently and effectively to hundreds or even thousands of participants without suffering any degradation. In the case of a prediction market that is deployed over the internet via a website, the only restriction on the number of participants are those imposed by the limitations of the underlying hardware and software platforms. In most plausible use cases these constraints are unlikely to become a limiting factor.

Group decision making systems need resources. These resources may be physical, such as rooms to meet in, financial resources in terms of employee's time, or other resources such as access to relevant databases, domain experts etc. Ultimately, these resources cost time and money. They must be paid for by the sponsor of the group decision making process. The cost of the resources versus the improved effectiveness of decision making is a trade-off that must be evaluated when determining whether or not to utilise group decision making in a particular decision space.

Similarly, prediction markets require resources. Employees will require time to participate in the prediction market. The prediction market will have to be developed or

sourced from a third party. Training may have to be provided to show participants how to engage with the prediction market.

In addition to these resources, which are similar in character to the resources required for other group decision making methods, prediction markets also require the provision of trading resources. Participants must have an initial portfolio in order to begin trading. In general purpose prediction markets, participants often fund the portfolio themselves. In an organizational context, it is more common for the organization to provide participants with an endowment. This endowment may be in virtual currency or real currency. If it is in virtual currency, then the organization may choose to provide some other real world incentive to participants, perhaps by exchanging virtual currency for prizes or the like. These issues are discussed in more detail in section 2.2.2.3. Three points are pertinent to this discussion. First, the provision of incentives in whatever form is an additional cost over other decision making systems. Second, the design of the incentive structure adds an additional overhead to the creation of a group decision making system. Choosing between the various incentive structures available requires consideration and analysis. Third, once the initial allocation has been made, the resources are not necessarily tied to a particular decision space. For example, it is possible to provide employees with a portfolio at the start of the year. After that, any time the participant engages in the prediction market, they can continue to use the same portfolio.

The definition of a group implies that it exists for a common, shared purpose. In a group decision making situation, that shared purpose is that the group has been brought together to make one or more decisions. That common purpose provides a rationale for the existence of the group. The group is usually created by one or more individuals, who direct the formation of the group because they have an interest in reaching a particular

decision. These individuals may be members of the group, or they may direct the group, presumably through authority gained from their hierarchical position in the organization.

Prediction markets also have a common purpose. Participants are attempting to predict the future outcome of an uncertain event. This common purpose is generally defined by the market sponsor. The market sponsor defines the contracts being traded. This involves identifying the event to be considered by the market, and also the resolution conditions of the contract. These activities correspond to setting up and defining the decision space in more traditional group decision making situations.

It is important to note the distinction in the purpose individual participants have in prediction markets as compared to other group decision making methodologies. In most group decision making situations, the participant's purpose is to contribute to decision making, through the provision of information, experience etc. The assumption is that the participant is prepared to engage with the decision making process completely, honestly and to the best of their ability. In reality, this is often not the case. A participant may be co-opted into a group decision making situation, and have no motivation to consider the problem being examined. This may lead to lack of participation, and a lack of commitment to the decision.

In contrast, individuals in a prediction market are expected to participate out of self-interest and are incentivised to provide truthful information by personal rewards. Most group decision making systems assume that individuals participate out of either a desire to reach the best decision, or loyalty to the group. In contrast, individuals participating in a prediction market are expected to trade out of self interest. Individuals do not need to derive utility from the act of participating in the group decision making

process, since the purpose that drives the prediction market operates at an individual level and is derived from self interest.

The first variable that is considered one of the process elements of group decision making is group roles. Groups, including decision making groups, are social constructs where different individuals instantiate different identities in the process of fulfilling different roles in the group. Belbin and other authors have identified the many and varied roles that exist within any group (Belbin 1996).

The concept of group roles can be examined at two levels in prediction markets. At one level, all participants are seen as being equal. All participants are presumed to be rational, interested in pursuing their own optimal outcome, with the market performing the aggregation role. The market maker fulfils the duties usually assigned to identities such as negotiator and facilitator in more traditional group decision making structures. This is the perspective most commonly used when analysing prediction markets.

From another perspective, it is also possible to identify different roles in the context of prediction market participation. For example, the economics literature distinguishes between rational and uninformed traders in a market. Extending this analysis, it can be observed that different participants interact with prediction markets in different ways. Some participants merely trade in the market once, based on their initial information. Other participants tend to repeatedly trade in a market. After taking an initial position, they revise their position, based on movements in the contract price or newly revealed information. Broadly speaking, participants who exhibit this type of behaviour can be seen as filling the searcher role.

Roles are not predefined in prediction markets. Instead, the role that an individual plays can ultimately only be determined by observing their trading behaviour. However,

different individuals play different roles in enabling the group as a whole to arrive at a decision.

Group norms are the commonly evolved rules, traditions and guidelines that govern the interactions of a group. Group norms are process elements which are inextricably linked with other process elements in group decision making such as group roles, communication processes, and decision making processes. Group norms are fluid. They generally evolve quickly at the start of the group formation process, before settling on a reasonably fixed form as the group develops.

Group norms exist in prediction markets. Participants receive information from the group through the contract price. Participants can pass information to the group by buying or selling contracts. As such, these basic operations enable group norms. However, in contrast to other group decision making systems, these norms are formal, fixed and in place from the very start of the operation of the group.

Group decision making requires communication processes. In any group decision making situation, individuals have to be able to communicate with each other, in order to transmit and receive information and ultimately to reach a decision. A group decision making process cannot exist in the absence of communication channels between the participants.

As has been previously mentioned, buy and sell orders enables a two way communication channel between participants. The act of buying or selling a contract indicates to the others in the market the participant's current evaluation of the question being considered. This communication channel is mediated by the price of the contract.

It is important to point out here that the bandwidth of this communication channel is considerably lower than the bandwidth of more traditional communication channels. Spoken language, particularly in collaboration with non-verbal cues, can transfer an enormous amount of factual and emotional information to other participants. Much of this subtle information is lost due to the bandwidth compression that occurs in prediction markets. Additionally, prediction markets don't allow participants to explain the rationale for the decisions that they have reached, without additional artefacts such as bulletins boards or similar methods for passing textual information to the group. For the purposes of this research such extensions are ignored. Thus it is fair to say that while prediction markets do provide a communication channel that is sufficient to meet the needs of group decision making, it is of a low bandwidth when compared to the communication channels used in other group decision making systems.

Group decision making systems must also allow for a decision making process. This is distinct from a communication process. A decision making process must allow the individual participants to reach agreement on the decision that is taken by the group as a whole. This is not a problem in situations where it is possible to reach consensus, which is to say total agreement by all the participants in the group. However, in many situations, it may not be possible to reach consensus. In the language of rational decision making, it may be impossible to reach a situation where the preferences of all the participants coincide. In this case, the group decision making process must contain a mechanism that resolves this impasse.

In the case of prediction markets, the contract price fulfils the role of the decision process. Every trade alters the contract price. When using a prediction market, this contract price is the aggregate opinion of all the participants in the market at every point in time. It automatically and immediately reflects the opinion of all the traders in the

market and so can be seen as a real-time decision making process that automatically changes to reflect the revealed preferences of the participants.

At some point, all group decision making processes can be subjected to an analysis of how effective they are at producing effective estimations of the consequences that will occur on selection of an alternative. The analysis must necessarily be conducted post hoc. Prediction markets can also be analysed in terms of their effectiveness at estimating the probability of consequences arising. One point to note here is that prediction markets generate numeric or point estimates of probability. It may be that analysis is easier to perform because of the nature of the output of prediction market. However, the actual process of evaluating the decision quality of prediction market is not qualitatively or quantitatively different from evaluating any other group decision making process.

Another output variable of a group decision making process is the development of the individuals involved in the group decision making process. By participating in group decision making processes, individuals can improve their skills in the problem domain. Individuals can access knowledge from other participants in the decision making process. They may acquire new skills or hone existing ones from observing other participants.

In common with other group decision making processes, prediction markets also allow for personal development. This can occur in a number of ways, and is summarised in Table 7.

Individual Attribute	Effect
Decision Making Skills	Prompts self evaluation Improves decision making through rapid feedback
Information Literacy	Improved information search Improved information evaluation Improved information application
Motivation	Improved alignment of personal and organizational goals

Table 7. Effects of Prediction Market Participation on Individuals

First, the nature of a prediction market is that individuals are asked to make a decision, which is then amalgamated with the decisions of all the other participants in the group. This process is iterative. Individuals make a decision and indicate it to the group via a trading order. They then receive feedback from the group in terms of the contract price. Based on this feedback, the individual can then adjust their estimate, and trade again, closing the trade-evaluate-trade loop. This iterative process allows for individuals improve their decision making skills. An individual may discover that their decision is different from the group. They should then engage in self-reflection, to determine whether their analysis is wrong, or the group's analysis is wrong. Self-reflection is an important element of learning. If the process of self analysis reveals to the individual that the groups estimate is more accurate than their own, then the individual is prompted to reflect on how they reached their decision and what error prompted this mismatch. Fundamentally, the feedback received by individuals in a prediction market allows them to improve their decision making skills in the domain that is the subject of the prediction market.

Second, prediction markets should help individuals to develop the skills associated with information literacy. Information literacy is the set of abilities that allow individuals to recognize when information is needed and to locate, evaluate and use information effectively. A person who is information literate will have a wide range of skills

including the ability to determine the nature and extent of what information is required, the ability to access the required information and the ability to evaluate information (Hoffman & Blake 2003). Information literacy is seen as being a vital skill in the modern business environment. The rise of the knowledge economy, the increasing importance of lifelong learning and the ever increasingly availability of information, with its attendant problem of information overload, mean that developing the skills associated with information literacy are all becoming more important. Prediction market participation provides a platform that allows individual participants to develop these skills. The provision of incentives for good decisions should prompt individuals to search for information pertinent to the issue under consideration. After data collection, individuals will have to evaluate the information and then integrate it with their existing heuristics. When combined with the rapid feedback discussed in the previous paragraph, prediction markets provides an environment that can prompt individuals to develop their information literacy skills.

Third, prediction market participation may affect an individual's affective commitment. Prediction markets will generally be created by a market sponsor in an organizational setting. The market sponsor creates this market because it is relevant and of interest to the organization as a whole. By utilizing prediction markets, participants are incentivised to develop an interest in the topic at hand. It is reasonable to suggest that in the pursuit of personal gain, individuals will take a greater interest in the topic as a whole. This greater interest will prompt increasing learning and search about the topic. In other words, prediction markets provide a mechanism that prompt individual preferences to become more closely aligned with organizational preferences.

The impact of prediction markets on individual's preferences and behaviours has not been explored in the literature on prediction markets. Most extant work in the literature

has focused on the composite entity, which is to say the prediction market as a whole. In particular, issues such as how prediction markets impact upon decision quality have been investigated. To a lesser degree, issues such as how the size of the group and the resources available impact upon prediction market performance have also been examined. The impact of group decision making on individual preferences and behaviours is often a rationale for deploying prediction markets in an organisational setting. Therefore, it is logical to suggest the impact of prediction market participation on individual preferences, skills and behaviours is an important issue that has heretofore been unexplored in the literature.

The significance of the social dimension of the group decision making process is clearly identified in the literature. The output of the social interactions of a group decision making process is referred to by several terms, with the preferred one in this dissertation being cohesiveness. It affects a host of issues, including the commitment of individuals to the decision reached, and the perceived legitimacy of the decision. However, too much cohesiveness can lead to phenomena such as groupthink or escalating commitment which negatively affect group decision making

Fundamentally, cohesiveness in a group is created by the social interaction of members of the group. As with other group decision making processes, prediction markets do engender cohesiveness. A decision space shared amongst all the participants is created. This provides a shared experience for all the participants in the prediction market, which can promote group formation. Since all the participants in the prediction market share a common experience, they can develop a common interest in the topic under consideration.

However, when compared to most other group decision making processes, the bandwidth of the communication channel is extremely limited. Only basic indications of intent can be sent in the form of buy or sell orders. The richness of verbal and non-verbal communication is stripped out the group decision making process when prediction markets are utilised. Equally, any emotional content is removed from the communications. Prediction markets are often used in an environment when participants are geographically and temporally separated and are not interacting at the same time. These limitations on the communications that can occur in a prediction market mean that individuals do not make the same emotional connections to other participants as they would in other group decision making situations.

Prediction markets operate by providing personal incentives for truthful revelation to participants. However, the rewards that they receive accrue by outperforming the group. In order to make a gain, the individual participant must make a better prediction than the current market estimate. It is easy to see how this paradigm can lead to the development of a “me versus them” mentality. Such a mentality is not conducive to the development of cohesiveness in a group.

Finally, the limited communication channels, and the nature of the incentives provided for participation in a prediction market mean that when compared to other group decision making processes, prediction markets are not good at promoting cohesiveness.

2.4. Significant Prior Research

This section provides a brief introduction to the extant academic research on prediction markets. The existing literature on prediction markets can be characterised as relatively small, but growing rapidly (Tziralis & Tatsiopoulos 2007). Within the field, it is possible to identify a number of distinct research agendas which are being pursued in

parallel by researchers in the area. The first and most prominent research theme is work which investigates the overall accuracy of prediction markets, both absolutely and vis-à-vis comparable group decision making mechanisms. A second research stream looks at the issues involved in designed prediction markets. Prediction markets do not emerge organically. They need to be designed in order to fulfil the expectations of markets sponsors. A growing body of academic work investigates the design decisions that must be made when prediction markets are to be deployed. A third research stream uses prediction markets as experimental economics test beds to better understand the operation of markets. A fourth research stream focuses on developing novel applications for prediction markets, both from a theoretical and practical perspective. Much of the academic research published is prompted by an awareness that organisational take up of prediction markets has not been as quick as early pioneers expected. Commentators point to a number of issues which are slowing the adoption of prediction markets in organisations, including a lack of awareness of prediction markets, a lack of information as to what are suitable problems domains for prediction markets, a perception that prediction markets are only attractive to certain types of individuals, and lack evidence demonstrating the benefits of prediction markets, particularly the more intangible benefits such as individual development that are associated with other forms of group decision making (K. Strumpf 2009).

One of the most important issues with regards to prediction markets is their performance (Wolfers & Zitzewitz 2004). The importance of this issue has led to a small, but growing body of research which investigates the accuracy of prediction markets, both absolutely and relative to comparable group decision making systems. At present, it is fair to summarise the empirical evidence published as cautiously optimistic

(Gruca et al. 2008; Ledyard 2006). Wolfers and Zitzewitz (2006) conclude that that it is too early to draw definite conclusions, but that results to date are promising.

There are many naturally occurring forms of speculative markets which share the characteristics of prediction markets. The effectiveness of these markets vis-à-vis other forms of group decision making has been well established in the literature. Orange juice futures outperform the National Weather Service in predicting the weather (Roll 1984). Other examples regularly cited in the literature include racetrack odds beating track experts, stock prices beating panels of experts in the post Challenger probe and gas demand markets beating gas demand experts (Hanson 2006; Ledyard 2006).

Turning to specific examples from the prediction market literature, it is fair to say that the longest running and therefore most studied prediction market is the IEM. The IEM has been in operation since 1988 (Forsythe et al. 1992), running markets on a wide range of political events in the United States and globally (J. E. Berg & T. A. Rietz 2006). Berg, Forsythe, Nelson and Rietz summarise the data from the IEM by stating that the market prices generated are accurate absolutely, and outperform large scale polling operations. (J. E. Berg, Forsythe, et al. 2008). The absolute percentage error for election eve vote share contracts in the IEM is 1.33% (C. Hall 2010). This compares favourably to the Gallup poll which has an error of 2.1% (Rajakovich & Vladimirov 2009). Importantly, the IEM has been shown to be capable of generating these results with trader pools that are not representative samples of the population (Bruggelambert 2004). Overall, IEM prices are accurate, both relative to alternatives and absolutely (J. E. Berg & T. A. Rietz 2006).

This improved accuracy extends to long run forecasts (J. E. Berg, F. D. Nelson, et al. 2008). The IEM outperforms polls over long time horizons of a month or more. Other

researchers have demonstrated that the IEM generates more consistent and accurate probability distributions as well (Bullen & McKenzie 2010).

Other political prediction markets have reported similar successes. Prediction markets operating in Germany (Beckmann & Werding 1996; Borghesi 2009a; Bruggelambert 2004), Austria (Ortner et al. 1995), Australia (Wolfers & Leigh 2002), Canada (Antweiller & Ross 1998) and Sweden (Bohm & Sonnegard 1999) have all demonstrated the ability to outperform public polling mechanisms.

While the empirical work is most extensive in examining the performance of prediction markets in forecasting political events, another body of work exists evaluating the performance of prediction markets in other domains. Spann and Skiera detail a number of experiments where prediction markets outperform other forecasting tools, including predicting box office movie receipts, forecasting pop-single chart position and the usage of different services by mobile phone users (Spann & Skiera 2003). Other studies demonstrate their effectiveness in forecasting demand for hospital services (Rajakovich & Vladimirov 2009), and estimating the length and severity of disease outbreaks (Polgreen et al. 2006). A regularly cited study examining their effectiveness as tools for sales forecasting concludes that prediction markets outperform official forecasting methods, provide consistent probability distributions and make accurate qualitative predictions as to the direction of divergence between forecasts and actual outcomes (K.-Y. Chen & Plott 2002).

While the majority of research that has used political prediction markets is in general supportive of the claims of prediction market accuracy, there is some contrary evidence. In particular, Jacobson et al (2000) discuss a prediction market on elections in Holland which performs significantly worse than comparable polling mechanisms. Other

research presents similar results in Germany (Berlemann & Schmidt 2001). In both cases, the authors acknowledge that the markets under consideration were very thin. They also suggest that the nature of the political systems under consideration, with lots of small parties vying for votes, may have affected performance.

The performance of prediction markets in terms of their accuracy has been described variously as cautiously optimistic and promising. Most authors agree that prediction markets have demonstrated the potential to be more accurate than competing mechanisms, although this potential is not always fulfilled. In general, the performance of prediction markets is seen as being a function of the suitability of the design of the prediction market for the problem domain being considered. This topic has been discussed in more detail in section 2.2.2.

Much recent academic work has moved away from introductory works on prediction markets, and has begun to focus on issues relating to the design of prediction markets. Particular areas that have received attention are the development of Automated Market Makers that have properties that make them suitable for prediction market deployment. Of particular interest here are Hanson's Market Scoring Rule (Hanson 2007b) and Pennock's Dynamic Parimutuel Market Maker (Pennock 2004). Other fertile areas of interest include work on incentive design (Y. Chen & Pennock 2010; Rosenbloom & Notz 2006; Servan-Schreiber et al. 2004) and investigations into the effectiveness of prediction markets in domains outside the traditional ones of political prediction markets (K.-Y. Chen & Plott 2002; O'Connor & Zhou 2008; Polgreen et al. 2006).

A second research stream has focussed on using prediction markets as experimental economics test beds. Such work has focussed on examining issues such as the effectiveness of prediction markets in allowing the aggregation of information (Brown

2010; Bullen & McKenzie 2010; Kálovcová & Ortmann 2009; Spears et al. 2009). Other work in this category has focussed on issues such as interpreting the price of the contracts in a prediction market (Manski 2006).

A third research stream has focussed on the development of theoretical frameworks to allow the application of prediction markets in non-traditional problem domains. Authors have developed frameworks suggesting the utility of prediction markets in a wide range of domains, including policy making (Hahn & Tetlock 2005), law (Abramowicz 1999), marketing (Dahan & Hauser 2002), human resources (Passmore et al. 2005) and education (Buckley et al. 2011). Some authors have suggested that prediction markets can play a role in determining scientific questions (T. W. Bell 2002; Hanson 1995). A development of this concept which is of note is an Ideas Market, which are prediction markets designed to allow participants to both submit and rank ideas (Dahan & Hauser 2002; Lavoie 2009).

2.5. Development of Research Questions

As befits a relatively novel area of research, there a number of open research questions regarding prediction markets. Much of the extant work in the literature has focussed on assessing the accuracy of prediction markets, absolutely and versus other comparable methods (J. E. Berg et al. 1996; J. E. Berg, Forsythe, et al. 2008; Berlemann & Schmidt 2001; Y. Chen et al. 2008; Christiansen 2007; Graefe & Weinhardt 2008). At this point, the evidence in the literature suggests that prediction markets “*can provide more accurate forecasting and effective aggregation than other predictive technologies*” (C. Hall 2010, p.45). The establishment of the basic credibility of prediction markets as a powerful aggregation tool has led to calls for studies which move beyond assessing prediction accuracy. “*In order for electronic markets to become serious alternative information systems to support decision-making, research in this area must move*

beyond its primary focus on predictive accuracy” (Gruca et al. 2005, p.22). This dissertation seeks to answer this call from the literature by providing empirical data which supports the contention that prediction markets can be a useful tool in organisational decision making.

