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Product Portfolio Management for the UK Motor Insurance Industry: A Study in Game Theory Perspective

by

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Declaration and Inclusion of Material

This thesis is submitted to the University of Warwick in support of my application for the degree of Doctor of Philosophy. It has been composed by myself and has not been submitted in any previous application for any degree.

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Gunnels Porter, S., 2012. Endsleigh Insurance. Warwick Business School Case Study Database.

Abstract

Product Portfolio Management is a complex strategy development process with mechanisms for evaluating market dynamics and competition; however none provide the managerial insight into competitive response required to stay one step ahead in the market. This research uses Game Theory as a tool to tackle and give perspective to a case study in the UK Motor Insurance Industry.

The case study focuses on Endsleigh and Zurich Insurance products presented on aggregator websites. To enable efficient modelling the players and portfolios were reduced through competitive strategic grouping and strategy analysis. Player utilities were generated through a customer survey and manipulation of known Product Portfolio utility optimisation functions. Finally, the model was analysed to find the Nash Equilibrium using a non-linear optimisation model written with parallel quadratic programming based on a quasi-Newton technique.

The Game Theory model of this highly competitive market provided valuable feedback into the market dynamics and competitive responses to product strategy decisions. When presented to the case companies it was expressed that the model provided market insights that would allow the company to preempt the market, reducing rework in product development and strategic decisions, and create a competitive advantage. Furthermore, when presented to the government regulatory body, they expressed interest in the model for the purpose of developing better regulations to control market dynamics in support of maximising market potential while protecting customer interests. Overall, the Game Theory model proved useful as a tool for evaluating the case study given the insights it provided, above and beyond alternate Product Portfolio analysis tools, into market dynamic, competitive response and customer behaviour.

List of Abbreviations

ABI - Association of British Insurers

AI - Artificial Intelligence

B2B - Business to Business

CII - Chartered Insurance Institute

CRM - Customer Resource Management

GT - Game Theory

IT - Insurance Times

NE - Nash Equilibrium

NHS - National Health Service

PDMA - Product Development Management Association

PPM - Product Portfolio Management

TPTF - Third Party, Theft & Fire

U.K. - United Kingdom

U.S. - United States

1. Introduction

Game Theory's Importance to Product Portfolio Management

1.1. Introduction

The initial motivation of exploring the use of Game Theory for Product Portfolio Management arose from a personal professional experience as a Product Manager and a curiosity in Game Theory and other Econometric Analysis. Then, while reading a simple magazine article regarding the history and current applications of Game Theory (Matthews, 2009), it was decided that a formal research project would be undertaken. The direct academic value was highlighted by the simplicity of the example presented of Game Theory used for Product Portfolio Management (Sadeghi & Zandieh, 2010). This representation was published in the same year this research was initiated, and prior to this there had been no published uses of Game Theory applied to Product Portfolio Management. You will find in these pages the results and journey of this research.

The objective of the research contained here is to demonstrate a business value to the inclusion of Game Theory in the Product Portfolio analysis process. A study was undertaken in Game Theory and its application to product portfolio management in the UK Motor Insurance Industry to determine the added value this perspective provided. To set the frame of reference for this research, this chapter will include an introduction to Product Portfolio Management, Game Theory and the UK Motor Insurance Industry.

1.2. Product Portfolio Management (PPM)

Product Portfolio Management, as the name suggests, is the management of a portfolio of products, through research, design, strategy and development of a product family and product roadmap, or future development of the products. There is also management of the product development, market release, maintenance and product end-of-life. The focus here is on the research and strategy development of the product family.

1.2.1. Design and Development

In the design and development of the product, the product manager needs to: identify the customer needs, define product specifications, source the product development, release the product and analyse the resulting sales and customer feedback (Ulrich & Eppinger, 2004).

In identifying the customer needs, multiple methods of research can be employed, such as: surveys, focus groups, and customer and sales interviews (McDaniel & Gates, 2007). These results are brought together to create the product specifications that maximise the market needs within technical and financial constraints (Jiao & Zhang, 2005). These specifications, or attributes, are also prioritised for the purpose of product development and product roadmaps.

The process of maximising the product attributes and prioritising involves further research into the attribute's cost and sales potential. When surveys are used some of the attributes' sales potential can be quantified by the customer utility factor, or historical sales data and qualitative forecasting methods can be utilised.

1.2.2. Marketing and Competition

When defining the product specifications, the product manager may also analyse the competition's alternate products available on the market. These findings may change the product strategy to either include similar product attributes, or modify the product to target an alternate consumer (Ulrich & Eppinger, 2004). The strategy taken here is dependent on company's overall strategy as defined by upper management or marketing.

The market analysis may be done by the marketing department or the product manager, but it will define the target customer. This will provide guidance on release strategy, marketing and product placement (McGrath, 1995).

During the design and development phase, part of the definition of the product and the financial constraints, was the target pricing of the the product. This pricing can be determined from the customer utility factors, competition, or market acceptance (McDaniels & Gates, 2007). The pricing is done in parallel with the product design due to the financial constraints, however defining the price requires thorough market research and understanding of the competition and market behaviour.

1.2.3. Creating a Portfolio

When creating the product portfolio the goal is to increase either market share, profits or both (Cooper et al., 2001). To maximise these goals there are two portfolio related targets that a company focuses on: niche or new markets, and minimising cannibalism.

Expanding to a product portfolio from a single product allows the company to diversify their consumer base into multiple markets and/or niches (Cooper et al., 1999). For instance, providing a scaled down and cheaper version of their product the company can target younger users. Or a product with specific additional or modified attributes can target a particular business audience.

One issue that companies wish to avoid when expanding into a product portfolio is cannibalism. Cannibalism is defined as the reduction of marketshare, profits or sales volume of one product offering due to the extension of the product portfolio (Cooper et al., 2000). The ultimate goal would be to increase the overall marketshare and/or profits from the company, or department; however, the release of a new product into a product family may reduce the marketshare and/or profits of the other related products. Consider the previous example, of the release of a scaled down and lower priced version of a product. The sales of the full scale version may see a slight hit from those individuals that would either save to afford the item, were near the price point or did not require all the attribute but overall the new version would expand the product and company's reach to include not only those that could not afford the product, but those that did not see the value in those attribute provided. The scaled down version may still accomplish what they wanted and be at a price point where the utility value out ways the price, therefore resulting in a purchase. This would result in an overall increase in marketshare and/or profits for the product portfolio, but a possible dip in the marketshare and/or profits for the core product.

The models for product portfolio optimisation vary in including either qualitative items, quantitative factors or both in the decision making model. An example of a purely qualitative model would be the works by Porter (2004). For more information on the available models and a discussion on their relation to this research, please see the Literature Review in Chapter 2.

1.3. Game Theory

Game Theory is an economic theory that focuses on the rational interaction between players and their responses to different strategies. Using this economic mathematical model, the best strategy or best response can be quantified and analysed. Over the past several years, Game Theory has been expanded to include several different types of interaction models and with a breadth of different applications.

This section includes a brief introduction of Game Theory, including the different parts of the economic model. For the sake of simplicity and its applicability to this research, the game theory model discussed here focuses on the n-player competitive game model.

1.3.1. Game Composition

A competitive game is defined as a game where strategic players have competing or opposing strategies. In some cases, these players are competing for the same pool of resources. This case is called a zero-sum game and, as an example, would be used when demonstrating the competition for marketshare. Alternatively, the players are competing for an expandable, but usually limited, resource like profits or utility value.

A game of a competitive nature is usually represented as either a matrix or, in the case of a turn-based game, a decision tree. Each entry in the matrix is the outcome for the players if they play that corresponding mix of strategies. With a multi-player came, the matrix becomes more difficult to visualise, but at its essence it is the same concept, only as a multi-dimensional shape where still each entry corresponds to a given strategy chosen by each player and the result for each player at that point is their utility for their strategy given the strategies of the other players.