2.5.1. General Focus Research Questions

The general research topic was the impact of information technology on decision making. After a comprehensive literature review, prediction markets were identified as being a novel form of group decision making which offers the potential to improve organisational decision making. This prompted a more focussed literature review of the relevant disciplines, decision making and prediction markets. From this review, two general focus research questions were identified.

One benefit widely accepted in the literature is that participation in group decision making prompts personal development (Hitt 2005; Ellis & Fisher 1994; March 1999a). Employees can develop new skills and abilities as a result of participating in group decision making. Employees improve decision making, both through practice and observing the decision making processes of others. They can develop ancillary skills, such as negotiation or information analysis. The effect of this participation is usually positive, and is often a significant factor considered when organisations choose whether or not to engage in group decision making (Boddy 2005; Jennings & Wattam 1998). Consequently, the first general focus research question springs naturally from these observations. As was pointed out in section 2.3.4, the effect of prediction market participation on individual’s skills and behaviours has not been investigated in the literature. The investigation of the effect of prediction market participation on individual’s skills, abilities and behaviours makes a contribution to our understanding of

the utility of prediction markets. From the perspective of practitioners, this research offers the possibility of demonstrating that prediction markets have a positive effect on individuals and thus provides a sound basis to deploy prediction markets in an organisational setting. The first general focus research question which arises from the literature can be stated thusly: “*What effect does prediction market participation have on individuals?*”

The extant literature often suggests that prediction markets are particularly attractive to individuals who have a high risk-taking propensity (Wolfers & Zitzewitz 2004; Servan-Schreiber et al. 2004; Gruca et al. 2008; Luckner & Weinhardt 2007; Christiansen 2007; Cherry & Rogers 2006). The nature of prediction markets is seen to be such that individuals who derive utility from forecasting uncertain future events are more attracted to them. This observation has important implications. It implies that individuals with high risk propensity are more likely to participate in prediction markets than individuals with low risk propensity. In any case, the importance of investigating the effect of behavioural traits on individuals is recognised by the literature. “*Identifying the characteristics of traders who appear to be crucial to market accuracy should enable market administrators to create prediction-market trader pools more likely to result in accurate price*” (J. E. Berg & T. A. Rietz 2006). Since the performance of prediction markets is closely linked to the volume of trades in the market, this implies that the performance of prediction markets is determined in part by the type of individuals involved in the prediction market. If an organisation happens to have population of individuals who have low risk propensity, then this hypothesis suggests that prediction markets will not be suitable for deployment in that organisation.

Further, the suggestion that prediction markets only attract individuals with a high risk propensity may well be the case in public prediction markets, since the rationale for

participating in such markets is financial reward and intrinsic utility. However, this is not necessarily the case in other prediction market setting, where incentives are structured differently. If the literature is wholly accurate, then the utility of prediction markets may be limited to organisations which have a population of individuals with a high risk propensity. To date, no empirical investigation of this hypothesis has occurred in an operating prediction market that closely approximates an organisational deployment of a prediction market. Given the importance of this effect on the utility of prediction markets as organisational decision making tools, this is an important research question. This gap in the literature prompts the second general focus research question *“What effect do personality traits have on prediction market participation and performance?”*

These two general focus research questions fulfil the criteria required of worthy research questions (Bryman & E. Bell 2003). In particular, the literature review clearly indicates that they are breaking new ground in the discipline. The investigation of these questions offers insights to both academics and practitioners, fulfilling the dual mandate that is commonly associated with business and management research. They are clear, in the sense that they are intuitively understandable. They are questions which are amenable to investigation and it is reasonable to suppose that a well designed research programme will be able to answer them. They connect with the existing literature and emerge from established theory and research. While they are clearly distinct questions, they are also similarities between them. They both focus on the individual participant in a prediction market, rather than the prediction market as a whole. Both are concerned with the relationship between an individual and the prediction market as a separate entity, and how those entities affect each other. However, the general focus research questions as presented are still too broad in order to allow for the creation of a complete

research project. Concepts such as personality traits need to be broken down in specific constructs that can be quantifiably measured.

2.5.2. Specific Research Questions

In order to break down the first general focus research question, constructs that correspond to personal development need to be identified. The effect group decision making is seen to have on individuals has been enumerated in section 2.3.4 and Table 7. A commonly suggested specific benefit of participation in group decision making is that it improves individuals decision making skills. However, this has not been investigated empirically in the context of prediction markets. This gap in the literature suggests the first specific research question, which is *“Does prediction market participation have a positive effect on individual’s decision making?”*

It is commonly suggested in the prediction market literature that one of the advantages of prediction markets over other group decision making systems is that they operate in real-time. Participants can alter their decisions in response to newly revealed information pertinent to the issue being discussed. Similarly, the group decision making literature posits that an advantage of group decision making is that individuals can acquire new information from other individuals, and factor this information into their decision making. However, these advantages only accrue if individuals do factor newly revealed information into their decision making when it comes to their attention. The prediction market literature suggests that this process occurs, and in this is supported by a host of experimental work from the economics discipline. However, only a very limited set of studies have demonstrated this effect to date in the context of prediction markets (Easton & Uylangco 2007; Gil & Levitt 2007). Additionally, these studies are based on general purpose prediction markets, rather than the more restrictive confines of

organisational prediction markets. Providing additional empirical confirmation of this effect, in a setting that more closely approximates organisational prediction markets prompts the second specific research question, which is *“Do prediction market participants factor newly revealed information into their decision making process?”*

Prediction market participation may prompt employees to search for new information, as is suggested by Sprenger et al (2007, p.192) when they write *“There are reasons to believe that markets provide a better incentive system for the discovery of new information”*. A benefit that is regularly suggested in the literature is that participation in prediction markets encourages individuals to search out, evaluate and integrate new information into their decision making process (Christiansen 2007; Hanson 1990; Wolfers & Zitzewitz 2004). This is distinct from individuals integrating information when they happen to encounter it. The prediction market literature suggests that participating in prediction markets encourages individuals to change their behaviour and actively search for relevant information in order to improve their decision making. This suggested ability of prediction markets to induce behaviours in individuals through the provision of incentives is obviously of great interest in the context of organisational behaviour. Providing a group decision making mechanism that prompts the development of these information literacy skills would be another important rationale for deploying prediction markets in an organisational setting.

While this suggestion has logical force, it is important to note that there are no empirical studies which either confirm or deny this hypothesis in the context of an ecological valid prediction market. Search for evidence of these altered behaviours leads to the formulation of the third research question, which can be phrased as follows: *“Do prediction market participants actively search out information pertinent to the decision spaces being considered by the prediction market?”*

As previously discussed, the second general focus research question is “*What effect does personality traits have on prediction market participation and performance?*” The immediate difficulty with this question is the impreciseness of the definition of personality traits. It is possible to consider hundreds of different personality constructs. For example, the IPIP contains standardised test for hundreds of different personality traits. In order to render this research question tractable, it is necessary to identify specific personality traits of interest. For this specific research project, two specific personality traits were selected, namely risk propensity and self-monitoring.

Risk propensity is a decision maker’s cumulative tendency to take or avoid risks. It is commonly suggested in the prediction market literature that individuals who have a high risk propensity are more likely to participate regularly in prediction market. They derive a utility beyond that of the monetary reward associated with the market from the act of making an uncertain decision. Risk propensity is therefore a behavioural trait that it is reasonable to suggest will have an effect on participation in a prediction market. The literature is silent on the question of how risk propensity affects individual performance. For the behavioural trait of risk propensity, we can identify two related but distinct questions. First, “*How does an individual’s risk propensity affect participation in a prediction market?*” Second, “*How does an individual’s risk propensity affect performance in a prediction market?*”

The other personality trait that was selected for analysis was a construct referred to as self-monitoring. Snyder (1974) points out that there are striking individual differences in how individuals mediate their self-expression and non-verbal communications. Individuals with high self-monitoring regulate their behaviour in order to promote a desired public image (Jenkins 1993). In the context of prediction market participation, individuals with low self-monitoring are consistent between their beliefs and their

actions. They should trade in accordance with their beliefs and the information they possess. In contrast, individuals with high self-monitoring should tend to divorce their actions from their beliefs (Snyder 1987). For example, an individual with high self-monitoring will factor into their decision making process how a decision will appear to others when making a decision, and will assume other are doing the same (Biais et al. 2005).

The investigation of self-monitoring is exploratory work. The behavioural trait of self-monitoring is not mentioned in the literature on prediction markets. However, a concern regularly cited in the literature is the possibility of manipulation in prediction markets. This has been discussed in detail in section 2.2.2.5. Manipulation of a prediction market generally occurs when an individual trades in a manner inconsistent with their beliefs and knowledge. High self-monitoring individuals should also trade in a manner inconsistent with their beliefs and knowledge. It was felt that this possible parallel would be interesting to investigate.

In the context of a prediction market, individuals with low self-monitoring will see the trades on the market as being simply reflective of information and beliefs of the traders. In contrast, an individual with high self-monitoring is more likely to assume that other participants will attempt to manipulate the market and hide their information as they themselves would. They are less likely to take the prices on a prediction market at face value and are more likely to reason about the strategies that underlie the creation of these prices. In a similar manner to risk propensity discussed above, two specific research questions can be identified. First, *“How does an individual’s self-monitoring affect participation in a prediction market?”* Second, *“How does an individual’s self-monitoring affect performance in a prediction market?”*

2.5.3. Summary of Research Questions

Table 8 displays the final list of general focus and specific research questions which were identified during the early part of the research process. These questions and the need to gather relevant information informed the design of the empirical data collection phase of the research project.

General Focus Research Questions	Specific Research Questions
What effect does prediction market participation have on individuals?	<ul style="list-style-type: none"> • Does prediction market participation have a positive effect on individual decision making? • Do prediction market participants factor newly revealed information into their decision making process? • Do prediction market participants actively search out information pertinent to the decision spaces being considered by the prediction market?
What effect do personality traits have on prediction market participation and performance?	<ul style="list-style-type: none"> • How does an individual's risk propensity affect participation in a prediction market? • How does an individual's risk propensity affect performance in a prediction market? • How does an individual's self-monitoring affect participation in a prediction market? • How does an individual's self-monitoring affect performance in a prediction market?

Table 8. List of Research Questions

2.6. Conclusion

This chapter has focussed on clearly identifying gaps in the extant literature which are suitable for a doctoral research programme. Two domains of literature were investigated, namely the literature on prediction markets, and the literature on decision making. Special care was paid to position prediction markets as group decision making tools. From the analysis of the literature, it is obvious that a specific concern is

understanding the low uptake of prediction markets in business organisations. Researchers have identified that prediction market research needs to move beyond investigations of prediction market accuracy in order to address some of the concerns of business organisations, and provide further rationales for deploying prediction markets. By investigating the effect of prediction market participation on individuals behaviours and skills, this research will provide an additional rationale that should prompt business organisations to deploy prediction markets. By investigating the effect of personality traits on prediction market participation and performance, this research will address some of the concerns that business organisations have regarding the suitability of prediction markets for organisational deployment. The next chapter focuses on the design of the study used to collect the data that permits investigation of these issues.

3. Research Methodology and Data Collection Design

3.1. Introduction

This chapter describes the research methodology used in this study. The discussion of research methodology is informed by Mcgrath's (1981) depiction of research as a set of interlocking decisions, where each decision affects and is in turn affected by every other decision. It provides a clear description of the decisions reached while developing this research programme. Where necessary, competing alternatives are reflected upon, and the rationale for the selections made provided.

Section 3.2 explores the philosophical issues that impact upon all levels on the research design. The epistemological and ontological position taken by the researcher are elucidated and defended. The impact of research ethics on research design is also explored in this section. Section 3.3 explores the various strategies available to researchers, and justifies the selection of a longitudinal research study as the correct methodology with respect to both the epistemological position of the researcher and the research questions posed. Section 3.4 describes in detail the longitudinal study used to capture the data in this study. Particular attention is paid to justifying the decisions that were reached when designing the prediction market which was the centrepiece of this study. Section 3.5 discusses in detail the data collection methods used to gather data. Section 3.6 describes the steps that were taken to ensure the quality of the data gathered and the research process as a whole. Section 3.7 concludes the chapter.

3.2. Research Philosophy

This section focuses on exploring the macro level issues which affected the design of this research study. These issues affect all the decisions and trade-offs that were made when designing the research programme. The first issue explored is the epistemological and ontological position of the researcher. The positioning of the researcher with regards to these philosophical questions shapes the entire research project. This is explored in section 3.2.1. Section 3.2.2 discusses ethical issues, and their impact on the research process is explored.

3.2.1. Epistemological and Ontological Position

Epistemology is the metaphysical branch of philosophy which deals with the study of knowledge. Epistemological issues concern the question of what should be regarded as acceptable knowledge in a discipline (Bryman & E. Bell 2003). Epistemological frameworks are used to understand how knowledge is created and the value of knowledge. Containing implicit concepts of knowledge, the limits of attainable knowledge and the way knowledge is generated, the epistemological position taken by the researcher will influence the research process from beginning to end.

A paradigm is a worldview that defines the nature of the world, the individual's place in it and the range of possible relationships between that world and its constituent parts (Guba & Lincoln 1994). Most discussions of epistemology begin by examining two competing paradigms. These paradigms are referred to as positivism and interpretivism (Robson 2002). These two paradigms are usually presented as representing either end of a continuum of epistemological positions. Various other paradigms are placed somewhere in the continuum between positivism and interpretivism.

Positivism is an epistemological position closely associated with the natural sciences. It assumes that knowledge, in the form of objective facts, should be gained from direct observation (Robson 2002). Only facts which can be confirmed by the senses can be considered knowledge. Under positivism, the purpose of research is ultimately to generate causal laws. Positivists look for universal relationships that exist between two or more variables. In order to do this, researchers gather large amounts of data. Complicated systems are broken down into simpler subsystems, until it becomes possible to isolate the variables of interest and analyse their interactions only.

In contrast to positivism, interpretivism views reality as a social construct. In its extreme form, interpretivism maintains there is no external reality that can be defined independently of human consciousness (Robson 2002). Under this paradigm, reality is viewed as being inextricably mediated by conceptual systems, and the concept of an independent objective reality is non sequitur.

Interpretivism is seen as being particularly closely linked to the social sciences. Proponents of interpretivism argue that positivism is an unhelpful paradigm to study the systems that are the concern of the social sciences. In particular, they argue that ignoring the meaning associated with human actions denies a basic attribute of the behaviours that are the concern of the social sciences. Human actions are meaningful, and have values. The positivist perspective that values and meanings are not the subject of scientific knowledge seeks to ignore some of the fundamental building blocks of reality from the perspective of an interpretivist.

The weakness of both paradigms in the face of both practical and philosophical objections has led to the emergence of many other epistemological perspectives. These positions generally take some of the tenants of one or both of the previously discussed

paradigms, and use them to generate a new epistemological position. One paradigm which has become influential, particularly in the social sciences is realism. Realism attempts to meld positivism and interpretivism into a more productive whole. It does not reject the existence of an objective, external reality as constructivism does (Saunders et al. 2003). However, it emphasises the importance of intangible social forces and their effect on human behaviour. It rejects the notion that positivist experimentalism is a tool that is sufficient to understand social systems. Positivist experimentalism is seen as being effective in simple linear situations. However, the world is seen as being messy, with experiments that effectively remove all external forces being both impossible to achieve in practice, and lacking in validity since the situation is simplified so much (Robson 2002). Realism posits that knowledge is a social and historical product, created by the dominant paradigms of the time, and is a function of the methods of data collection and analysis used to create it. Realism also explicitly accepts the embeddedness of social actions. Events and behaviours cannot be separated from the social context they occur in. This perspective emphasises the importance of ecological validity in the context of research. Positivistic research seeks to identify deterministic laws which apply in all situations. Realism recognises that in the open systems which are the subject of study in the social sciences deterministic laws cannot be established. At the same time, realism does recognise causality.

This recognition of the importance of causality in realism is often illustrated by the example of gunpowder (Robson 2002). *“In realist terms, the outcome (the explosion) of an action (applying the flame) follows from mechanism (the chemical composition of the gunpowder) acting in particular contexts (the particular conditions which allow the reaction to take place)”* (Robson 2002, p.30).

Using a perspective of realism informs the entire design of the research project. The researcher aims to trigger the mechanism being studied. Since instantiation of the mechanism being studied is dependent at least in part upon the context, the researcher must also be able to either create or access the specific context. In this paradigm, a researcher is a “*system builder*” (Robson 2002). Data is collected not by dispassionate observation, but by the active work of the researcher in selecting or creating the system to be observed.

This research was conducted using a stance of realism. As such, this stance affected the design of the entire research strategy. In order to study prediction markets, the researcher was required to create a prediction market, or in the language of realism, instantiate the mechanism being studied. The importance of context in the realist perspective is reflected in the attention paid to creating an ecological valid study, as discussed in section 3.6.3.

Ontology is the philosophical discipline that deals with the nature of objects. The relationship between researchers and the social actors and objects under study form the basis of ontological questions. From the perspective of the social sciences the central ontological question is whether social entities such as organizations or culture can be considered entities that have an objective reality in their own right, or whether they should be considered social constructions, built up from the perceptions and actions of social actors (Bryman & E. Bell 2003). Two positions are described in the literature, namely objectivism and constructivism.

Objectivism is “*an ontological position that asserts that social phenomenon and their meanings have an existence that is independent of social actors*” (Bryman & E. Bell 2003, p.19). Social phenomena such as organizations can be discussed in the same way

that objects such as tables and chairs can be discussed. An organization is seen as having a structure and attributes such as rules, regulations and social norms. The organization is created by individuals, but also creates pressure to conform on individuals who are members of the organization. From this perspective, an organization, or a similar social object is seen as being as real as any other object, and thus can be studied in a similar manner.

Constructivism is a contrasting ontological position, which asserts that “*social phenomena and their meanings are continually being accomplished by social actors*” (Bryman & E. Bell 2003, p.20). Constructivism denies social objects independent reality. Instead it views them as constructs that are best understood by examining the social actions that create them, rather than attempting to examine the construct as a whole. Constructivism emphasizes the transitory nature of social constructs. Lacking an independent existence, social objects are in flux, constantly being defined and redefined over time.

Taking the stance of realism affects the ontological position taken by the researcher. Knowledge is recognised as being a social construct, which is in part always contextualised. The abstract representation of deterministic laws which are universally applicable is rejected on practical and philosophical grounds. At the same time, the existence of an underlying objective reality, albeit one that can only be observed imperfectly is accepted. This “*third way*” rejects the ontological dichotomy of the objective and constructivist positions. Instead it recognises that social objects such as organisations are both the product and medium of human action. This perspective means that researchers should choose the tools that are suitable for the research purpose, rather than select quantitative or qualitative approaches based upon the ontology they believe in.

This dissertation has used quantitative research methods such as surveys, questionnaires and direct observation, in the form of recording the actions of individual participants in numeric terms. However, this was based on their suitability as tools to investigate the research questions, rather than an adherence to the objectivist paradigm of enquiry. As such this choice is acceptable when viewed from the perspective of realism.

3.2.2. Research Ethics

Ethical concerns as they apply to research “*refers to the appropriateness of your behaviour in relation to the rights of those who become the subject of your work, or are affected by it*” (Saunders et al. 2003, p.129). This definition of research ethics emphasises that ethical concerns must be considered throughout the research process, from initial research design all the way through to analysis and write-up (Robson 2002; Saunders et al. 2003). Most research institutions expect researchers to adhere to the highest ethical standards when conducting research. Most universities have a Research Ethics Board whose role is to independently vet research proposals for ethical sensitivity. Research ethics boards are generally given a remit to protect the research subjects, the researcher and the institution. Many different ethical frameworks exist and it is possible to use a number of perspectives when considering the ethical issues raised by research. Bryman and Bell (2003) suggest that a researcher should consider four main issues when engaging in the research process.

First, the researcher must consider whether or not the research has the potential to cause harm to participants. Second, the researcher should be sensitive to the issue of consent and ensure where possible that participants provide informed consent. Individuals have a right to, and expectation of privacy. How this right impacts upon the research process must be considered by the researcher. Research which leads to an actual or perceived

invasion of privacy raises ethical concerns (Bryman & E. Bell 2003). Finally, they identify deception as an ethical issue that must be addressed by researchers. “*Deception occurs when researchers represent their research as something other than what it is*” (Bryman & E. Bell 2003, p.545). Deception is often widespread to various degrees, because the investigation of particular research questions may require that participants react naturally to the experimental treatment or observation. At the same time, deception should be minimised where possible.

In general, the ethically purest way of addressing such concerns would be to hold researchers to the highest standards possible. In such a scenario, research processes would involve no deception or possibility of harm, however remote, no violations of privacy would occur and all participants would give fully informed consent. In reality, such standards are impossibly high, both theoretically and practically for a number of reasons. First, it is often impossible to practically meet such standards. For example, removing all possibility of any type of harm occurring to an individual in a research process is impossible. As an extreme example, a participant travelling to an interview may have an accident. Providing fully informed consent requires a level of knowledge that is unobtainable from a philosophical perspective.

Leaving aside the practical difficulties of reaching absolute standards, the ethical issues surrounding research must be considered in a wider perspective. It is often the case that researching specific issues requires the weakening of the highest ethical standards. For example, requiring fully informed consent from all participants would imply that no research can ever be conducted on children, since they can never provide informed consent. In such cases, the ethical concerns raised by a research proposal must be balanced against the greater societal good that may be provided by that research project.

These observations imply that ethical guidelines cannot be absolute. A researcher must take on the burden of ensuring that research is conducted as ethically as possible, given the practical constraints imposed by an imperfect reality, and balanced against the possibility of a societal greater good emerging from the research. This research project was informed from the outset by an awareness of the importance of conducting ethical research. The research strategy and research methods used were approved prior to any data collection by the Kemmy Business School Research Ethics Committee (see Appendix E).

3.3. Research Strategy Choices

Research is “*something that people undertake in order to find out things in a systematic way, thereby increasing their knowledge*” (Saunders et al. 2003, p.3). Two important concepts emerge from this definition. First research is conducted to “*find out things*”. This implies that research is conducted for a purpose. There may be a multiplicity of reasons for conducting research, including describing, explaining, criticising and analysing (Saunders et al. 2003). Second, this definition emphasises that research is conducted “*systematically*”. Conducting research systematically means that the process is based on logical relationships and not just beliefs. It implies awareness of not just what activities the researcher engages in, but why those activities are chosen. Other authors emphasise the importance of engaging in research sceptically and ethically (Robson 2002). Conducting research sceptically means ensuring that the research process and outputs are subject to public evaluation, scrutiny and possible disconfirmation. Research should always be carried out in an ethical manner, and should ensure that the interests and concerns of parties involved in and affected by the research are taken into account.

The conception of research as being a systematic endeavour lends itself naturally to viewing research as a process. Most textbooks present research as a multi-stage process in which a set of activities should be conducted in a prescribed order. Such a view is usually found implicitly in the presentation and ordering of chapters in books on research methodology, and is often found explicitly described within textbooks. The precise nomenclature of these activities varies between authors. Saunders et al (2003) suggest that most descriptions of the research process generally include:

- Formulating and Clarifying a Topic
- Reviewing the Literature
- Choosing a Strategy
- Collecting Data
- Analysing Data
- Writing Up

This description of research as a linear process has a number of commendable attributes. First, there is an implicit logic to the ordering. For example, it is not possible to analyse data before collecting it. A similar logic can be found to hold between most of the steps presented. Second, this structure reduces the risk of errors that damage the worthiness of the research. For example, collecting data without analysing the literature runs the risk of duplicating existing research. Third, the presentation of research as a process emphasizes the systematic nature of research.

While having certain positive attributes, the presentation of the research process as a linear process is critiqued in the literature as being overly simplistic (Saunders et al. 2003). In reality, it is accepted that the research process is far messier than the progression presented in the literature. Often the researcher will be forced to adjust research design in response to issues such as access or ethical considerations. Data may emerge that suggests different analysis methods to those originally planned. Certain research strategies, in particular active research, suggest iterative cycles of research,

where theory informs data collection, which in turn modifies theories and so on (Robson 2002). Thus, the structured research process outlined above provides useful guidelines on how to structure a research process, but should not be taken past the point of usefulness.

Any research process involves making a variety of decisions and choices throughout the research process. For example, the epistemological position taken by a researcher will influence the research methods utilised by the researcher (Bryman & E. Bell 2003). This is of particular import when the researcher turns to consider issues of research quality. As McGrath (1981) points out, the decisions reached in a research process inevitably reflect trade-offs between competing requirements. For example, improving internal validity may adversely affect external validity. It is incumbent upon a researcher to document these decisions, analyse their effect and clearly rationalise the basis of the choices made in order to ensure high quality research.

Research strategy is “*a general plan of how you will go about answering the research question(s) you have set*” (Saunders et al. 2003, p.90). Research strategy is informed by both the research purpose, and the research questions. It will contain clear objectives and specify what data is to be collected and how it is to be analysed. The ontological and epistemological position taken by the researcher will also impact upon the selection of research strategy. However, research strategy is a practical phase of the research process (Saunders et al. 2003). Issues such as how access to data will be obtained, and what specific sources will be consulted are considered as part of the generation of research strategy. Ethical concerns will also affect the generation of research strategy.

At the macro level of research strategy, two broad types of research strategy can be identified. Fixed design research strategies call “*for a tight pre-specification before you*

reach the main data collection stage” (Robson 2002, p.87). Fixed design research strategies are formalised and planned in advance. Fixing the research design in advance necessarily implies that the research questions are tightly defined in advance. This in turns means that fixed research designs are commonly, though not exclusively associated with descriptive and exploratory research projects. Similarly, the data collected in fixed research design is usually numeric (Robson 2002). Fixed designs are often associated with quantitative research methods, such as fixed questionnaire surveys or experiments.

Flexible design research strategies evolve during data collection (Robson 2002). In response to data collected, the researcher may alter the population, the sample or the data collections methods being used. The plastic nature of the research process means that this research strategy is more suited to exploratory research. This inherent flexibility allows the researcher to modify the research process to examine new phenomena as they emerge from the data collected. Flexible designs are often associated with qualitative research methods such as interviews and ethnography, which collect non-numeric data such as speech and text (Robson 2002).

Byrman and Bell (2003) identify five distinct types of research strategy. The first type of research strategy is an experimental strategy. An experiment is *“a classical form of research that owes much to the natural sciences.”* (Saunders et al. 2003) It will typically involve the generation of a hypothesis, the selection of a sample and the allocation of said sample into various experimental groups, the introduction of a planned change to one or more independent variables, the measurement of one or more dependent variables, and the control of other variables. A second form of research strategy is a cross-sectional research (Bryman & E. Bell 2003). The defining characteristic of a cross-sectional study is that it occurs at a particular point in time

(Saunders et al. 2003). It is a research strategy that aims to analyse the characteristics and attributes of a particular population at a point in time. In contrast, the third type of research strategy, a longitudinal study aims to observe individuals and events over time (Saunders et al. 2003). A longitudinal study will take repeated data measurements over a period of time (Bryman & E. Bell 2003). The strength of a longitudinal study is that it can be used to observe change and development over time. The fourth research strategy, a case study is “*a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence*” (Robson 2002, p.178). A case study aims to investigate a phenomenon in a realistic context. It is commonly used in the social sciences. Finally, a comparative research strategy is a “*direct comparison between two or more cases*” (Bryman & E. Bell 2003, p.62). Its purpose is to compare and contrast the differences between the different populations being considered in the research.

Any of these research strategies can be used in conjunction with a fixed or flexible research strategy. For example, a fixed cross-sectional study may use a survey instrument to gather data from the population under consideration, while a flexible cross-sectional study may use a qualitative method such as an interview to gather data from the population. The precise nature of the research strategy employed by the researcher is determined by a host of other choices made throughout the research process. The choice of research strategy made in this project, and the effect it had on the research process is described in section 3.4

Research methods, sometimes referred to as research tactics are “*simply a technique for collecting data*” (Bryman & E. Bell 2003, p.32). As Bryman and Bell point out, the terms research methods and research strategy are often used interchangeably. In this dissertation, the strict definition proffered above is adhered to, and the term research

method is used to refer to the specific technique used to collect data. The larger question of how the data collected is used to answer the research questions is considered the domain of research strategy.

In general, three broad classifications of research methods can be identified. Researchers can watch individuals, using observation. Alternatively, the researcher may choose to directly ask participants for information, or researchers can attempt to gather data using an inference process, by examining indirect evidence. Robson (2002) identifies five macro level research methods, namely Questionnaires; Interviews; Tests and Scales; Observation and Additional Methods. In order to collect the data used to investigate the research questions posed in this study, both tests and observation were used.

3.4. Research Design and Approach Adopted

This section focuses on describing the design of the research process. A number of issues are addressed in this section. Section 3.4.1 describes the overall research strategy. It provides the rationale for selecting a longitudinal study and a detailed description of the how the study was conducted is presented. Section 3.4.2 describes the market mechanism used in this study. Section 3.4.3 describes the contracts that were used in the market. Section 3.4.4 describes the incentive structure used in the research study, while section 3.4.5 discusses the audience selected for the study and the rationale for its selection. This breakdown mirrors the description of prediction market design decisions which is elucidated in Section 2.2.2. As well as justifying the research design, this section also serves as a demonstration of the researcher's competency in designing and deploying prediction markets.

3.4.1. Longitudinal Study Design

The overall research strategy utilised in this study is that of a longitudinal study. The selection of this methodology is mandated by two considerations, which will be discussed in turn. The first consideration is the epistemological position taken by the researcher. The second is the nature of the research questions. Both of these factors demand the utilization of this research strategy.

As previously mentioned, this research is undertaken from the perspective of realism. Realism attempts to combine the strengths of both the positivist and interpretivist perspectives. In particular, realism emphasises that social systems such as an operational prediction market can only be understood in a particular context. In order to generate findings which can be applied to real world contexts, care must be paid by the researcher to ensure that data is collected in a valid context. This perspective on knowledge requires that the researcher generates findings that have ecological validity. Experimental work brings rigor to data collection, however the price that is paid for this rigor is the diminution of ecological validity. To give a specific example related to this study, a number of studies in the past have demonstrated that individuals participating in a prediction market will incorporate newly revealed information into their decision making. However, these studies have taken place in laboratory settings. As such, the context of these studies is far removed from the context in which an organisational prediction market is likely to be deployed.

The nature of the research questions also mandated the selection of a longitudinal study. In particular the research questions which focus on the effect of prediction market participation on behaviours require the observation of these behaviours over an extended period of time. In order to investigate whether individuals seek out new

information to inform their decision making, it is necessary to observe individual's behaviours. To ensure that this observation is valid, it is necessary to carry out this observation over a relatively long period of time.

Both of the general focus research questions identified examine the relationship between individuals and a prediction market. This observation mandates that the researcher be in a position to observe a prediction market in operation and also access the individual participants. This methodology is relatively common in the literature. For example, an analysis of articles published in the *Journal of Prediction Markets*, reveals that of the 41 articles published between 2007 and 2009 inclusive, 23 of those articles focused on work which analysed data derived directly from a prediction market.

As such this contextualises the first decision that shaped the design of the data collection phase. Two alternative routes for gaining access to a prediction market could be envisaged. The first option would be to use an existing prediction market and use that as the source for the data. The second option would be for the researcher to create a prediction market from scratch. This was the alternative eventually selected, both because of challenges with using an existing prediction market, and the perceived advantages of developing a custom designed prediction market from scratch.

The difficulty presented in using a pre-existing prediction market such as Inkling Markets (www.inklingmarkets.com), Intrade (www.intrade.com) or some other prediction market provider can be summarised as being issues around the lack of control. In many cases, such providers are commendably open to engaging with academic researchers. However, such organisations operate as commercial entities. Prediction market providers must offer markets that their customers are interested in, rather than markets that are suited to the needs of academic researchers. For example, a

prediction market provider will not offer the same question repeatedly to customers, purely to evaluate decision making over time. They seek to operate large numbers of diverse markets. Prediction markets providers often see data on trading patterns and individual trading behaviours as being information that has a commercial value, and may be unwilling to release their intellectual property into the public domain. By their nature, such companies usually operate over the internet, and offer access to markets to any interested trader at any time. This means they are unable to create markets that have a stable population, and often will only have a hazy knowledge of the demographics of their traders. Public access, for profit prediction markets traditionally attract a population of traders which is significantly different from the norm (J. E. Berg, Forsythe, et al. 2008). This population would be significantly different from the demographic profile of a typical modern business organisation. While it is entirely possible that only similar traders will actively trade on an organisational prediction market, starting with a uniform population pre-supposes this, whereas investigating this is one of the major focuses of this study.

As well as overcoming some of the difficulties that using a pre-existing prediction market presents the research process, using a custom designed prediction market offers a number of advantages. First, it offers more control to the researcher. The decision that the participants have to make can be presented in such a way as allow for the identification of the effects of newly revealed information. The market sponsor can select a specific population to draw participants from, which in turn allows for better demographic analysis of the population. It also allows for the identification of participants and the targeted deployment of tools such as personality profiling questionnaires. A final advantage of this approach is unrelated to the specifics of research design. The process of creating a prediction market, creating questions,

creating incentive structures and generally operating a prediction market provides the researcher with in depth practical knowledge and experience of how to create, deploy and manage a prediction market.

Researchers in the area have commonly used custom designed prediction markets in their research programs. The analysis of the *Journal of Prediction Markets* mentioned earlier reveals that of the 23 published articles which used an operational prediction market to investigate their research questions, 12 of them used pre-existing prediction markets, while 11 of them used custom designed prediction markets. In the context of this research question, certain attributes were required that necessitated the development of a custom prediction market. In particular, it was necessary to repeatedly ask the same question in order to evaluate changes in decision making ability. It was necessary to be able to cross-reference trader's scores on personality tests with their individual trading behaviour. It was necessary to be able to ask questions that had very specific characteristics in order to detect the impact of information revelation on traders and the market as a whole. All of these requirements necessitated the creation of a custom prediction market.

Following the initial pilot deployment of a prediction market, which was used to gain experience of the operational issues involved in running a prediction market, the data collection phase of the research project was operationalised by the deployment of the Insurance Loss Market (ILM).

The ILM was live for a ten week period from Monday, September the 14th to Friday, November 20th 2009. This was for most of the 2009 fall semester. For each week in the period, the market opened on Monday at 9:00 am and closed on Friday at 5:00 pm. At the market close each Friday, students' forecasts were evaluated against the insurance

losses as provided by Xactware. Xactware is a well known provider of data to the insurance industry. At 9:00 am on the Monday of every week, each participant was provided with €5,000 in notional funds that they needed to allocate by predicting insurance losses in each of three states, namely California, Florida and New York. These three states were selected for this study on the basis of their location and economic significance. This was made operational by providing a series of loss bands where participants could allocate their capital in the ratio they considered to be optimal. Figure 5 provides an example of the ILM interface. It shows the range of loss bands available to participants in the New York market for the week ending 9th of October 2009.

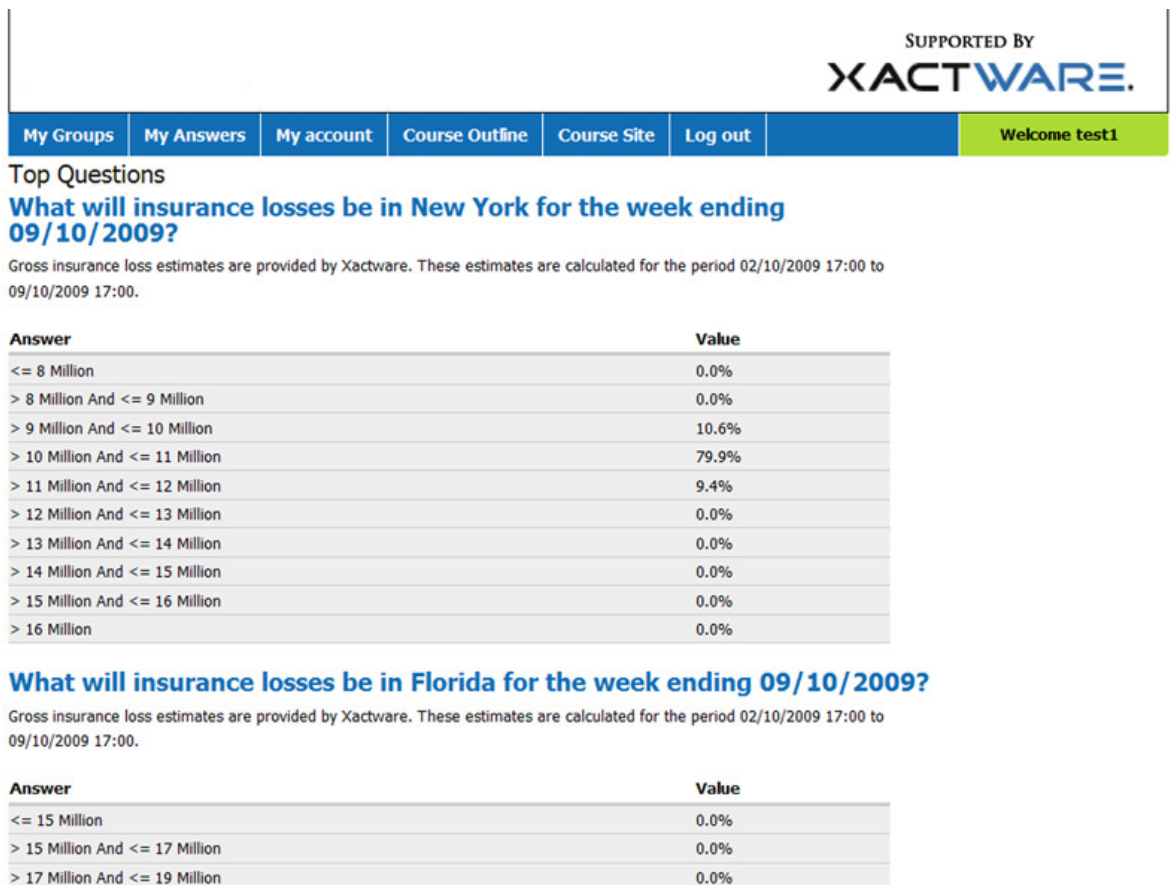


Figure 5. The ILM Interface

As trading activity commenced, the market dynamic produced a distribution of outcomes as participant's evaluated historical information, such as recent weather patterns and recent insurance claims, as well as forward-looking information such as hurricane development, weather forecasts and potential hazards such as wildfires. Such information is easily sourced from the Internet. Market participants had to evaluate the importance of the available historical information as well as the relevance of new information when making a decision.

The activity in this market is similar to that carried out in the real insurance markets every day as insurance and reinsurance underwriters transfer insurance risks. The ILM website made a number of information sources available to participants, including lecture notes, research articles on insurance and risk management and theoretical models that are applied in risk management and forecasting. However, no "current" information, in terms of news articles on recent events in the regions of interest was posted on the site. This was a specific design decision taken in order to encourage students to search for information.

As part of the overall implementation of the ILM, the problem difficulty was adjusted over time. The individual markets in the ILM started with very large losses bands which were progressively tightened over a number of weeks. Each market had ten distinct loss bands. In the first week of operation, the lowest loss band was "Losses less than 5 million" and the highest loss band was "Losses greater than 45 million", with the eight loss bands in between these two extremes changing in steps of 5 million. The loss bands were tightened in all the markets until the fifth week, when the loss bands ranged from "Losses less than 17 million" to "Losses greater than 25 million", with individual loss bands changing in steps of 1 million. It becomes more difficult to select the correct loss band as the bands tighten.

This research strategy was designed in order to provide the data required to investigate the research questions which emerged from the literature.

Requirements of Research Process
1) Large, Stable Group of Participants
2) Repeated Decision
3) Discrete events that would impact upon decisions
4) Information not immediately available
5) Ability to measure behavioural traits of participants
6) Ability to quantify performance
7) Ability to quantify participation

Table 9. Requirements of the Research Process

In order to meet the demands of the research process, the prediction market needed to meet a number of requirements. First, the research demands a large, stable pool of participants. The risk management module in question was taken by over 400 students and the class did not change over the course of the term. Second, in order to measure changes in decision making over time, it was necessary to present participants with the same decision repeatedly, and examine how their performance varied over time. In this process, the students were presented with the same decisions repeatedly, namely what will insurance losses be in the three states under consideration. Third, in order to investigate the impact of information on participants, it was necessary to be able to identify discrete events which should have a measurable impact upon the prediction market. While the estimation of insurance losses is influenced by real-world, real-time events, it is nonetheless relatively easy to identify the large scale environmental events that would affect the prediction market. Fourth, it was also necessary that participants should have to engage in information search in order to partake in the prediction market

successfully. While information on relevant information is widely and freely available, students in Ireland are unlikely to read about weather events in the United States by accident. Accessing information about these events would require students to actively search out this information. Fifth, in order to evaluate the effect of behavioural traits on prediction market participation and performance, it was necessary to be able to measure these behavioural traits. Since the nature of the population meant the researcher had direct access to the participants, it was possible to measure the behavioural traits of individuals. Sixth, it was necessary to be able to measure the performance of participants, so that it can be correlated with behavioural traits. This data collection design naturally created a performance metric which can be used for this purpose. Finally, it was also a requirement of the data collection process that a metric for measuring participation be established. In a similar manner to the performance metric, the number of trades that a participant made during a given week naturally emerges as a metric that can be used to measure participation. Thus, this data collection structure met all the requirements of the research process. It allowed for the collection of data that can be used to directly address the research questions identified earlier in the research process.