The Player Utility is defined as the perceived value of the strategy to the given player. The Player Utility can be defined by a series for factors that are qualitative, quantitative or both. In learning the basic concepts of Game Theory, the player utility is stated as a standardised, nondescript value, or even 'points' in an interaction. When creating a more detailed market model, this utility is described using a utility algorithm that describes the players decision making process.

1.3.2.   Market Equilibrium

In analysing the game, a researcher can look at the general interaction of the players or look at the mutual optimum result for the players. This result is defined as the Nash Equilibrium, or the point at which neither of the players could increase their result by changing their strategy. In an economic standpoint, this equilibrium is viewed as the point at which a market reaches equilibrium. This point can always be defined, even if it needs to be defined as a mixed strategy (Nash, 1951).

With knowledge of the ultimate market equilibrium given the current market condition, a company is able to gain a first mover advantage and keep ahead of the competition as they move toward the ultimate equilibrium point. Of course, the optimal path toward this equilibrium may not be obvious. The game model can also provide these insights by viewing the impact on competitor responses as your strategy changes.

This model is also valuable to government regulators. The ability to modify the player utility through regulation, fines and incentives will change the ultimate market equilibrium. Regulator can use the model to 'test' regulation changes and see the true impact their changes have on the dynamic behaviour of the market players.

Although Game Theory as a tool in Product Portfolio Management has been briefly introduced, the model was too simple to be applicable in competitive markets (Sadeghi & Zandieh, 2010).

There are several different models that are not discussed above, in this brief introductions. More detail on the different models available and their applications can be found in the Literature Review (Chapter 2).

1.4. Industry Review

The Industry focus in the research here is the UK Motor Insurance Industry and specifically the market dynamics of the price-comparison (or aggregator) web-sites.

The UK Insurance market is typically divided into two markets: Non-Life and Life. The Non-Life market can again be segmented into: Property & Casualty and Accident & Health. Most insurance categories are optional household expenses, like Heath Insurance, for instance, where the National Health Service (NHS) provides basic healthcare and emergency services and the purchase of health insurance is an option that would provide better service and a higher level of coverage (i.e. for some procedures that may be considered optional). Motor insurance, on the other hand, is a legal requirement for any car on the road.

Historically, insurance was sold through a broker, an individual with a physical office in an economic area that helped in choosing the best insurance for the individual or company. In 1984, DirectLine changed the market dynamic by selling insurance direct to the public over the phone. In the early 2000s, on-line aggregator web-sites were set up to provide an online price comparison model, allowing customers to quickly see several quotes directly from insurers and brokers, side-by-side. Aggregator sites are visited by approximately 77% of insurance customers (Insurance Times, 2011), and an expected 56% of new business is through a price-comparison site (Datamonitor, 2012). The adoption of telematics for a portion of the market is a recent potential market shift that has not yet taken off. This technology is discussed in the research results, but is not included in the current market model presented in this research. For more information refer to the Analysis of Data and Industry Impact chapters (chapter 4 & 5).

The UK Motor Insurance industry is a key component of the insurance market. The market is fragmented, but size does matter. 60% of customers sign to the single largest provider, and 93% of customers are signed to the largest 10 providers, leaving only 7% for the remaining hundreds of providers (CII - Underwriting Faculty, 2011). In recent years, the price transparency provided by the aggregator web-sites has changed the insurance industry dramatically. Price-transparency has not only

allowed for further customer discrimination, but has opened the market up to scrutiny from politicians. This has increased pressure on insurers to change the way they look at their product and determine how they will take advantage and succeed in this new market (Gunnels Porter, 2012).

In recent years, for many reasons, the number and size of claims has risen dramatically, leaving insurers paying out more in claims than they are receiving in premiums. In the industry the ratio of operating costs, including claims payouts, to premium income is referred to as the combined ratio. A ratio of under 100% ensures profitability, but is rare in the industry. Many insurance companies operate at just above or near 100% and additional income arises from investments or other measures, leaving the companies in danger of generating substantial losses. In 2013, the UK Motor Insurance Industry made a £53m underwriting loss (ABI, 2015).