3.4.2. Market Mechanism

The structure of a prediction market is such that the value attributed to a specific loss band will increase or decrease as the number of participants investing in it fluctuates. Specifically, the ILM used Hanson's Market Scoring Rule as an automated market maker (Hanson 2007a). As more participants select a specific loss band its value increases and simultaneously the value of all other loss bands will decrease proportionately. This structure also means that at any time throughout the execution of

the market, participants had the opportunity to re-evaluate their decisions in the light of newly revealed information and change their decision where they deemed it appropriate.

Hanson's Market Scoring Rule is the most commonly used market mechanism for implementing prediction markets (C. Hall 2010). It has all of the desirable attributes of a market maker described previously in section 2.2.2.1. Its only drawback is that it requires the market sponsor to carry some financial risk, albeit one that can be calculated in advance. However, in this situation, since participants were rewarded in virtual currency, this was not a limitation.

In order to deploy the prediction market used in this study, a third party organisation called QMarkets (www.qmarkets.com) was retained. QMarkets provide prediction markets to organisations, including businesses, public sector bodies and educational institutes. QMarket's platform provides all the functionality required to implement this research process. An overall market can be created, to which user accounts can be added. Specific contracts can be added or deleted throughout the operation of the market, allowing for the delivery of weekly questions as per the research design. The platform also allows for the creation and deletion of user accounts, facilitating the management of the over 400 participants in the prediction market. A variety of reports are available, which provide access to the information required to conduct analysis. In particular, a report detailing every trade made by every user can be downloaded at any time. This raw data source can be analysed to investigate the research questions which drove this research project.

3.4.3. Contract Design

The ILM required learners to predict Weekly Insured Property Losses for California, New York and Florida. The Weekly Insured Property Losses are the total monetary

amounts that all insurance companies will have to pay due to claims on the policies outstanding in those states for that week. For the sake of convenience, Weekly Insured Property Losses are referred to as insurance losses hereafter.

Estimation of insurance losses is a skill directly linked to the learning outcomes for the module in question. Insured property losses are easily quantifiable after that time period has elapsed, which makes them suitable for use in a prediction market. In this case, the insurance losses for the states in question were provided at the end of each time period by Xactware, a large international provider of data to the insurance industry. At a regional level, variations in insurance losses are influenced by phenomena such as hurricane activity, wildfires or sub-zero temperatures. These events are inherently unpredictable, meaning that learners were required to make decisions under conditions of uncertainty. However, this uncertainty is bounded. It occurred in a reasonably well-understood system. Only large scale environmental events are likely to affect insurance losses at a regional level. Data on such events is readily available. Hurricanes and similar environmental events are covered by national and international news organisations, depending upon the scale of the event. However, acquiring such information requires learners to engage in information search. While a hurricane in the Caribbean will certainly make the news channels in Florida, and probably the United States, it would be unlikely to receive widespread coverage in Europe except in the case of an extremely violent event.

These questions were operationalised by offering relevant contracts. Each contract consisted of a question, in the form of “What will insurance losses be in [State] for the week ending [End Period]”. In this format, [State] took the value of either New York, Florida or California, while [End Period] were assigned to the end date of the week

being considered. Each week, three questions were posed, corresponding to the three states being considered by participants. These questions were

- What will insurance losses be in California for the period ending 09/10/11
- What will insurance losses be in Florida for the period ending 09/10/11
- What will insurance losses be in New York for the period ending 09/10/11

Each question had 10 answers associated with it. These options were mutually exclusive. An example of the answers associated with the questions would be

- ≤ 8 million
- > 8 million and ≤ 9 million
- > 9 million and ≤ 10 million
- > 10 million and ≤ 11 million
- > 11 million and ≤ 12 million
- > 12 million and ≤ 13 million
- > 13 million and ≤ 14 million
- > 14 million and ≤ 15 million
- > 15 million and ≤ 16 million
- > 16 million

Only one of the options could be correct at the end of the week, when the actual insurance losses that occurred were provided by Xactware. All the options started with the same price of 10 virtual dollars. As students invested in an option, the price of that option rose, and the price of all other options fell.

At the end of the week, when the actual insurance losses were revealed, students received 100 virtual dollars for every share they had invested in the correct option, and

0 virtual dollars for every other share. This process was repeated for each of the three states being considered.

3.4.4. Incentive Design

The ILM contributed 17% of the total marks for the module, with 8% of the marks allocated for participation and 9% allocated for performance. This allocation of marks was in-line with the general allocation of marks for continuous assessments, and was sufficient to ensure students were motivated to participate. Marks were also allocated for participation, with 8% of the marks assigned for participation. Students received 0.8% of the total marks available for the module for each of the ten week they participated in the ILM. In order to gain participation marks for a week, ILM participants had to undertake at least one trade in each state. There was no upper limit on the number of trades they could make, and they could trade throughout the week.

The other 9% were allocated on the basis of performance in the ILM, meaning that 0.9% of the marks for the module were available to students each week. At the end of each week, the ILM was resolved, converting student's portfolios back to virtual cash. Student's performance was ranked in order from highest to lowest in terms of their virtual cash balance. It is important to note here that students' performance was measured relative to the rest of the class rather than in terms of absolute performance. Students whose virtual cash balance placed them in the top 20% of all students for that week received the full 0.9% of marks available for that week, with fewer marks being allocated to lower percentiles.

This assessment procedure had a number of benefits. By allocating marks just for participation, learners were given an incentive to participate in the market. At the same time, allocation of marks for performance encouraged careful decision making and

maintained the competitive element of the ILM, which is important in providing motivation. The incentive scheme used by the ILM is similar to that which would be used in an organisational setting, balancing the need to incentivise participation with the need to prompt truthful information revelation. Resetting students' virtual cash balance every week ensured that students had an incentive to participate to the best of their ability every week and avoided a situation where students who made poor decisions at the beginning would be subsequently disadvantaged for the entire term.

3.4.5. Audience Design

Having reached the decision to create a custom prediction market, a major decision to consider was the contextual location of the prediction market. The focus of this dissertation is investigating prediction markets as organisational decision making tools. As such, it is intuitively obvious that the first alternative that would be considered is creating a prediction market within an organisation. However, a number of factors ultimately lead to this alternative being considered unsuitable.

One major concern with any research project is negotiating the issue of access to data. In the social sciences, such access usually involves gaining permission of the relevant organisation(s) in order to be permitted to survey, test or observe stakeholders of the organisation. Organisations are often reluctant to grant access. Management may worry, for example, that employees will be diverted from their work by filling in questionnaires. In addition to the challenges traditionally associated with gaining access to an organisational setting, implementing a prediction market as required by this research programme has additional factors which may give an organisation pause when considering deploying a prediction market. It is generally accepted that in order to deploy prediction markets successfully, some sort of incentive must be offered. The

challenges this presents in an organisational setting have already been discussed. In addition, organisations are reluctant to engage in what is essentially exploratory research, particularly in the current economic climate. Prediction markets are still a relatively novel concept, and many organisations fear being used as “guinea-pigs” to investigate an unfamiliar decision making paradigm.

In addition to requiring more of a commitment from organisations, and thus having a higher bar for access, other factors in the organisational deployment of prediction markets also had to be considered. First, when deploying prediction markets in an organisation, it is almost axiomatic that the host organisation would determine the nature of the decisions being evaluated by the prediction market. Discussions with organisations led to organisations considering deploying prediction markets in problem domains such as project management or forecasting. Collaborating with organisations in these contexts certainly offers exciting research opportunities. However, from the perspective of this particular research question, they have a number of drawbacks. First, the researcher would have little or no knowledge or control of the information that drives changes in the market prices. Since information would be privately held, both from an individual and organisational perspective, there would be little chance of the researcher being able to link information events with trading behaviours in order to investigate the research questions being considered. Second, such problem domains generally have timeframes measured in months. As a consequence of this, gathering the data required to create a longitudinal analysis would take years. Increasing the duration of the data collection phase to a period this long would essentially make the entire project untenable.

Given the restrictions that would be placed on deploying a prediction market in a organisational environment, an alternative conception of the research plan, which

involved deploying a prediction market in an educational environment was conceived. In the initial stages of evaluating this alternative, the focus was on understanding how prediction markets could be integrated into a pedagogical environment. A review of the educational literature was undertaken, and plans were discussed with several experienced academics. Over the course of this investigation, it became apparent that prediction markets had the potential to be an innovative pedagogical tool in their own right. This insight evolved into one of the interesting outcomes of this research programme.

At the same time, the deployment of a prediction market in a pedagogical environment offered a flexibility that allowed for the design of a highly tailored prediction market. In particular, it was possible to design the market in such a way that the information events that affected the market could be quantified. The population of market participants could be well defined, and could be accessed for the testing which would be required to evaluate the effect of personality traits on prediction market participation and performance. It was possible to structure the incentives offered by the prediction market in terms of grades, reducing the financial resources required to manageable proportions in the context of a doctoral research programme, while at the same time providing a worthwhile incentive.

3.5. Data Collection

In the broadest sense, there were two main sources for the data that was collected to investigate the research questions posed. The first source was the prediction market itself. The prediction market is a software artefact, which records the trading decisions of participants. The second main source of data was a questionnaire designed to measure the behavioural traits of interest in this study. These data sets could be cross-referenced by providing participants with a unique identifier which they used when

participating in the prediction market and filling in the questionnaire. Both of these data sources are described in more detail in the following section.

3.5.1. Prediction Market Data Collection

Every time a participant interacts with the market, a record is stored in the backend database. Table 10 details the information that is stored for each such transaction.

Variable	Description
Date	The time and date of the transaction
Market	The specific market the trade relates to e.g. California, Florida or New York
Answer	The specific contract selected by the participant e.g. > 15 million and <= 16 million
User ID	The participants unique identifier
Operation	The type of the transaction, e.g. Buy, Sell or Expire
Num Units	The number of contracts bought or sold by the participant
Initial Price	The initial price of the contract
Result Price	The price of the contract after the transaction has occurred
Operation Cost	The total cost of the transaction in virtual currency

Table 10. Transaction Data collected by the Prediction Market

The market stored a record in the backend database of every time a participant interacted with the market. It captured a comprehensive data set of information on both participation and performance on each individual over a weekly period. For each week, all the transactions that occurred were stored in the database. The number of transactions which occurred are detailed in Table 11.

Week	No. Trades	No. Users	Mean Trade	Max Trades	Min Trades
1	14,209	371	35.2	697	1
2	12,089	374	29.4	324	1
3	12,775	375	44.2	918	1
4	11,023	387	25.0	402	1
5	11,718	371	24.3	325	1
6	11,214	375	19.8	318	1
7	8,680	333	18.5	338	1
8	13,054	368	36.3	628	1
9	9,998	364	29.53	781	1
10	10,498	385	26.8	523	1
Total	115,258				

Table 11. Weekly usage statistics for the ILM

In total 115,258 separate transactions by 401 distinct participants were recorded by the ILM over the 10 weeks of its operation. This raw transaction data was processed to calculate information which was used both in the operation of the ILM itself and also in investigating the research questions.

3.5.2. Behavioural Traits Data Collection

In order to capture data on the behavioural characteristics of individuals, standardised instruments which measure self monitoring and risk propensity were taken from the International Personality Item Pool (IPIP). The International Personality Item Pool (IPIP) was introduced by Lewis Goldberg (1999) and developed further in a number of papers (Goldberg 1999; Goldberg et al. 2006). The IPIP is intended as “*an international effort to develop and continually refine a set of personality inventories, whose items are in the public domain, and whose scales can be used for both scientific and commercial purposes.*” (International Personality Item Pool 2011). The IPIP is designed to have a number of desirable characteristics. First, it is designed to be a broad-bandwidth

instrument. This instrument contains metrics to measure a wide variety of personality traits (Goldberg 1999). Second, it is designed to be a public domain instrument, freely available for use to academics and other researchers. As a consequence of this openness, the IPIP is continually being updated and validated by research findings in a way that other instruments are not. Third, the IPIP is specifically designed to be customisable (Goldberg et al. 2006).

In order to measure the personality traits of interest in this study, a number of instruments were considered, for example the Minnesota Multiphasic Personality Inventory 2 and the California Personality Instrument. When compared to the Minnesota Multiphasic Personality Inventory – 2 (MMPI-2), the IPIP has a number of advantages which makes it more suitable for this study. First, the MMPI-2 does not measure the specific behavioural traits of interest in this study (Minnesota Multiphasic Personality Inventory - 2 2011). Second, the MMPI-2 is not in the public domain. With regards to the California Personality Inventory (CPI), another well known personality inventory, the IPIP also compares favourably. The CPI is not customisable by the researcher. The CPI is an exhaustive test, taking between 75 and 90 minutes to complete (California Personality Instrument 2011). Given that only a limited set of personality constructs were of interest in this study, the coverage offered by this instrument was counterproductive.

The IPIP has been extensively used in previous academic research. As of September 2011, 452 distinct peer-reviewed journal articles have been published which use the IPIP inventory (International Personality Item Pool 2011). A specific goal of the IPIP is to increase the validity of the instrument, through the use of comparative studies which are enabled by its open nature (Goldberg et al. 2006). The IPIP inventory has been

constantly improved since its introduction, and its validity has been confirmed in a number of studies (Dudley et al. 2005; Piedmont et al. 2000; J. Johnson 2005).

As well as the instruments measuring risk propensity and self-monitoring, an additional instrument measuring risk avoidance was also included in order to increase validity, since risk avoidance is an inverse behaviour of risk propensity. These instruments consist of a set of questions which respondents agree or disagree with using a Likert scale. These questions were combined randomly into a questionnaire. The questionnaire distributed can be seen in Appendix B.

One hundred questionnaires were distributed to a random sample of the participants. The collection of data from a sample of 100 students was directed by concerns regarding survey fatigue. As part of the relevant module, students were surveyed regarding a number of issues, primarily regarding teaching quality on the module. In response to the concerns raised by survey fatigue, 100 students were surveyed. This represented just under 25% of the population. In the context of the survey delivery, a relatively high response rate was guaranteed. Statistical tests normally require over 30 data points in order to allow the application of statistical methods (Field 2009). Since the data collection context virtually guaranteed this many response, the distribution of 100 surveys was enough to guarantee sufficient data to allow the analysis of the research questions (Field 2009).

Ninety four responses were received, of which 86 were found to be valid. The questionnaires were used to generate scores for self-monitoring, risk propensity and risk avoidance were calculated for all the respondents in the prediction market. This data was then cross referenced with the trading data captured by the prediction market itself.

No demographic data was captured in the surveys. The Research Ethics Committee directs the collection of as little personal data as it possible to conduct the research. Demographic breakdown in terms of gender or age was not specifically required to answer the research questions posed, so this data was not collected.

3.6. Research Quality Assurance

This section of the dissertation focuses on research quality. Particularly in the context of academic research, it is incumbent upon the researcher to endeavour to ensure the quality of the research. The cornerstone that enables high quality research is what Strauss and Corbin (1990, p.42) refer to as the “*theoretical sensitivity*” of the researcher. “*Theoretical sensitivity refers to a personal quality of the researcher. It indicates an awareness of the subtleties of meaning to data... [it] refers to the attribute of having insight, the ability to give meaning to data, the capacity to understand, and capacity to separate the pertinent from that which isn’t*”. Theoretical insight is an intellectual attribute of an individual. It can be developed through training, experience and intellectual exercise. Indeed, part of the benefit of engaging in a doctoral research process is that the researcher develops his or her theoretical sensitivity, enabling them to move on to conduct high quality research in contexts separate and distinct from the original subject of the doctorate.

As part of this doctoral programme, the researcher engaged in a number of practices to improve theoretical sensitivity, including: reviewing in-depth a number of the academic tomes on research methodology; attending multiple courses on research methodology in general and quantitative and qualitative research methods; consulting with experienced researchers in the university and beyond; and finally taking the time to reflect upon the research methods and processes that were used. These activities improved the theoretical sensitivity of the researcher. It enabled the design of a research process that

is informed by the demands of creating high quality research that generates conclusions that can be trusted and makes a genuine contribution to the state of the art in the discipline.

The following sections use the headings identified by Robson (2002) to discuss the quality of research. He states that high quality research should be replicable, reliable and valid. Each of these attributes of current research project is discussed in turn, with specific attention being paid to the steps taken by the researcher to ensure the quality of this research process. This discussion of quality is informed by recognition of McGrath (1981) concept of conflicting desiderata. *“All research evidence involves some population (here A for Actors) doing something (here, B for Behaviour) in some time/place/thing setting (here C, for context). It is always desirable to (ceteris paribus) to maximize (A) generalizability with respect to populations, (B) precision in control and measurement of variables related to the behaviour(s) of interest, and (C) existential realism, for the participants, of the context within which those behaviours are observed. But, alas, ceteris is never paribus, in the world of research”*. McGrath (1981) points out here that steps taken to improve the validity of research in one way inevitably reduce the validity of the research in others. The role of the researcher is not to seek an unobtainable standard of validity, but rather to carefully consider the alternative strategies available and select from them with a sensitivity borne of both the nature of the research process and a consideration for the wider implications of the research. With this in mind, where trades-offs have been made in the research process, the rationale for these trade-offs is explained and justified.

3.6.1. Replicability

The first attribute of high quality research is replicability (Bryman & E. Bell 2003). In the natural sciences, this usually implies that the research process can be replicated precisely, with the clear expectation that the same results are reached, and the same conclusions arrived at. Replicability in the social sciences tends to have a looser meaning. Much of social science research uses a realist or interpretivist epistemological perspective which recognises the central importance of context. In this paradigm, a research process and, therefore, the results obtained and the conclusions drawn cannot be definitively divided from the context. In this framework, replicability in the social sciences has come to mean that the research process can be repeated.

To this end, the researcher has extensively documented the entire research process and data collection methods used in the research project, particularly in section 3.4. The context of the research project is clearly described. Functional issues such as what the decision scenarios were used are described clearly and unambiguously. A description is offered on how the prediction market was integrated into the pedagogical context. Virtually all the resources that were used to run this project are publicly available. The prediction market software was provided by a third party called QMarkets. The tools used to measure behavioural traits are taken from the International Personality Item Pool (IPIP), a source of freely available standardised psychometric instruments. Where other variables are used, such as performance or participation, their derivation is clearly explained. The only exception to this is the data used to resolve the prediction market at the end of the week. This information was provided by Xactware as part of an arrangement with the University of Limerick, and normally has to be purchased. In

summary, all reasonable steps have been taken to ensure that this research project is replicable in whole by other researchers.

3.6.2. Reliability

In the context of high quality research, reliability is “*the consistency or stability of a measure; for example, if it were to be repeated, would the same result be obtained?*” (Robson 2002, p.93). Reliability is closely linked to replicability. Reliability is a major concern in quantitative research, although it is also importance in qualitative research. The epistemological position of the researcher will impact upon the weighting assigned to reliability. A positivist conceives of a fundamental, underlying reality which can be measured. In this paradigm, research aims to uncover that fundamental reality and research methods aim to measure that underlying reality. A high quality research instrument should be able to measure that reality reliably. In contrast, an interpretivist believes that reality is a social construct, constantly in flux. The reliability of an instrument is less of a concern here, since absolute reliability is fundamentally unobtainable. In the interpretivist paradigm, no instrument can be completely reliable, since reality itself is constantly changing and is specific to a particular observer at a particular time and place.

Philosophical and epistemological considerations aside, reliability is nonetheless an attribute pursued by researchers. Bryman and Bell (2003) identify three factors which affect the reliability of research, namely stability, internal validity and external validity. It is important to note here that the terms internal validity and external validity have different emphasis in the context of reliability. This dissertation follows the conventions and terminology used by Bryman and Bell (2003). Internal validity and external validity, as they refer to more general validity concerns, are discussed in section 3.6.3.

Stability refers to the constancy of a metric over time (Robson 2002). A reliable metric should not vary over time. For example, an intelligence test administered on Wednesday to an individual should return the same results as an intelligence test administered on Tuesday. A second key criterion when considered reliability is internal validity (Bryman & E. Bell 2003). Internal validity is usually discussed in the context of multiple indicator measures. For example, a questionnaire may have several multiple choice scalar questions designed to capture the risk propensity of an individual. The scores from the individual questions are aggregated in order to measure the risk propensity of an individual. If the measure has internal validity, then a high score in one question should be reflected in high scores in the related questions. Finally, external validity, the third criterion used to discuss validity, is concerned with how much subjectivity exists in the testing instrument. For example, answers to an open ended question are often divided into categories by researchers. This implies that the researcher chooses which category a particular answer is assigned to. This introduces an element of subjectivity into the research process.

Robson (2002) describes four main threats to reliability. Participant error is when a respondent's answers fluctuate widely from time to time due to factors which occur on a more or less random basis (Robson 2002). For example, a respondent's emotional state is constantly changing in response to positive and negative external events. A construct designed to measure the emotional state of an individual will not return a consistent measurement, because the individuals underlying emotional state is always changing. Participant bias is caused by a conscious or subconscious desire of a participant to skew the outcome of the research. For example, an individual may see themselves as an extrovert. When asked to complete a questionnaire such as a Myer-Briggs test which measures extroverism, they may answer the questions in a manner that will lead to them

being classified as extroverts. Related to participant error is observer error. This is when the actions of the observer affect the measurement being taken. For example, a teacher who grades students when they are tired may assign lower grades than a teacher who assigns grades when they are alert. Finally, observer bias occurs when the observer has a conscious or subconscious bias towards a particular outcome. The observer may ask questions in a particular tone of voice, phrase questions in a certain way, or engage in any of myriad of behavioural patterns which skew the data being collected.

In order to increase the reliability of their data and conclusions, diligent researchers will work to remove or reduce these biases. The specific actions that should be taken are dependent upon the research strategy and methods being used. Specific actions taken in the context of this project are discussed below.

In this research project, it is possible to identify three main sources of data. These are, in turn, the questionnaires which were used to gather information on the behavioural traits of individuals, the trading data generated by the operation of the prediction market, and the data on environmental events which should impact upon the outcome of the prediction market. The data collected from the operation of the prediction market was aggregated to create measures of performance and participation. In the following section, each of these data sources is evaluated in terms of the attributes of stability, internal validity and external validity.

Turning first to the data collected on behavioural traits, collecting information such as this is traditionally a difficult task. Gathering reliable information on a tacit characteristic such as risk propensity is a notoriously challenging task for the most experienced and diligent researcher. However, for the purposes of this research, the creation of an instrument to gather this data was deemed to be beyond the scope of the

research project. Instead, standardised instruments for measuring risk propensity and self monitoring were utilised. These were sourced from the International Personality Item Pool (IPIP). As such the researcher takes the position that the stability, internal validity and external validity of this instrument is assured by IPIP. This is not to suggest in any way that these instruments are beyond controversy or reproach. It is intuitively obvious that all research instruments and metrics are subject to continual scrutiny and revision. However, it is not the purpose of this research project to engage in such activities, and so the reliability of the research instruments taken from IPIP are taken as a given.

The second major source used in this research was the data collected by the prediction market itself. In general, this consists of a chronologically ordered list of trades made on the market. Each trade consisted of the username of the trader, the date and time of the trade, the value of the trade in virtual currency, the number of contracts transferred in the transaction, and the market price that resulted from the trade. As such, this information is factual in nature.

This raw data was in turn used to create two metrics that were of interest. The first variable was participation, and the second was performance. Participation for a particular week was calculated as the number of trades that an individual participant made for that week. The stability of this variable can be considered from two perspectives. Within a particular week, the stability of this variable is essentially infinite, barring errors in the summing of the number of trades that occurred. On the other hand, it would be expected that the stability of this variable would change as this is a longitudinal study that seeks to discover change in the variables of interest over time. The internal validity of this variable is high, since it is a single value used to measure the construct of interest. The external validity of the instrument is also high.

The data used to generate the measurement of participation is factual in nature, and is transformed by a standard mathematical operation. As such, there is little scope for subjectivity to interfere with the creation of this variable.

The second variable generated from the raw prediction market data was performance. The performance of an individual participant in a given week is the value of their portfolio after the market has been resolved. For the purposes of this discussion, it is sufficient to note that market resolution is a mathematical operation performed on the trades that occurred in that week. It shares the characteristics of participation in terms of reliability. The stability of the variable is high within a week, but is expected to vary across weeks. The internal validity is high, since it is a unitary measurement. The external validity is also high, since the operations used to create it are essentially objective in nature.

In order to identify changes in trading behaviour caused by traders responding to information, it was necessary to identify events which should cause said changes. In this study, two types of events can be identified. The first is the release of historical information by the market sponsor. These are the previous weeks' insurance losses in a particular state. Again, this is essentially factual information, which was released at the same time every week. The other type of event is a major environmental event, which would be of sufficient magnitude to influence behaviour on the market. For the purposes of identifying such events, events were selected which severe enough to be reported nationally by two of major news networks in the U.S. This was to ensure that learners could be expected to have found out about these events given a reasonable level of search. The two news networks chosen were CNN and ABC, because of their national and international coverage. Since these events are essentially unique, the stability of this metric is of little concern. The technique used to select these events

remained consistent over the duration of the prediction market, increasing the stability of the variable. The internal validity was enhanced by only selecting events which were reported on both news networks. The external validity of this variable is open to question. Essentially the severity of the events was gauged by whether or not they were reported by the news networks in question. Whether or not any event is reported on a news network is of course a subjective decision, influenced by a myriad of factors, including the perceptions of reporters, editors and other individuals involved in the selection of stories and also the amount of “news” on a particular day. This subjectivity was reduced by only selecting events which were of sufficient magnitude to be reported by two separate international news organisations.

3.6.3. Validity

One of the major determinants of high quality research is the validity of the research. Validity is “*concerned with whether the findings are really about what they appear to be about*” (Saunders et al. 2003, p.101). Bryman and Bell (2003) assert that validity is in many ways the most important criteria for evaluating the trustworthiness of research. They state it is “*concerned with the integrity of the conclusions that are generated from a piece of research*” (Bryman & E. Bell 2003, p.33). When considering validity it is important to note that different textbooks often refer to the same concepts using different terms. For example, Bryman and Bell (2003) refer to external validity, which Saunders et al (2003) and Robson (2002) label as generalizability. For the sake of convenience in this dissertation the threats to validity are discussed using the terminology offered by Bryman and Bell (2003), noting where relevant alternative terminology used by other authors. Bryman and Bell (2003) identify four main types of validity, namely measurement validity; internal validity; external validity and ecological

validity. In this context, measurement validity is concerned with establishing that the variables used in the study accurately measure the phenomenon of interest. Internal validity is primarily concerned with the trustworthiness of casual relationships established in the research process. External validity determines how far beyond the specific research context the conclusions drawn from the research can be extended. The level of realism in the research context is the concern of ecological validity. The steps taken by the researcher to enhance the validity of this research project are discussed below.

Measurement validity, often referred to as construct validity, is “...*the questions of whether a measure that is devised of a concept really does reflect the concept that it is supposed to be denoting*” (Bryman & E. Bell 2003, p.33). A commonly used example is that of IQ tests. Concerns regarding the measurement validity of such instruments can be demonstrated by posing the following question. Does an IQ test really measure inherent variations in intelligence? If an individual’s results in an IQ test are affected by factors such as the individual’s educational background or their familiarity with IQ tests and IQ testing procedures, then the measurement validity of an IQ test is diminished. Its measurement of the underlying variable of interest is being clouded by other variables and factors.

Measurement validity is related to reliability. Reliability is a necessary condition of measurement validity, but is not sufficient. It is perfectly possible to have a reliable instrument that does not measure the underlying construct of interest. For example, it is possible to create a reliable measurement of speed. However, such a metric is not a valid measurement of a construct such as dangerous driving, since it is perfectly possible for fast drivers to be safe and slow drivers to be dangerous.

There is no single approach to quantifying or enhancing measurement validity. Two common approaches exist. The first is to evaluate the face validity of the instrument. This equates to applying common sense to analyse whether there is a rational, logical reason for believing the instrument measures the variable in question. A second approach is to compare the results of the instrument measuring the variable in question with a third, external measurement of that variable. For example, an IQ test may be validated by comparing the IQ measurements derived from the test with results in exams. This approach examines the predictive criterion validity of the measurement. Neither of these approaches offers an infallible approach to guaranteeing measurement validity.

The variables in this study can be evaluated in terms of their measurement validity, namely the measurements of behavioural traits, the measurements of participation and the measurement of performance. The behavioural traits are measured using a pre-existing standardised instrument. As before, the measurement of concepts such as risk propensity and self-monitoring is an inherently challenging task. This research is happy to use the standardised instruments provided by the IPIP (Goldberg 1999).

Participation is measured in this study by counting the number of trades undertaken by a participant. At one level, this metric is a quantifiable measurement of the number of trades undertaken on the market, and as such has reasonable measurement validity. At another level, this dissertation recognises that such a metric may be an imperfect measurement of an individual's engagement with the prediction market. It is possible to argue that an individual may engage in a large amount of research and investigation, but only make one or two trades on the market. In order to account for this possibility, the researcher would have to engage in a time consuming and intrusive observation of the behaviour of all the individual participants. Given the number of participants involved,

the duration of the prediction market and the ethical concerns that would be raised by such a programme of observation, such a data collection programme is impractical. An alternative approach would be to ask participants to monitor their own behaviour and self report. However, such an approach would be at least as open to criticisms regarding its measurement validity as the approach taken.

Performance is measured by the value of the participant's portfolio after resolution of the market. An evaluation of the measurement validity of this metric proceeds in a similar manner to the evaluation of the participation metric. At one level of analysis, the amount of virtual cash in a participant's portfolio after resolution of the market reflects a quantitative measurement of the participant's success or failure interacting with the market. At a more abstract level, it can be argued that this metric does not capture a participant's ability to make decisions, which is the underlying construct of interest. A participant may be highly skilled at making decisions, but not be comfortable using the prediction market, or may be highly skilled at reaching the correct conclusions regarding the decision scenario, but simply be too lazy to indicate their opinion. Again, it is possible to conceive of alternative data collection approaches which would capture the underlying construct using intensive observation or self-reporting. As before however, the practical and methodological issues with such data collection methods militate against them and mean that the approach used is as valid a measurement as is possible given the constraints of the project.

Internal validity is primarily concerned with causation. *“Internal validity is concerned with the question of whether a conclusion that incorporates a causal relationship between two or more variables holds water. If we suggest that x causes y, can we be sure that it is x that is responsible for variation in y and not something else that is producing an apparent casual relationship?”* (Bryman & E. Bell 2003, p.34). Ensuring

internal validity requires that the researcher can accurately distinguish between correlation and causation. Leaving aside issues of reliability and measurement validity, it is usually possible to establish correlation to a degree of error using statistical tools. However, correlation does not imply causation.

Two macro level strategies can be deployed to reduce threats to internal validity (Robson 2002). If the threat to internal validity is known, then the researcher can design the research strategy and choose research methods in such a way as to reduce the threats in internal validity. Alternatively, the researcher can use randomisation in the selection of samples. This approach is a central tenant of the design of true experiments. However, while randomisation can minimise the threats to internal validity, it is not guaranteed to remove them entirely.

This research process attempts to establish a number of casual relationships between variables. In particular, it is possible to identify two taxonomies of relationships. First, the research aims to investigate the relationships that exist between the occurrences of information events such as hurricanes and the trading behaviour of participants in the prediction market. Second, the research investigates the relationships that may exist between behavioural traits of individuals and their behaviour in the prediction market.

In establishing a casual relationship between external events and behaviours observed in the prediction market, it is impossible to establish a casual relationship beyond all possible dispute. The external events being studied are for all intents and purposes completely independent of both the prediction market and the researcher. An example of such an event would be a hurricane in the Caribbean. Because the researcher cannot affect these events, they cannot be controlled for. It is intuitively obvious that such an event will impact upon insurance losses in Florida on the week of its occurrence.

However, the independence of these events also serves to strengthen the case for believing in the existence of a casual relationship. Since it is obvious that a hurricane will affect the insurance losses in Florida, it is reasonable to suggest that traders will change their trading behaviour in response to it. Conversely, while it may be impossible to prove empirically, it seems unlikely that the trading behaviour of a group of students in Limerick can cause a hurricane in the Caribbean. Similarly, it seems unlikely that another, unknown variable causes both a hurricane and a change in the trading behaviour in the participants in the prediction market. While it is impossible to prove definitively, the balance of probabilities would suggest that where a correlation between an independent external event and a trading pattern can be established, the casual relationship would be that the external event causes the change in trading behaviours.

The other type of casual relationships that this research investigates is those that are hypothesised to exist between behavioural traits and trading behaviours such as participation and performance. The nature of the casual relationship hypothesised here is again obvious, with the suggestion being that trading behaviours are caused by behavioural traits possessed by the individuals in question. In general, behavioural traits are seen as being the relatively fixed, long lasting patterns of behaviour of an individual. As such, a logical analysis of the relationship would suggest that it is unlikely that the number of times an individual trades on a prediction market affects their risk propensity. This logic extends to the other trait/behaviour pairs investigated in the course of this research. However, in this case, it is far more difficult to discount the possibility that another, third variable is the root cause of the observation of a correlation. Behavioural traits are notoriously interrelated. It is entirely possible that other behavioural traits have a stronger explanatory effect on the changes in the observed variables than a casual relationship between the variables. In this context, it is

important to note that the behavioural traits measured were selected for the reasons explained in section 2.5.2. Strong theoretical reasons exist to suspect that a casual relationship exists between these variables. Numerous authors have suggested that risk propensity affects both performance and participation in prediction markets (Wolfers & Zitzewitz 2004; Tziralis & Tatsiopoulos 2007).

External validity is very commonly referred to in the literature as generalisability, and authors agree that the terms can be used interchangeably (Robson 2002). External validity *“is concerned with the question of whether the results of a study can be generalised beyond the specific research context”* (Bryman & E. Bell 2003, p.34). In some cases generalisability may not be a pressing concern of the researcher. The research may be focussed on discovering information about a particular context. Alternatively, the researcher may be engaged in exploratory research. They may be looking to establish the existence of relationships in a context, with a view to demonstrating the generalisability of such relationships in later work.

In quantitative work, the most common approach to improving external validity is to use a representative sample of the population of interest. Given a large enough sample, statistical methods allow conclusions to be drawn regarding the population as whole, within a specific degree of error. Once the sample used in the research is representative, random and significant, then inferences can be drawn. If it is not possible to use representative sampling, two general approaches can be identified (Robson 2002). First, direct demonstration can be used. This is when a researcher investigates a relationship observed in a specific context by directly testing it in a different context, proving or disproving the existence of that relationship in the new context. Alternatively, the researcher may make a case, providing rational and logical arguments as to why the relationship discovered in the research should be generalisable.

This research aims to investigate the effect of prediction market participation on individuals in organisations, and the effect of the behavioural traits of individuals on their performance and participation in the prediction market. As such, the framing of the research question identifies the population that is being investigated. It is the group of people who interact with prediction markets in their workplace. Since the sample used in this study is a group of students, at first glance, it is not representative of the sample of interest. In particular, the age profile of the sample differs significantly from the population of interest. However, the sample selected does share many of the characteristics of the population of interest. Once the selection attributes that are predetermined by the selection method used, such as age and educational qualifications are ignored, the sample is essentially random. In particular, there is no reason to assume that the selection method used means that the proportion of people with a high or low risk propensity will differ from the population as a whole. A similar argument holds for the self-monitoring behavioural trait, although of course it is possible that the sample does in fact differ from the population in some significant way. Since these personality traits are a particular focus of the research project, if their prevalence in the sample does not differ from the population as a whole, then the findings of the research do retain a degree of external validity. This can be contrasted with an alternative formulation of the research strategy, which would be to use public prediction markets. Participants in public access prediction markets are generally assumed to be attracted in part by the utility of the thrill of taking risks. It is reasonable to assume that a sample selected from the population of participants in public prediction markets would be significantly different from the population of individuals who are participating in a prediction market because it formed part of their work duties. While the generalisability of this study is limited by the sample selected, it is reasonable to suggest that the sample has enough of

the characteristics of the population of interest to retain a degree of external validity sufficient to meet the requirements of the research project.

The final criterion identified by Bryman and Bell (2003) is ecological validity. “*This is the question of whether social scientific findings are applicable to people’s every day natural social settings*” (Bryman & E. Bell 2003, p.34). Ecological validity is viewed as being related to external validity, but recognises that research findings are artefacts of the data collection and analytic tools used by social scientists. If such tools produce a large enough divergence, then the results collected by research may not accurately measure the phenomenon in question in the real world. This is a criticism often levelled at experimental work, where the accoutrements of experimental design strip out so much of the variation inherent in realistic situations that the results gathered are of little use in understanding relationships and behaviours in a realistic, social context.

Ecological validity is determined by the realism of data collection environment. For example, while laboratory experiments run in experimental economics create a highly regulated environment which allows for the capture and control of unique variables of interest, many researchers question the applicability of the findings generated by such research programmes. A laboratory based setting is obviously so different from the real-world environment, that the findings become little more than artefacts of the data collection and analysis methods.

There is a strong thread of experimental work on prediction market in the literature, and it undoubtedly makes a very valuable contribution to our understanding of the mechanics and operation of prediction markets. However, this research from the outset has always been focused on maintaining ecological validity. For example, testing for the effect of information revelation in a laboratory setting is a conceptually simple process

which has been performed many times in the past. In order to combat this limitation of existing research, there have been calls in the literature to study prediction markets in more realistic settings. *“There should be less emphasis on documenting successes in predicting future events and more study of how conditions far removed from a lab setting might affect the functioning of prediction markets”* (Gruca et al. 2005, p.22). This research answers that call by investigating prediction market operation in a more realistic setting. In the realistic context presented in this research, factors like fatigue and inattention will come into play. Individuals will not be presented with information in a standardised format. Instead, they will have to search out qualitative information such as news reports and integrate it into their decision making. Such an approach unavoidably reduces the control the researcher has over the variables being studied. However, the trade-off is that the context gives a better insight into how individuals behave in the real world. While an individual may use information that is actively presented to them in a laboratory experiment, the question addressed by this research project is: will an individual actively search out information in a realistic context.

Consequently, there are a number of aspects of the research programme which were explicitly designed to heighten the ecological validity of the research. First, the basic structure was designed in order to mimic the situation that is likely to be found in an organisational setting. While the assignment of grades replaced the provision of financial rewards, the basic pattern of the incentive scheme used is certainly applicable in an organisational context. Some incentives are awarded for participation, while some are awarded for performance. Second, the decisions scenarios selected are real-time, real-world problems, which are linked to the student’s module. This corresponds to the situation which would exist in an organisation, where individuals are asked to make decisions about their organisation. Third, participants have imperfect knowledge of the

decision space. Second year students studying in Limerick are unlikely to have in-depth knowledge of how to calculate the likely insurance losses in Florida. Similarly, in an organisational setting, an individual working in the accounting department is unlikely to have in-depth knowledge of likely product sales for the next quarter. However, the whole rationale beyond prediction markets is that the group as a whole should have the required knowledge. Fourth, the decision scenarios will be affected in real-time by chaotic and unpredictable effects. This is similar to the situation that will hold in business organisations, where decisions are constantly being reconsidered in the light of changing economic conditions, competitors' actions, and in the light of the limitations identified by bounded rationality.

In summary, the ILM was designed in such a way as to closely mimic the operation of a prediction market in an organisation. It operates in real-time, over a long period of time and offers individuals a tangible benefit. This means that the data that is collected is gathered in a reasonably realistic environment, and that the ILM has a relatively high level of ecological validity.

3.7. Conclusion

This section has presented a description of the research design used to address the research questions identified in section 2.5. The process can be viewed as a series of interlocking decisions, where each decision affects, and is affected by every other decision made by the researcher. Considerations such as the epistemological and ontological position of the researcher, research ethics and the access available all determine the shape of the research strategy.

The nature of the research questions posed and the epistemological position taken by the researcher in this study mandated the use of a longitudinal study as the macro level

research strategy. Following on from this, the specifics of data collection was presented in detail. This analysis is presented in the following chapter.

4. Analysis and Results

4.1. Introduction

This chapter presents the data collected in answering the research questions which were identified and discussed in detail in section 2.5. Two general focus research questions emerged from the literature. First, the effect prediction market participation has on individuals needs to be explored. Second, the literature on prediction markets commonly raises questions as to the effect individual behavioural traits have on prediction market participation and performance.