Insurance is about risk and security. For most types of insurance, customers weigh the risk of unexpected payouts against the regular cost of an insurance policy; however, to reiterate, there are Acts of Parliament and regulations that require a customer to hold insurance in certain cases. One such case is the ownership and operation of a car, requiring to have at minimum Third Party accident insurance. Third Party accident insurance is defined as insurance covering the other driver's expenses, if the insurance holder is found to be at fault. These regulations and risk of penalty increases the risk when evaluating the product.

The minimum insurance required to operate a car is Third Party Insurance Coverage; however, most drivers purchase Comprehensive Insurance Coverage, covering damage to ones own car and self, damage to the other party(s), theft of ones car and fire damage. Some levels of cover can be included as add-ons, which are additional types of cover that complement the primary purchased insurance coverage. For instance, in motor, one might purchase Comprehensive Insurance Cover, then add-on breakdown cover or lost key insurance. As beneficial as add-ons are to the consumer and to net written premiums, price is the primary driver when purchasing most types of insurance. According to the insurance times survey, price is considered as 'very important' when purchasing insurance for 81.7% for motor insurance customers (Blackman, 2012). Customer service and branding were secondary and tertiary deciding factors.

Despite evidence that a competitive pricing strategy has an advantage, 78% of insurers believe that the reputation of good customer service is the number one sales driver (CII - Underwriting Faculty, 2011). In 2010, insurance industry ad-spend was almost £60million, and when questioned 80% of insurers believe that a strong brand image allows for a 5-10% premium increase (CII - Underwriting Faculty, 2011).

With the increased use of price comparison sites, the value of these drivers has become more apparent. Insurance policies are presented on price comparison sites in increasing price order, except for sponsored listings. It is apparent that customers perceive price as important, for a majority of customers purchase from the top ten listed policies and almost never scroll to a subsequent pages for further listings (Blackwell, 2011). Nevertheless, only 30% of customers choose the first listed quote and 58% select a policy from the top five cheapest options on the page (Datamonitor, 2012). This diversion from a pure price driver has lead insurers believing that it is the perception of good customer service and a reliable brand that will sway a customer's decision.

Pricing has become more visible to the customer and many fear the market will become further commoditised. One insurer expressed that profitability and product innovation have decreased, and so has loyalty (CII - Underwriting Faculty, 2011); However, of the customers using price-comparison websites, only 34% switched their motor insurance. Even more to the point, 13% of customers had never changed insurance providers for motor insurance (CII - Underwriting Faculty, 2011).

Brokers were the most anxious of the new market dynamic, fearing the elimination of high street branches and a squeeze of the middle man; however, more than half of quotes provided on aggregator site are provided by brokers (Gunnels Porter, 2011), and although some have not survived the shift, and many physical high street branches have been closed, brokers still gain a good portion of the insurance premium market share.

The research here focuses on a case study in the UK Motor Insurance industry and the company of interest has been Zurich and Endsleigh Insurance. Zurich is an insurance broker with operations globally and a broad range of customer types, including commercial, and also acquired Endsleigh Insurance in 2010. Endsleigh Insurance is an insurance broker with a focused niche market of student and university staff insurance products. Further discussion on the case study company can be found in the Analysis chapter.

1.5. Conclusion

Product Portfolio Management typically uses analysis techniques that are two dimensional in that they do not take into account the response by the competitor of product decisions in a reliably quantitative way. The added insights of competitor response could save valuable resource in constant realignment and reactive response to market dynamics.

Currently, companies develop intricate market plans and road maps with minimal evaluation of the future responses of the competition. When analysis is done it is usually qualitative analysis by market or

industry experts with historical wisdom of market dynamics. Although this may be highly valuable in existing and stable market environments, many markets undergoing dynamic shifts or entirely new markets, do not have access to a reliable a resource for this analysis.

The use of Game Theory is a known economic model that can provide insights into the competitive response and other market dynamics in an scalable manner. It is with these additional insights that a company can gain a competitive advantage, and in a highly competitive industry like the UK Motor Insurance Industry, this advantage can make a valuable difference to the bottom line and to the future prospects of the company.