The first general focus research question was subsequently refined into three specific research questions. First, does prediction market participation have a positive effect on individual's decision making? Second, do prediction market participants factor newly revealed information into their decision making processes? Third, do prediction market participants actively search out information pertinent to the decision spaces being considered by the prediction market? All of these questions revolve around how participating in a prediction market affects the behaviour of an individual. Analysis of these question is presented in section 4.3.1

The investigation of the second research question was operationalised by identifying personality traits from the literature and evaluating whether these traits affect prediction market participation and performance. Two traits were selected, risk propensity and self monitoring. This in turn led to the formulation of four specific research questions, namely:

- How does an individual's self monitoring affect performance in a prediction market?
- How does an individual's self monitoring affect participation in a prediction market?
- How does an individual's risk propensity affect performance in a prediction market?
- How does an individual's risk propensity affect participation in a prediction market?

These issues are investigated in section 4.3.2. Analysis and conclusions are presented in section 4.4. Section 4.5 concludes the chapter.

4.2. Population Sample Profile

The specific class chosen as the population for this study was a 2nd year undergraduate class in Risk Management at the University of Limerick. A total of 403 students took this module. There were 193 male students representing 47.8% of the population, while 210 of the students were female, representing 52.2% of the population. Research ethics guidelines in the University of Limerick specify that only the minimum amount of personal data required for the research purpose be captured, so no further demographic data was collected. Anecdotally, the vast majority of the population would have been between 18 and 20 years old. Most of the population would have completed the Irish Leaving Certificate, and have no further educational qualifications.

In order to validate the reliability of the instruments used to capture data on participants self-monitoring, risk propensity and risk avoidance, a Cronbach's alpha test was carried out (Cronbach 1951). Cronbach's alpha is a method of calculating the correlation coefficient of every possible split of the data in the questionnaire. Cronbach's alpha is

the “*most common measure of scale reliability*” (Field 2009, p.674). A value of 0.8 is generally accepted as a guideline point for cognitive tests such as intelligence tests (Field 2009). For psychological constructs, the focus of this research, values above 0.6 can be reasonably accepted because of their diversity (Kline 2000).

The item statistics and reliability statistics for the self-monitoring are shown in Table 12 and Table 13 respectively. They show a Cronbach’s alpha of .74, indicating that the instrument used to collect data on self-monitoring was reliable.

	Mean	Std. Deviation	N
Use Flattery To Get Ahead	2.94	1.148	88
Would Not Be A Good Comedian (Pos)	3.02	1.295	88
Would make a good actor	2.89	1.368	88
Am likely to show off if I get the chance	2.77	1.257	88
Like to attract attention	2.83	1.116	88
Am good at making impromptu speeches	2.35	1.296	88
Don't like to draw attention to myself (Pos)	2.80	1.166	88
Put on a show to impress people	2.75	1.064	88
Am the life of the party	3.07	1.059	88
Hate Being the Center of Attention (Po)	3.03	1.033	88

Table 12. Item Statistics for Self-Monitoring

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.737	.750	10

Table 13. Reliability Statistics for Self-Monitoring

The item statistics and reliability statistics for risk propensity are shown in Table 14 and Table 15 respectively. They show a Cronbach’s alpha of .68, which is well within the guidelines.

Item Statistics			
	Mean	Std. Deviation	N
Would never go hang gliding or bungee jumping	3.71	1.434	92
Avoid dangerous situations	3.12	1.036	92
Know how to get around the rules	3.46	.954	92
Stick to the rules	3.11	1.063	92
Seek danger	2.27	.962	92
Seek adventure	3.86	.921	92
Am willing to try anything once	4.02	.949	92
Enjoy being reckless	2.66	1.170	92
Take risks	3.66	.881	92
Would never make a high-risk investment	3.66	1.041	92

Table 14. Item Statistics for Risk Propensity

Reliability Statistics		
	Cronbach's Alpha	
	Based on	
	Standardized	
Cronbach's Alpha	Items	N of Items
.677	.692	10

Table 15. Reliability Statistics for Risk Propensity

The item statistics and reliability statistics for risk avoidance are shown in Table 16 and Table 17. They show a Cronbach's alpha of .69, similar to risk propensity and well within the guidelines for psychological constructs.

Item Statistics			
	Mean	Std. Deviation	N
Would never go hang gliding or bungee jumping	2.31	1.437	93
Avoid dangerous situations	2.89	1.037	93
Do Dangerous Things	3.18	1.073	93
Seek danger	3.73	.957	93
Seek adventure	2.15	.920	93
Do crazy things	2.71	1.069	93
Am willing to try anything once	1.98	.944	93
Enjoy being reckless	3.35	1.176	93
Take risks	2.34	.878	93
Would never make a high risk investment	2.34	1.037	93

Table 16. Item Statistics for Risk Avoidance

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.687	.698	10

Table 17. Reliability Statistics for Risk Avoidanc

4.3. Data Analysis

This section presents the analysis of the data collected in order to answer the research questions.

4.3.1. Effects on Participating Individuals

In section 2.5.3 it was suggested prediction market participation had three effects on the cognitive domain of learning. First, participant's decision making skills in the problem domain being considered will improve. Second, participants will incorporate newly revealed information into their decision making. Finally, participants will actively search out relevant information.

In this context, it is important to note that the group participating in the prediction market remained constant throughout the execution of the market. The variances in decision making observed over the course of the study cannot be due to variation in background or ability, since the population is essentially invariant throughout the case study.

The first research objective is to explore the effect prediction market participation had on learner's decision making skills. Figure 6 plots the weekly average portfolio value of all learners. There are two observable trends in this graph. The first major trend is that the average portfolio value drops from week 2 to week 7. This drop in average portfolio value is explained by the policy of gradually increasing the difficulty of the problem for

the first 5 weeks through the mechanism of narrowing the loss bands described in section 3.4.1. As the problem difficulty increases the average portfolio value drops as would be expected.

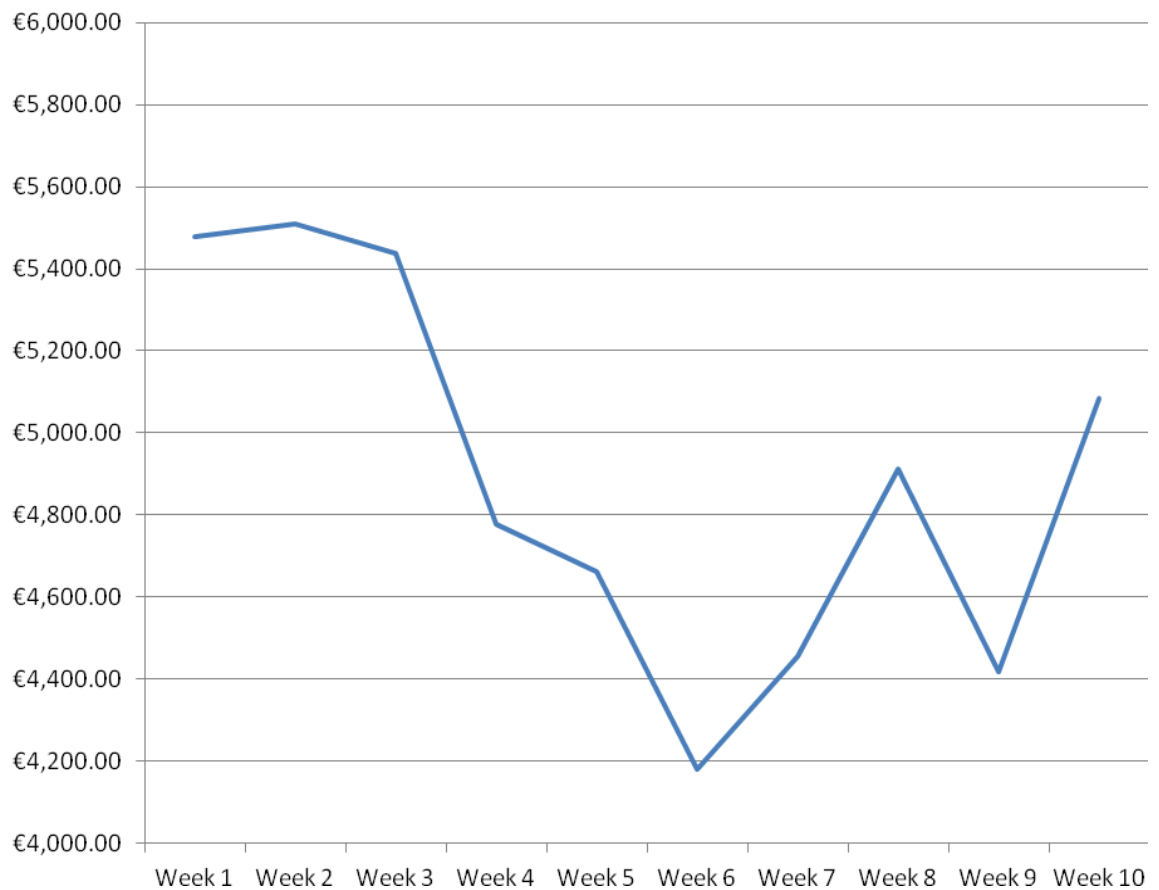


Figure 6. Average Portfolio Value after Each Week.

In week 6 the problem bands were stabilised and did not change subsequently throughout the term. From week 7 onwards, the general trend in the average portfolio value is upwards. This trend suggests improved decision making performance.

While this demonstrates that decision making improved over the module, the nature of a prediction market means that improvements in performance could be driven by a subset of the market participants who excelled at the ILM, driving up the average portfolio value. In Table 18, learners are first ranked by marks over the entire term. This ranked

list is then divided into five separate percentiles. The row “0-20 Percentile” represents the top 20% of students ranked by performance, and so on. For each percentile created, the average portfolio value for all the learners in that percentile is calculated for each week.

Percentile	Week 1	Week 2	Week 3	Week4	Week 5	Week 6	Week 7	Week8	Week 9	Week 10
0 - 20	9135	8612	10596	12141	12761	10242	9695	9772	9720	9704
20 - 40	6020	5706	5525	5486	4955	4743	5112	5350	4768	5436
40 - 60	5182	5245	4766	3958	3569	3638	4066	4559	3905	4625
60 - 80	4549	4874	4022	2162	3569	2174	2801	3543	2790	3723
80-100	2586	3129	2240	250	434	338	744	1576	1185	2112

Table 18. Average Portfolio Value by Percentile

Two trends emerge here. In all the percentiles except the highest, the pattern observed in Figure 6 is replicated. The average portfolio value declines until week 6 and then begins to rise. This is an indication that once the problem difficulty stabilised, learners decision making began to improve over time, regardless of their decision making skill in the ILM vis-à-vis their peers.

The average portfolio value of the top 20% of performers has a different trend. Performance peaks during week 6 and then gradually declines. One property of a prediction market using an automated market marker is that the possible loss to the market sponsor is limited. This means that a prediction market is a zero sum game across all the participants. The rise in average portfolio value for the top percentile of students early in the ILM is an indication that there was an appreciable gap in the decision making of the stronger students earlier in the module. However, as the ILM continued, the weaker student’s decision making began to improve. This reduced the advantage the stronger students had and, therefore, reduced their average portfolio value.

A participant holds a position in the ILM if they hold at least one stock in a particular loss band when the market closes. In Table 19, the average number of positions held by all students across the three states in the ILM is shown. As the loss bands available to select from grow tighter, a rational decision maker will engage in risk diversification and hold more positions, weighting their investment according to their assessment of the probability of the event occurring. Risk diversification is a risk management strategy, which aims to reduce the overall risk associated with a portfolio through investing in several different contracts. In the case of the ILM, a learner engages in risk diversification by investing in a number of different loss bands, rather than just investing in the one outcome that the learner thinks is most likely to occur.

Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10
3.72	3.37	3.84	3.96	4.5	4.8	5.1	5.75	5.44	5.22

Table 19. Average Number of Positions Held

As shown in Table 18, an overall increase in risk diversification over time was observed. This was an indication of improved decision making for two reasons. First, it indicates increasingly rational behaviour amongst traders. Second, risk diversification is a key theoretical concept that is explored in the module under consideration. The application of risk diversification is an indication that learners are taking theoretical concepts from the learning experience and utilising them in their decision making process. The improvement pointed to in this data is arguably of limited generalizability. It can be seen as an improvement in participant's ability to interact with a prediction market rather than a more fundamental improvement in decision making in the underlying problem domain. However, this trend does demonstrate an appreciable difference in the decision making behaviours of individuals over time. As such, it can be seen as further

evidence to support the contention that the decision making processes of participants evolve and improve through exposure to a prediction market.

The second objective of this project was to search for evidence in participants trading behaviours that indicates they are reacting to newly revealed information. To investigate this, a suitable information event was identified. Every Thursday, data regarding losses in the three states in the previous week was released to students. It was anticipated that recent historical data such as this should impact upon student's decision making.

Figure 7 shows the average number of trades per day, broken down by state. Data for week 1 of the operation of the ILM is not included in this analysis. This was the week that the ILM was introduced to students. As a result, trading patterns were extremely atypical in this week, with enormous amounts of trading occurring immediately after the lectures introducing the ILM to students. In all three states, the trading behaviour is broadly consistent. The most active trading day is Monday, with the average number of trades per day declining as the week progresses. However, a noticeable increase in the number of trades can be observed on Thursday, particularly in California and New York. This indicates increased trading activity on a Thursday, which is consistent with the behaviour that would be expected if learners were re-evaluating their decisions based on new information, in this case the disclosure of the previous week's losses.

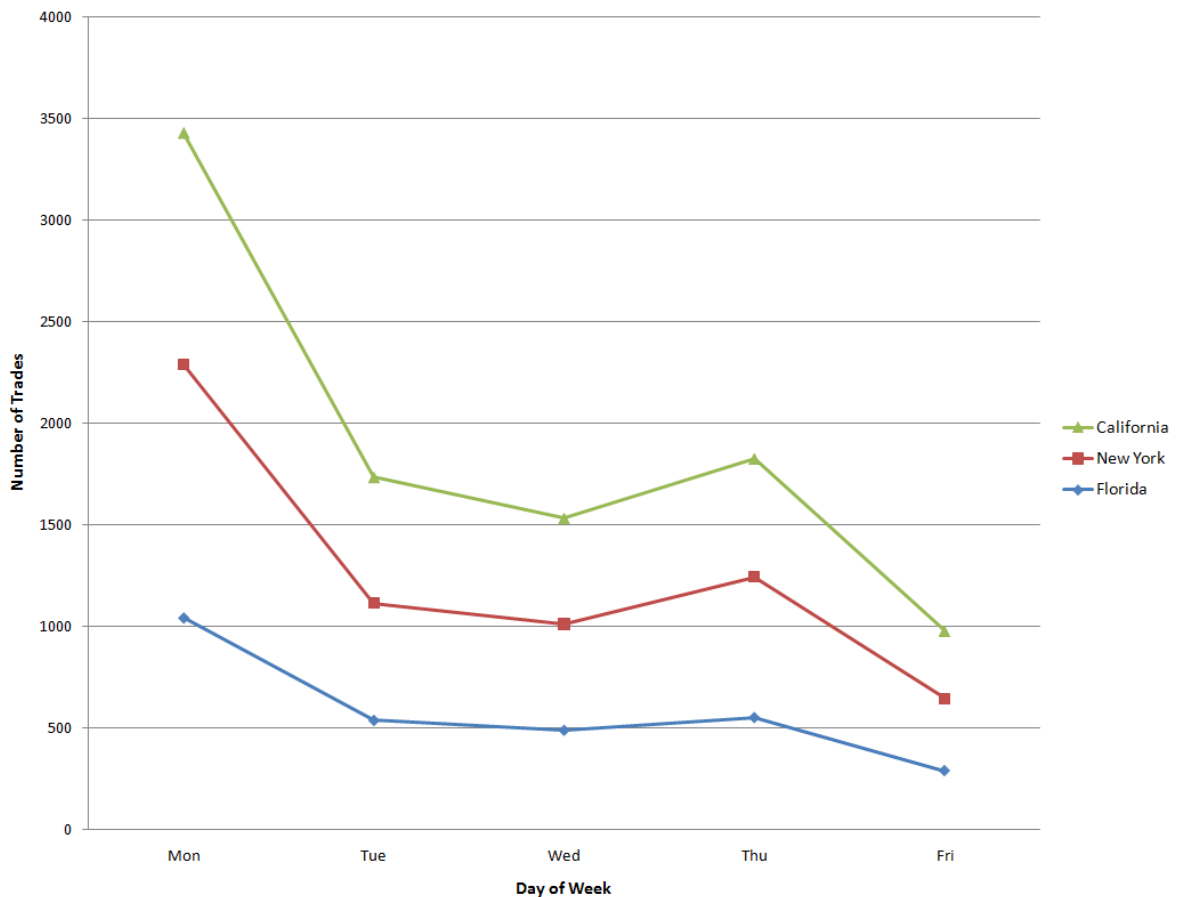


Figure 7. Trading Volume by Day

The final objective of this section is to search for evidence to suggest that students are actively searching for relevant information to inform their decision making. To probe this question, events that had the following properties were identified. First, the event should be reasonably expected to impact upon the ILM. Second, the event should not have been revealed to students through traditional academic channels. In effect, it should be an event that learners would have had to actively search out and discover.

Events which fit these criteria are weather events which could be reasonably expected to affect insurance losses in the three states under consideration. For the purposes of identifying such events, environmental events severe enough to be reported nationally by two of the major news networks in the US were selected. This criterion was used in

order to ensure that learners could be expected to have found out about these events given a reasonable level of search. The two news networks chosen were CNN and ABC.

Two specific events occurred which met our criteria over the time period in question. The first event was a major storm which occurred in California on the 13th and 14th of October. The storm threatened to cause major flooding and land-slides in California, as reported by both CNN and ABC. The second major event was the formation of Hurricane IDA. The formal classification of Hurricane IDA was announced by the National Hurricane Center on the 4th of November and was reported by both CNN and ABC. Appendix C gives a list of the significant environmental events which occurred during this time period.

The evidence used to assess participants response to these events is shown in Table 20, Table 21 and Table 22. These show the number of trades in California, Florida and New York for each week. Data for week 1 of the operation of the ILM is not included in this analysis, for the reasons described in the previous section. Each cell shows the number of trades that occurred in the market on the day in question for the given week. The highlighted cells in the table above are days in which the number of trades in a particular state are two standard deviations above the average number of trades in that state for that day. The impact of both of these events can be clearly identified from the data above. An increase in trading occurred in both the Florida and California markets on the 15th of October. A similar increase in trading can be observed on the 15th of October in the New York market, although this does not reach the level of two standard deviations. An increase in trading in all three states is to be expected, as participants re-evaluate their portfolios in response to the external shock.

Week	Start Date	Monday	Tuesday	Wednesday	Thursday	Friday
2	21/09/2009	1211	844	507	455	307
3	28/09/2009	1863	1095	608	456	308
4	05/10/2009	1187	696	484	725	640
5	12/10/2009	1191	286	533	1121	349
6	19/10/2009	1361	600	344	423	180
7	26/10/2009	340	560	439	600	271
8	02/11/2009	1135	663	959	535	355
9	09/11/2009	1078	412	433	278	250
10	16/11/2009	974	652	379	524	325

Table 20. Trades in California

Week	Start Date	Monday	Tuesday	Wednesday	Thursday	Friday
2	21/09/2009	1259	591	854	499	479
3	28/09/2009	1804	406	670	416	332
4	05/10/2009	1149	520	342	455	257
5	12/10/2009	919	316	488	1005	339
6	19/10/2009	1044	588	432	476	215
7	26/10/2009	333	459	438	620	335
8	02/11/2009	1155	607	1098	524	227
9	09/11/2009	1143	800	377	454	363
10	16/11/2009	799	591	289	453	230

Table 21. Trades in Florida

Week	Start Date	Monday	Tuesday	Wednesday	Thursday	Friday
2	21/09/2009	993	855	612	832	633
3	28/09/2009	1623	597	552	414	271
4	05/10/2009	1230	602	378	451	510
5	12/10/2009	1345	310	459	1122	428
6	19/10/2009	1571	717	358	1008	262
7	26/10/2009	421	578	547	724	465
8	02/11/2009	1600	681	641	826	392
9	09/11/2009	1247	417	417	318	188
10	16/11/2009	932	721	828	680	325

Table 22. Trades in New York

The effect of Hurricane IDA can also be clearly identified in the market. A significant surge in trading can be observed on the 4th of November in both the Florida and California markets. As with the storms in California, the increase in trading can also be observed in the New York market, although again this does not reach significance.

There are three other significant spikes observed in the trading data. The increase in trading observed on Tuesday the 29th of September and Friday the 9th of October is most likely attributable to learners responding to wildfires reported in California at that time. However, a number of wildfires were occurring in California so these spikes cannot be conclusively tied to any one event. The last significant increase in trading was in the New York market on the 18th of November 2009. No significant event can be correlated with this trading event.

4.3.2. Effect of Behavioural Traits

The second general level research question identified is concerned with investigating how personality traits impact upon participation and performance in the prediction market. This was operationalised by identifying two particular personality traits from the literature. This lead to the formulation of four specific research questions namely:

- How does an individual's self monitoring affect performance in a prediction market?
- How does an individual's self monitoring affect participation in a prediction market?
- How does an individual's risk propensity affect performance in a prediction market?
- How does an individual's risk propensity affect participation in a prediction market?

The measurement of the personality traits has been previously discussed in section 3.5.2. These research questions are concerned with evaluating how individuals with different personality traits vary in terms of participation and performance. In order to create a stable relative metric to allow comparisons between individuals, every

participant in the prediction market was ranked in terms of their absolute performance each week. These rankings ran from 1, the highest performing participant for that week, to N, the lowest performing participant in that week, where N is the number of participants who traded on the market for that week. In order to calculate an overall performance ranking, the median of the ranks that the participant received for the 10 weeks of the prediction markets execution was calculated. This metric is used as a measurement of the participants overall performance in the prediction market versus their peers.

A similar approach was used to measure to create a metric for participation. Each participant was ranked in terms of the absolute volume of trades that they made during the week for each week. As above, these rankings ran from 1, the participant with the highest number of trades for that week to N, where N is the number of participants who traded on the market for that week. In order to calculate an overall participation ranking, the median for the ranks that the participant received for the 10 week of the prediction market was calculated.

In order to measure correlations between the variables of interest in this study, Spearman's correlation coefficient was used (Field 2009). Spearman's correlation coefficient is used when the data collected is an ordinal value, as in the case of the performance and participation variables used to answer these research questions (Field, 2009).

Before examining the specific research questions which are the focus of the study, it is worth pointing out one highly significant finding which emerged from an analysis of the data set. As shown in Table 23, performance in the ILM is significantly related to participation, $r_s = .38$, $p < .01$. This indicates that there is a significant positive

relationship between performance and participation. The highest ranked performers tend to be the highest ranked participants and vice versa. This result is not unexpected in itself. As has been pointed out in the literature, many authors suggest that performance in a prediction market is significantly affected by participation. More importantly, this insight is often used to suggest that enhancing participation in a prediction market is a key driver of improving overall performance. This result provides additional justification for this viewpoint, by providing direct evidence that performance in a prediction market is positively related to participation.

Correlations^a

			Performance	Participation
Spearman's rho	Performance	Correlation Coefficient	1.000	.337**
		Sig. (1-tailed)	.	.000
	Participation	Correlation Coefficient	.337**	1.000
		Sig. (1-tailed)	.000	.

** . Correlation is significant at the 0.01 level (1-tailed).

a. Listwise N = 94

Table 23. Performance versus Participation

The first relationship between the variables examined is the relationship between self-monitoring and performance. Table 24 shows that performance is significantly correlated with self-monitoring, $r_s = .24$, $p < .05$. It is important to note that since performance is an ordinal variable, with ranking running from 1 to N, with 1 being the best performer overall, this relationship indicates that as self-monitoring increases, actual performance decreases. In order to confirm this effect, a second test was carried out. The cases were divided into quartiles, with individuals who scored in the bottom quartile identified as Low Self Monitors and assigned a category of 1, while individuals

who scored in the top quartile were identified as High Self Monitors and assigned a category of 3.

			Self Monitoring	Performance
Spearman's rho	Self Monitoring	Correlation Coefficient	1.000	.239*
		Sig. (1-tailed)	.	.013
	Performance	Correlation Coefficient	.239*	1.000
		Sig. (1-tailed)	.013	.

*. Correlation is significant at the 0.05 level (1-tailed).

a. Listwise N = 86

Table 24. Self-Monitoring versus Performance

A Mann-Whitney Test was then performed comparing these two groups (Field 2009). A Mann-Whitney test is a statistical test that is used to evaluate if two samples of ordinal data are distinct (Field, 2009).

Table 25 shows that performance levels in low self-monitors ($Mdn = 138.25$) differ significantly from participation levels in high self-monitors ($Mdn = 210.5$), $U=150.00$, $z= -2.229$, $p < 0.05$, $r = 0.03$. Both tests performed come to the same conclusion, namely that low-self monitors are higher performers, and high self monitors are lower performers. This result suggests that the most successful participants in the prediction market were those who did not engage in behaviour which was intended to deceive other participants with their behaviour or information. Instead, the most successful participants were those who traded according to their own beliefs.

Ranks				
	SMQuartile	N	Mean Rank	Sum of Ranks
Performance	1.00	26	19.27	501.00
	3.00	19	28.11	534.00
	Total	45		

Test Statistics ^a	
	Performance
Mann-Whitney U	150.000
Wilcoxon W	501.000
Z	-2.229
Asymp. Sig. (2-tailed)	.026

a. Grouping Variable: SMQuartile

Table 25. Mann-Whitney Test, Self-Monitoring Versus Performance.

The next relationship evaluated is that between self-monitoring and participation. Table 26 fails to demonstrate a significant correlation between self-monitoring and participation. Similarly, a Mann-Whitney test shown in Table 27 fails to demonstrate any significant difference in performance between high self monitors and low self monitors.

Correlations ^a			Self Monitoring	Participation
Spearman's rho	Self Monitoring	Correlation Coefficient	1.000	.095
		Sig. (1-tailed)	.	.193
	Participation	Correlation Coefficient	.095	1.000
		Sig. (1-tailed)	.193	.

a. Listwise N = 86

Table 26. Self-Monitoring versus Participation

Ranks			
SMQuartile	N	Mean Rank	Sum of Ranks
Participation 1.00	26	22.12	575.00
3.00	19	24.21	460.00
Total	45		

Test Statistics ^a	
	Participation
Mann-Whitney U	224.000
Wilcoxon W	575.000
Z	-.529
Asymp. Sig. (2-tailed)	.597

a. Grouping Variable: SMQuartile

Table 27. Mann-Whitney Test: Self-Monitoring versus Participation

These tests imply that self-monitoring as a personality trait does not have any significant affect on the volume of trades undertaken by participants in a prediction market. This implies that self-monitoring as a personality trait neither promotes nor inhibits participation in prediction market.

The next section focuses on the impact of risk-propensity on performance and participation in prediction markets. Measurements of both risk propensity and risk avoidance were calculated for respondents. These are seen as being inverse personality traits, which is to say that an individual who demonstrates high risk propensity will demonstrate low risk avoidance and vice versa. Consequently, any effect which emerges in one dimension should be mirrored in the other dimension. Therefore, to improve the reliability of the conclusions reached from this section of the analysis, the effect observed was measured for both risk propensity and risk avoidance. If observed effects in one dimension are mirrored in the other, that serves to improve trustworthiness of the effect observed.

The first analysis undertaken investigated the relationship between risk propensity and performance. Table 28 reveals no significant relationship between performance and risk propensity. Similarly, no significant effect is observed between risk avoidance and performance. It is worth noting, however, that these two variables are extremely highly correlated with a negative relationship, as one would expect.

Correlations^a

			Risk propensity	Risk Avoidance	Performance
Spearman's rho	Risk propensity	Correlation Coefficient	1.000	-.946**	.053
		Sig. (1-tailed)	.	.000	.313
	Risk Avoidance	Correlation Coefficient	-.946**	1.000	-.007
		Sig. (1-tailed)	.000	.	.473
	Performance	Correlation Coefficient	.053	-.007	1.000
		Sig. (1-tailed)	.313	.473	.

** . Correlation is significant at the 0.01 level (1-tailed).

a. Listwise N = 86

Table 28. Risk Propensity versus Performance

Similarly, a Mann-Whitely test shown in Table 29 fails to demonstrate any significant differences between high risk takers and low risk takers. This allows us to conclude that risk propensity has no significant effect on performance in a prediction market.

Ranks			
RTQuartile	N	Mean Rank	Sum of Ranks
Performance 1.00	25	21.10	527.50
3.00	17	22.09	375.50
Total	42		

Test Statistics ^a	
	Performance
Mann-Whitney U	202.500
Wilcoxon W	527.500
Z	-.256
Asymp. Sig. (2-tailed)	.798

a. Grouping Variable: RTQuartile

Table 29. Mann-Whitney Test: Risk Propensity versus Performance

Finally the impact of risk propensity on participation in a prediction market was investigated. As with the previous analysis, risk avoidance is also included, in order to improve the reliability of conclusions reached. Table 30 shows that risk propensity was positively correlated with participation, $r = .25$, $p \leq 0.01$. It is important to note here that since participation is an ordinal variable, which run from 1 to N, where N is the participant with the lowest number of trades, this positive relationship implies that individuals with low risk taking personality traits traded more, and individuals with high risk taking personalities traded less. A similarly sized, but inverted relationship can be observed between risk-avoidance and participation, $r = -.25$, $p \leq 0.05$, as shown in Table 30. This is as we would expect if the effect being observed is genuine and serves to bolster the credibility of the findings.

Correlations^a

			Risk propensity	Risk Avoidance	Participation
Spearman's rho	Risk propensity	Correlation Coefficient	1.000	-.946**	.251**
		Sig. (1-tailed)	.	.000	.010
	Risk Avoidance	Correlation Coefficient	-.946**	1.000	-.245*
		Sig. (1-tailed)	.000	.	.011
	Participation	Correlation Coefficient	.251**	-.245*	1.000
		Sig. (1-tailed)	.010	.011	.

** . Correlation is significant at the 0.01 level (1-tailed).

* . Correlation is significant at the 0.05 level (1-tailed).

a. Listwise N = 86

Table 30. Risk Propensity versus Participation

In order to further investigate this relationship, a Mann-Whitney test was performed comparing high risk takers and low risk takers. Participation levels in low risk takers (*Mdn* = 151.00) differ significantly from performance levels in high risk takers (*Mdn* = 220.00), $U=128.00$, $z= -2.165$, $p < 0.05$, $r = 0.03$ as shown in Table 31.

Ranks

	RTQuartile	N	Mean Rank	Sum of Ranks
Participation	1.00	25	18.12	453.00
	3.00	17	26.47	450.00
	Total	42		

Test Statistics^a

	Participation
Mann-Whitney U	128.000
Wilcoxon W	453.000
Z	-2.165
Asymp. Sig. (2-tailed)	.030

a. Grouping Variable: RTQuartile

Table 31. Mann-Whitney Test: Risk Propensity versus Participation

A Mann-Whitney test was also carried out comparing the difference in participation between individuals with high risk avoidance and low risk avoidance. Table 32 shows that this test does not reach significance, with $p = 0.95$. However, it should be noted that as one would expect the means are reversed from the order displayed in the analysis of

risk takers. While p does not reach the significance level of 0.05, the relationship is significant at the 10% level.

Ranks				
	RAQuartile	N	Mean Rank	Sum of Ranks
Participation	1.00	24	23.63	567.00
	3.00	17	17.29	294.00
	Total	41		

Test Statistics ^a	
	Participation
Mann-Whitney U	141.000
Wilcoxon W	294.000
Z	-1.667
Asymp. Sig. (2-tailed)	.095

a. Grouping Variable: RAQuartile

Table 32. Mann Whitney Test: Risk Avoidance versus Participation

Overall, the analysis presented strongly suggests that there is a significant relationship between risk-propensity and participation in a prediction market. It suggests that low risk takers are likely to participate more in the prediction market, and high risk takers are likely to participate less. The effect is demonstrated to significance by all the tests undertaken, with the exception of the Mann-Whitney test of high and low risk avoidance groups.

A multi variant analysis of a model examining how risk propensity and self-monitoring affect participation was conducted. The result of this analysis is shown in Table 33, Table 34 and Table 35 below. As shown in Table 33, the R^2 is quite low at 0.67, indicating that this model does not have a large amount of predictive power. Other, unexplored variables must explain much of the variation in participation. However, the ANOVA in Table 34 demonstrates that the amount of variability that is explained by this model is significant ($p \leq 0.1$). The coefficients analysis in Table 35 supports the

relationships found in the earlier analysis. Risk taking has a significant positive relationship with participation ($b = 4.499$, $p < 0.05$). The relationship between self-monitoring and participation is not significant.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.258 ^a	0.67	0.44	86.87891

a. Predictors: (Constant), Risk Taking, Self Monitoring

Table 33. Summary: Risk Propensity, Self-Monitoring on Participation

ANOVA^b

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	44755.036	2	22377.518	2.965	.057 ^a
	Residual	626479.499	83	7547.946		
	Total	671234.535	85			

a. Predictors: (Constant), Risk Taking, Self Monitoring

b. Dependent Variable: Participation

Table 34. ANOVA: Risk Propensity, Self-Monitoring on Participation

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
		1	(Constant)	60.002		
	Self Monitoring	-.491	1.545	-.036	-.318	.752
	Risk Taking	4.499	1.882	.267	2.390	.019

a. Dependent Variable: Participation

Table 35. Coefficients: Risk Propensity, Self-Monitoring on Participation

Finally, the multi variant analysis examining how risk propensity and self-monitoring affect performance shows the R^2 is quite low at 0.51. This indicates that this model does not have a large amount of predictive power. Therefore, other, unexplored variables

must explain much of the variation in performance. The ANOVA in Table 37 demonstrates that the amount of variability that is explained by this model is not significant ($p \leq 0.2$). This means that the variability in performance is not explained well by the personality traits chosen. However, the coefficients analysis in Table 38 supports the relationships found in the earlier analysis. This allows one to conclude that self-monitoring has a significant positive relationship with participation ($b = 2.270$, $p < 0.05$) and that the relationship between risk propensity and participation is not significant.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.227 ^a	0.51	0.29	65.23484

a. Predictors: (Constant), Risk Taking, Self Monitoring

Table 36. Summary: Risk Propensity, Self-Monitoring on Performance

ANOVA^b

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	19144.975	2	9572.488	2.249	.112 ^a
	Residual	353213.478	83	4255.584		
	Total	372358.453	85			

a. Predictors: (Constant), Risk Taking, Self Monitoring

b. Dependent Variable: Performance

Table 37. ANOVA: Risk Propensity, Self-Monitoring on Performance

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	101.561	48.726		2.084	.040
	Self Monitoring	2.270	1.160	.221	1.956	.049
	Risk Taking	.218	1.413	.017	.154	.878

a. Dependent Variable: Performance

Table 38. Coefficients: Risk Propensity, Self-Monitoring on Performance

4.4. Findings

4.4.1. Group Decision Making

One of the primary goals of this thesis was to establish the effect prediction market participation has on individuals. Individual development is seen as being a major rationale encouraging organisations to choose to utilise group decision making. Organisations will use group decision making, not necessarily because of the inherent superiority of the results, but because they believe that participating in a group decision making situation will sharpen the skills and abilities of employees. If prediction markets are to be viewed as a group decision making tool, then proving that prediction markets can have a positive effect on individuals needs to be examined, so as to provide organisations with a rationale to deploy prediction markets above and beyond improved forecasting accuracy.

The data analysed and presented in this section was collected with a view to answering three research questions with respect to group decision making. These questions were; (i) What effect does prediction market participation have on the accuracy of individual decision making? (ii) Do prediction market participants factor newly revealed information into their decision making processes?; and (iii) Do prediction market

participants actively search out information pertinent to the decision spaces being considered by the prediction market?

An analysis of the data suggests that prediction market participation has a positive effect on the decision making ability of participants. Two trends in trading behaviour and performance that support this statement can be observed. First, as measured by the virtual capital at the end of a week, individual student's performance improved once the problem difficulty stabilised. Second, students engaged in more diversification over the duration of the module. Both of these observations support the hypothesis that prediction market participation had a positive effect on participant decision making. A possible explanation for this improvement is that participant's decision making in the problem domain improved due to their exposure to a course on risk management simultaneously with their participation in the prediction market. It is possible that the improvement in decision making observed was due to the application of knowledge acquired in the course rather than knowledge acquired through interaction with the prediction market. Within the limitations of this study, this possibility cannot be discounted. However, constructivist learning theories emphasise that the simple delivery of information is not enough to prompt learning and develop inherent knowledge. Learners must be given the opportunity to apply knowledge in a realistic context to fully enable learning. Prediction markets provide the rich, interactive and dynamic environment that allows the internalization of supplied information and its conversion into knowledge, thereby improving decision making. In a constructivist learning paradigm, prediction market participation provides the crucial platform that allowed participants to take static information and build and improve the internal models that enable decision making.

As regards the second question, an analysis of the data shows that learners were dynamically incorporating new information into their decision making as it became available. When information on the previous week's losses is presented to learners, they use this information to adjust their decisions. This is evidenced by the upsurge in trading that occurs in the market.

The final research question in regard to group decision making investigated whether or not there is evidence to suggest that prediction markets prompt participants to actively search out new information, and incorporate it into their decision making. The data presented in section 4.4.1 strongly suggests that this is the case. The large surges in trading that can be observed can be correlated with events in the real-world. These surges in trading are most easily explained by assuming that users are actively searching out information and factoring it into their decision making. Since this information is not revealed to the participants, nor were they likely to have come across it randomly, it would appear that participant's information consumption patterns are modified by participation in the prediction market.

4.4.2. Prediction Markets

As discussed extensively in section 2.5, it is theorised in the literature that personality traits and behavioural characteristics of individuals will impact upon prediction market performance and participation. It is suggested that prediction markets are only attractive to individuals with high risk propensity. This hypothesis has impact implications for the organisational deployment of prediction markets. If true, it would suggest that prediction markets are only suitable for use in organisations that have a high proportion of individuals with high risk propensity. This is empirically addressed in this study and

the analysis has revealed a number of relationships which are new in themselves, and have important implications for practitioners and suggest further research.

Turning first to the issue of performance, this study found that individuals with low self monitoring personalities tend to perform better in prediction markets. High self monitoring is associated with mediating ones behaviour on the basis of one's expectations of other's behaviours. In the context of a prediction market, this personality trait would lead to behaviours such as trading on the expectations of others rather than on one's own information. This behaviour is inimical to the information revelation that is at the core of the power of prediction market. It suggests that in the long run, such behaviour is counterproductive. It is more profitable, in terms of rewards gathered from the prediction market to trade on information than it is to attempt to beat the market by predicting and manipulating the trades of others. A rational trader fares best by trading according the information they possess. This supports the position that individuals will reveal information truthfully in a prediction market and so bolsters the supposition that prediction markets can be used as a reliable tool for information collection, information aggregation and decision making.

One concern that is often raised regarding prediction markets is that they may be vulnerable to certain types of manipulations, as discussed in section 2.2.4. The root cause of such manipulations is individual participants attempting to gain undeserved rewards through strategic information revelation or trading. This result suggests that it is possible to design prediction markets in such a manner as to minimise the risk of such manipulations arising. By careful design of incentives and markets, it is possible to create prediction markets where the rational course of action is the truthful revelation of information. This undermines the rationale for engaging in market manipulations, thereby reducing the risk of them occurring. This is an extremely complex issue, which

merits further research. However, the conclusions drawn from this study suggest that a possible avenue for dealing with these concerns is to design markets in such a manner as to make it irrational to attempt to manipulate them.

This study highlights the relationship between performance and participation. It found that performance was significantly linked to participation. Individuals who participate more in the prediction market perform better. This is not an unexpected result, with the literature strongly suggesting that this is the case. This study provides empirical support for this hypothesis and makes an important contribution in that manner.

This study demonstrates a significant relationship between risk propensity and prediction market participation, namely that risk takers participate less in the market. At first sight, this finding appears to contradict much of the literature. This relationship is posited to exist in prediction markets in general, and likely holds for general purpose public prediction markets which are the subject of most existing empirical studies. This study demonstrates the limits of generalising this relationship however. The ILM was created with the express purpose of mimicking a prediction market in a corporate environment. In particular, the incentive structure utilised was similar to that which the literature suggests should be used in corporate prediction markets. One part of the reward available is offered for participation, while another part of the reward is offered for performance. In this situation, the risk is in not participating, since not participating means forsaking the participation reward available. Consequently, this study demonstrates that prediction market do not inherently attract individuals who enjoy risk, and deter individuals who avoid risk. It demonstrates clearly that participation is a function of incentive design. Therefore, the correct design of incentive structures means that a prediction market can be made attractive both to risk takers and risk avoiders. It means that prediction markets should not be categorised as a decision making tool that

should only be used in an environment where individuals who enjoy risk are likely to participate. As such, designing incentive structures in such a manner as to optimally encourage participation from risk takers and risk avoiders is a fertile area for further research. This study serves to confirm the importance of this and will prompt further research in the area.

4.5. Conclusion

This chapter has analysed the data collected by a longitudinal study of a prediction market in operation. Given that it was focussed on maintaining ecological validity, it makes a number of important contributions to the design and operation of prediction markets, both in the academic domain and to practitioners. It provides a further rationale for deploying prediction markets in an organisational setting. It demonstrates that prediction market participation can engender positive behavioural changes in employees. It empirically investigated how personality traits impact upon prediction market participation and performance. It demonstrated that through careful incentive design, prediction market performance and participation can be decoupled from behavioural traits such as risk propensity. This is an important finding that emphasises the generalisability of prediction markets as an organisational decision making tool.

5. Conclusions

This dissertation describes the genesis, evolution and conclusion of a body of research work which has made two significant contributions. First, it investigates the impact of prediction market participation on individual decision making behaviour. Second, it examines the impact of individual personality traits on performance and participation in prediction markets. This chapter serves two purposes. For each of the contributions made, the research findings, scholarly contributions and implications for practice are elucidated in 5.1. Section 5.2 examines the limitation of this research with section 5.3 concluding by outlining further research opportunities.

5.1. Research Contribution

This section considers the contributions of this dissertation. Section 5.1.1 summarises the contribution in terms of the effect prediction markets have on individual decision making. Section 5.1.2 summarises the contributions in terms of the relationship between personality traits and prediction market performance and participation.

5.1.1. Effects on Participating Individuals

The identification of the nature of individual behaviour and the alteration of that behaviour as a product of prediction market participation is, as previously mentioned, a significant contribution of this dissertation. The identification of this proposed benefit of prediction market participation led to the formulation of a research agenda that aimed to establish whether these effects occurred. What particularly distinguishes this research is the design of the study to closely mimic an organisational deployment of a prediction market, within the constraints of the research design and practical considerations. In

character, structure and design, the ILM is a reasonable facsimile of an organisational prediction market. It represents an environment that more closely matches an organisational setting than the controlled experiments found in experimental economics, or a public access prediction markets.

Analysis of the literature and theory building reveals three main effects that prediction market participation should have on the individual. It is important to note that these three aspects are closely related, but distinct. For example, it is possible to conceive of an individual improving their decision making skill without necessarily analysing new information as it arises, or searching out new information. This analysis can be continued for all combinations of the effects being investigated. It is also important to note that these effects drive learning. The context of a prediction market, educational or organisational, does not change the fundamental nature of the effects that occurs.

The data presented in this study found that individual decision making ability improved in a problem domain due to prediction market participation. In general, it is more accurate to state that repeatedly interacting with a decision making scenario improves individual's decision making skills in that problem domain. This is a relatively straightforward observation. Gaining experience by repeatedly considering a problem and making a decision is not a contentious suggestion. Nonetheless, this dissertation presents the first empirical study of a prediction market operating in a realistic environment that demonstrates these effects. As such, this is a major contribution to the development of prediction markets as a valuable decision making framework.

Prediction markets by their very nature allow participants to analyse newly revealed information, and factor it into their decision making. This is suggested in the literature, and a considerable body of work in experimental economics has attempted to

investigate this in the past. However, this study empirically demonstrates such behaviours in individuals in a realistic representation of an organisational prediction market.

Finally, this study found that prediction market participation actively encourages information search in individuals. It was possible to observe trading contingent on the information search responses by individuals. Evidence was found of participants actively searching out information related to the topic under consideration. Individuals were found to alter their information consumption behaviours as a result of participating in a prediction market. Identifying this change in behaviour and providing empirical support for it in a realistic prediction market setting is a major contribution of this study.

As regards practice, the identification and classification of the effects prediction market participation have on individuals has important implications. First, it provides a new rationale and scope for using prediction markets. Prediction markets can prompt specific behaviours that modify behaviour and focus participant interest. This greatly increases the potential to deploy prediction markets beyond those already presented in the literature. This has been supported by a number of informal conversations with practitioners and represents a major contribution of this study.

The observation that prediction market participation can be used to modify individual's information consumption offers another rationale for deploying prediction markets in an organisational setting. Informally, organisational leaders have expressed great interest in this aspect of prediction markets. It opens the possibility of prediction markets being used as communication tools within organisations. For example, management may decide that a certain project has a particular organisational priority. In order to convey this to employees, the organisation could set up a prediction market with specific

questions relating to that project. This research study shows that such an initiative will have the effect of focusing individual employee's attention, and prompting them to search out information pertinent to that project.

5.1.2. Effect of Personality Traits

The literature regularly suggests that the personality traits of individuals are likely to affect prediction market participation. In particular, it is commonly asserted that prediction markets are likely to attract participation from individuals who enjoy risk and risk-taking. This possibility has a major impact upon the suitability of prediction markets as organisational decision making tools. If prediction markets only attract risk taking individuals, than in an organisational setting with a cross-section of personality types, only a subset of individuals are likely to participate. To date, no empirical investigation of this has been presented in the prediction market literature. This study is the first to offer an empirical investigation of the effect of personality traits on prediction market participation and performance. The research contributions of this research are relatively straightforward to elucidate.

First, the analysis demonstrates that individuals who display a low risk taking personality are likely to participate more than individuals who have high risk taking personalities. It also found that risk propensity does not significantly affect performance.

Second, the research findings demonstrate no significant link between self-monitoring and participation. However, they do demonstrate a significant link between self-monitoring and performance. The implication of this is that individuals who trade on actively sought out information perform better than those who attempt to manipulate the market. This implies that in a prediction market, the rational strategy is actually to trade

honestly rather than trading in order to manipulate prices. Given the limitations of the strength of the relationship between self-monitoring and trading behaviours, this conclusion must be treated with caution. Nonetheless, it suggests another possible route for dealing with the challenge of market manipulation. If individuals are aware that the best performing strategy in the long run is to reveal information honestly, then the rationale for engaging in manipulative trades is diminished for a rational trader.

Returning to the issue of risk propensity and its impact upon participation, the discontinuity between the behaviours which would be expected from the literature and those observed can be attributed to the context of the prediction market. The design and incentive structure of the ILM is such that it closely resembles an organisational prediction market. That design has the effect of altering the expected relationship between risk propensity and participation. This allows this study to make two further significant contributions. First, it clearly demonstrates that prediction markets can be designed in such a way as to be attractive to both risk taking and risk averse individuals. Second, it demonstrates the limitations of the existing consensus in the prediction market literature. That suggests that prediction markets are only attractive to risk taking individuals. This holds in contexts such as general purpose prediction markets. However, this relationship is not universal, and this study demonstrates the limits of that relationship and represents another significant contribution.

In regards the implications for practice, two main contributions emerge from this research. First, this research demonstrates that prediction markets are not a group decision making tool which only attracts risk taking individuals. By demonstrating that personality traits are not the ultimate determinant of participation in a prediction market, this study provides further evidence to suggest that prediction markets can be used

successfully in a wide variety of contexts and situations. It reinforces the view that prediction markets have a central role to play as a group decision making tool.

Second, this research provides the first empirical framework for managers when designing prediction markets. If a manager feels that their organisation is full of risk taking individuals, then this research implies that the incentive structure should heavily reward performance. If a manager feels that an organisation has a more evenly balanced spread of personality traits, then the incentive structure should be more evenly balanced between rewarding participation and performance.

5.2. Research Limitations

As has been discussed throughout this study, the goal of research is to create high quality research. In particular, academic research is held to the highest standards, and it behoves a researcher in that domain to maximise the quality of the research process and the integrity of the research findings. This pursuit of excellence is tempered by the knowledge that the quality of all research is compromised to some degree. There are three fundamental causes of the limitations on the quality of a piece of research. First, the quality of the research is affected by the limitations placed on the acquisition of knowledge. In particular, epistemological positions such as interpretivism and realism, with their conception of knowledge as a social construct that cannot be disentangled entirely from the observer, means that no knowledge can ever be considered absolutely true. Second, research does not occur in a vacuum. Researchers face practical constraints in terms of time, resources, and access that bound the research process and inevitably affect the quality of the research process. Third, as a consequence of the epistemological and ontological positions taken by the researcher and the practical considerations that must be wrestled with, the researcher is often forced to make decisions, which trade-off quality in one dimension for quality in another.

Accepting that limitations are unavoidable to some degree in any research process places two burdens upon the researcher. First, the researcher must be cognisant when designing the research process, in so far as it is possible, to reduce the limitations of the research. Where trade-offs are made, the decisions should be rationalised and elucidated as clearly as possible. Second, it is incumbent upon the researcher to clearly specify the limitations of a given piece of research, so other parties can clearly see what these limitations are. This serves a number of purposes. It reduces the risk of false conclusions being drawn or incorrect decisions being made on the basis of an incorrect interpretation of a piece of research. Second, identifying the limitations of a piece of research often provides signposts to other researchers who can attempt to apply new research strategies and methodologies in an attempt to overcome the limitations of an existing piece of research.

Many of the limitations of the current research have already been discussed in the previous sections. As the specific dimensions of quality were discussed in the previous sections, limitations that affected these dimensions were also identified in detail. As such, this section merely summarises the limitations that have already been discussed in greater detail previously. This is done to provide the reader with a convenient and transparent listing of the limitations of this research.

The first limitation of this research relates to the creation of the constructs used to measure the variables of interest in this study, particularly participation, performance and the behavioural traits. These concerns have been discussed in section 3.6. Behavioural traits are measured using a standardised but well established instrument (Goldberg 1999). Quantitative measures taken from the prediction market are used to evaluate performance and participation. These constructs have face validity, which is to say there seems to be a rational, logical connection between the variable used and

construct being measured. However, it is important to point out, like any psychological instrument, that the validity of these measurements is not beyond question.

The second limitation of the study involves the nature of the casual relationships that are investigated. A number of categories of these relationships can be identified, in particular casual relationships between real-world events and trading behaviours in the prediction market, and behavioural traits and trading patterns in the prediction market. These relationships are examined in more detail in section 3.6. Focusing as it does on maintaining ecological validity, this longitudinal study loses some of the control that is associated with more stringent experimental studies. As such, this weakens the ability of the research to establish definitive casual links. However, in all of the relationships examined, a logically persuasive argument can be made defending the casual relationships that are posited.

The third limitation of the study involves the external validity or generalizability of the research. In particular, the sample selected, namely third level students, is significantly different from the population of interest, namely employees in business organisations using prediction markets. In section 3.6, argumentation is presented outlining why this does not necessarily undermine the research. Nonetheless, the external validity of this study is weakened by the sample selected, and this must be recognised as a limitation of the current study.

5.3. Issues for Further Research

This dissertation has presented evidence that found that prediction markets improved the decision making skills and altered the information use and search patterns of individual participants. In presenting empirical evidence supporting these hypotheses, this study makes a contribution. Nonetheless, the credibility of any conclusions drawn

from one piece of research must always be questioned. Further research testing for these effects, particularly in different contexts would provide corroboration for the conclusions reached in this dissertation.

This study has demonstrated that the risk propensity of individuals is not the ultimate determinant of prediction market participation. Prediction markets can be designed in such a way as to make participation attractive to both risk taking and risk averse individuals. However, investigating how to precisely calibrate these rewards, and the precise balancing of rewards for participation and performance is still an unexplored area of research.

Several exciting research possibilities emerge from the positioning of prediction markets as pedagogical tools. It is suggested that the presentation of real-world problems will improve student's motivation to study. It is proposed that the competitive element of prediction markets will improve motivation in learners. Further empirical work investigating whether or not these hypotheses hold is warranted.

Finally, the scalability of prediction markets raises other interesting possibilities. Once operational, a prediction market can be used to deliver problem scenarios to a very large number of participants. This raises the intriguing possibility of creating learning communities that go beyond the traditional boundaries of many courses. Therefore, it should be possible to leverage prediction markets to create learning communities that include participants from many different classes and universities. It may also be possible to include professionals working in industry. The creation and management of such a diverse community of learners raises many challenges, but also offers many potential benefits to all concerned. In effect, prediction markets are a tool that can be used to unlock the potential of such diverse communities, and research aimed at

examining the practical and pedagogical benefits and challenges of creating such communities is to be welcomed.

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Appendix A: IPIP Instruments & Scoring Instructions

For positively keyed items, the response "Very Inaccurate" is assigned a value of 1, "Moderately Inaccurate" a value of 2, "Neither Inaccurate nor Accurate" a value of 3, "Moderately Accurate" a value of 4, and "Very Accurate" a value of 5.

For negatively keyed items, the response "Very Inaccurate" is assigned a value of 5, "Moderately Inaccurate" a value of 4, "Neither Inaccurate nor Accurate" a value of 3, "Moderately Accurate" a value of 2, and "Very Accurate" a value of 1.

Once numbers are assigned for all of the items in the scale, just sum all the values to obtain a total scale score.

Self Monitoring

Key	Statement
Positively Keyed	Would make a good actor.
Positively Keyed	Put on a show to impress people.
Positively Keyed	Am likely to show off if I get the chance.
Positively Keyed	Am the life of the party.
Positively Keyed	Am good at making impromptu speeches.
Positively Keyed	Like to attract attention.
Positively Keyed	Use flattery to get ahead.
Negatively Keyed	Hate being the center of attention.
Negatively Keyed	Would not be a good comedian.
Negatively Keyed	Don't like to draw attention to myself.

Risk Propensity

Key	Statement
Positively Keyed	Enjoy being reckless.
Positively Keyed	Take risks.
Positively Keyed	Seek danger.
Positively Keyed	Know how to get around the rules.
Positively Keyed	Am willing to try anything once.
Positively Keyed	Seek adventure.
Negatively Keyed	Would never go hang-gliding or bungee-jumping.
Negatively Keyed	Would never make a high risk investment.
Negatively Keyed	Stick to the rules.
Negatively Keyed	Avoid dangerous situations.

Risk Avoidance

Key	Statement
Positively Keyed	Would never go hang gliding or bungee jumping.
Positively Keyed	Would never make a high-risk investment.
Positively Keyed	Avoid dangerous situations.
Negatively Keyed	Seek danger.
Negatively Keyed	Am willing to try anything once.
Negatively Keyed	Do dangerous things.
Negatively Keyed	Enjoy being reckless.
Negatively Keyed	Seek adventure.
Negatively Keyed	Take risks.
Negatively Keyed	Do crazy things.

Appendix B: Personality Trait Questionnaire

Please write down your ID Number

Please use the rating scale next to each phrase to describe how accurately each statement describes you. Describe yourself as you generally are now, not as you wish to be in the future. (1 = Very inaccurate, 2 = Moderately inaccurate, 3 = Neither inaccurate or accurate, 4 = Moderately Accurate, 5= Very Accurate)

	1	2	3	4	5
1) Use flattery to get ahead	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2) Would not be a good comedian	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3) Would never go hang gliding or bungee jumping	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4) Would make a good actor	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5) Avoid dangerous situations	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6) Do dangerous things	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7) Come straight to the point	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8) Know how to get around the rules	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9) Sympathize with the homeless	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10) Am likely to show off if I get the chance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
11) Dislike im perfect work	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
12) Stick to the rules	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
13) Let people pull my leg	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
14) Seek danger	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
15) Seek adventure	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
16) Do crazy things	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
17) Like to attract attention	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
18) Am good at making impromptu speeches	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
19) Don't like to draw attention to myself	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
20) Get a head start on others	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
21) Am willing to try anything once	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
22) Put on a show to impress people	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
23) Do things in a logical order	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
24) Am the life of the party	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
25) Believe in a logical answer for everything	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
26) Hate being the center of attention	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
27) Enjoy being reckless	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
28) Believe in an eye for an eye	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
29) Take risks	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
30) Am not as strict as I should be	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
31) Would never make a high-risk investment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Appendix C: Chronology of Severe Weather Events

Date	State	ABC/CNN	Event	Source
04/10/2009	CAL	ABC	Firefighters Try to Protect Calif Mountain Town	
08/10/2009	CAL	ABC	S. Calif. Wildfire Stalled, Containment Increasing	http://abcnews.go.com/US/wireStory?id=8778469
13/10/2009	CAL	ABC	Calif. Storm Causes Power Outages, Mudslide Fears	http://abcnews.go.com/US/wireStory?id=8814239
13/10/2009	CAL	CNN	Storm threatens California with flooding, mudslides	http://edition.cnn.com/2009/US/weather/10/13/california.rain/index.html#cnSTCText
14/10/2009	CAL	CNN	Mudslide Menace Eases in Calif. as Storm Weakens	http://abcnews.go.com/US/wireStory?id=8823338
16/10/2009	NYC	CNN	Winter's Bite Not Becoming For Mid-October	http://wcbstv.com/cbs2crew/noreaster.winter.nyc.2.1252149.html
19/10/2009	CAL	CNN	Hurricane Rick weakens, but still Category 5 storm	http://edition.cnn.com/2009/WORLD/americas/10/18/hurricane.weather/index.html#cnSTCText
27/10/2009	CAL	ABC	Crews Rush to Contain CA Wildfire Ahead of Winds	http://abcnews.go.com/US/wireStory?id=8923213
04/11/2009	FLD	NHC	Hurricane IDA Alert (National Hurricane Center)	http://www.nhc.noaa.gov/pdf/TCR-AL112009_IDa.pdf
04/11/2009	FLD	CNN	Hurricane IDA Forms	http://edition.cnn.com/2009/WORLD/weather/11/05/tropical.storm.ida/index.html
10/11/2009	FLD	CNN	Ida bears down on Gulf Coast	http://edition.cnn.com/2009/WORLD/weather/11/08/tropical.storm.ida/index.html#cnSTCText

Appendix D: Publications that were generated from this dissertation

Peer Reviewed Journal Articles

Buckley, P., Garvey, J. & McGrath, F., 2011, A Case Study on Using Prediction Markets as a Rich Environment for Active Learning, *Computers and Education*, Vol. 56, No. 2, 418-428. (ISI impact factor 2.059, Ranking 9/139 Education)

Garvey, J & Buckley, P. 2010. Implementing Control Mutuality Using Prediction Markets: A New Mechanism for Risk Communication, *Journal of Risk Research*, Vol. 13, No. 7, 951-960. (ISI Impact factor 0.569, Ranking 41/68 Social Sciences, Interdisciplinary).

Buckley, P. & Garvey, J. Using Technology to Encourage Critical Thinking and Optimal Decision-Making in Risk Management Education. *Risk Management and Insurance Review* (Accepted)

Garvey, J. & Buckley, P. 2010. Teaching the Concept of Risk: Blended Learning Using a Custom-Built Prediction Market. *Journal of Teaching in International Business*, Vol. 21, 346-357.

Book Chapters

Buckley, P., Garvey, J., McGrath, F., (Forthcoming, 2011), Using Prediction Markets to Deliver Authentic Learning Experiences in T. Le and Q. Le, eds. *Enhancing Pedagogy, Engagement and Empowerment in Education: Creating Learning Friendly Environments*. IGI Global.

Conference Papers

Buckley, P., McGrath, F., 2007, 'Using Information Aggregation Markets for Decision Support', The IASK International Conference Global Management 2007 (ICGM 07). Faro, May 2007.

Buckley, P., McGrath, F., 2007, 'Factors affecting prediction market performance', KBS Research Conference, Limerick, May 2007.

Buckley, P., McGrath, F., Davis, C., 2008, 'Facing the Challenges of Diversity in Large Group Teaching', E-Learn 2008, Las Vegas, Oct 2008.

Buckley, P., McGrath, F., 2008, 'Managing Prediction Markets', University of Copenhagen Conference on Forecasting, Copenhagen, December 2008.

Buckley, P., Garvey, J., McGrath F., 2009, 'Using Prediction Markets for Risk Communication', KBS Research Conference, Limerick, 12th May 2009.

Buckley, P., McGrath, F., 2009, '*Managing Prediction Markets*', SIGMIS 2009, Limerick, May 2009.

Buckley, P., Garvey, J., McGrath, F., 2009, '*Using Prediction Markets to Create an Active Learning Environment In Large Groups*', NAIRTL '09, Trinity College, Dublin, Nov 2009.

Buckley, P., Garvey, J., McGrath, F., 2011, '*Enabling Active Learning in Large Groups*', NAIRTL '11, NUIG Galway, June 11. (Forthcoming)

Appendix E: Research Ethics Approval

From: Michelle.Cunningham [mailto:michelle.cunningham@ul.ie]
Sent: 22 October 2008 11:17
To: Patrick Buckley
Cc: Fergal.McGrath
Subject: KBSREC - Oct 08 - PhD - Patrick Buckley

Dear Patrick,

Your application has been reviewed by the KBS Research Ethics Committee and I am pleased to inform you, that your application has received research ethics approval subject to the following:

The student has been requested to include the contact details of the KBS Research Ethics Committee on the Information Sheet.

KBS Research Ethics Committee contact details are:

Dr Martin Mullins
Chair, KBS Research Ethics Committee
Department of Account & Finance
Kemmy Business School
University of Limerick

Martin.Mullins@ul.ie

Kind regards

Michelle Cunningham
Administrator
Research Ethics Committee
Kemmy Business School
University of Limerick