The research contained here uses Game Theory and the UK Motor Insurance Industry case study to improve upon previous Product Portfolio Management analysis models and bring valuable business and regulatory insights to the management of a company's add-on portfolio. The perspective gained from the game model in this case study are used to provide valuable insights to the UK Motor Insurance Market and to the companies that operate in this market. The contributions aim to expand upon current knowledge in academia, corporate operations and regulatory policy areas.

This dissertation contains 6 chapters that will address the stages of the research process, and conclusions discovered through the analysis of the collected data and representative models. Chapter 2 is a review of the literature relating to Game Theory and Product Portfolio Management and a discussion on this research's contribution to this discussion. The methodologies used in the research are outlined in Chapter 3 and the data analysis process is discussed in the following chapter, Chapter 4. The concluding industry, company and government insights based on the research analysis are detailed in Chapter 5. Finally, a summary of the research process and the academic and business value of the findings can be found in Chapter 6.

2.   Literature Review

Existing Work in Product Portfolio Management and Game Theory

2.1. Introduction

This research was motivated by the extensive gap in the understanding of using Game Theory for Product Portfolio Management. There is minimal research in the specific area of Game Theory as applied to Product Portfolio Management; therefore the objective of this research was to expand upon current understanding of Game Theory and its application to Product Portfolio Management and the value this perspective provides through the market insights intrinsic to the model results. This research uses a real case study and Game Theory to analyse some issues in Product Portfolio Management and includes valuable business and regulatory insights for the UK Motor Insurance Industry.

The case study methodology markedly pulls analysis methodologies specific to the area of interest from their applicable field (Yin, 2009); Therefore, to analyse a case in product portfolio management, the ideal tools would be those currently employed by companies in the case market and academic models available in product portfolio management. These current tools prove lacking in their three dimensional perspective of market dynamics and competitive response.

This chapter will review the literature in areas that developed the interest and concepts of utilising Game Theory as a tool in gaining further perspective into the market for the use in Product Portfolio Management and product strategy development in Insurance.

2.2. Product Portfolio Optimisation

Product Portfolio Management is a broad area of study and although the research in this area is extensive, it remains two-dimensional in looking into the market from the company perspective. This section will review the literature coverage as of the time of this publication, and the contributions this research provides to analysing a case, compared to the current product portfolio optimisation processes available. In today's literature the existing frameworks for Product Portfolio Analysis focus on marketing, product management and portfolio optimisation algorithms.

For reference, the stage-gate process is a new product development practice, following from Product Line Planning to the Commercialisation that is common in the market and has been adopted by many

successful companies (Griffin, 1997). This process is the industry standard with each company varying the stages and steps taken to product release. The product portfolio optimisation process, that is investigated in this research, is included in the Line Planning stage and feeds into the Strategy Development phase before each product is studied during Concept Generation and Screening.

2.2.1. Marketing

From a marketing perspective, product development focuses on the stages and details of product release and development independently.

There has been extensive work on survey methods and data analysis on surveys used to understand the customer and market before the decision of product design and strategy are reviewed (Sapsford, 1999; Grover & Vriens, 2006; McDaniel & Gates, 2007; Creswell, 2009; Blaxter, et al., 2010; etc.). The most recent research focuses on 'big data', including the recent influx of data available for market research, including Consumer Resource Management (CRM) systems, sales, market, social media and consumer behaviour data, and how this information can be maximised for product management decision models (Wierenga, 2008). The research in this dissertation utilises the discrete choice conjoint analysis methodology and applies it to the insurance industry and add-on features to the insurance product. This is the first time discrete choice conjoint analysis has been used in this context within an academic framework and the findings contributed great value to understanding consumer behaviour, specifically in developing the game model. However, the conjoint analysis alone did not include the analysis of the impact of competitor strategy on the product success like a game model provides.

There is also research and texts covering product placement and consumer analysis performed in preparation for the product launch, as well as the product planning phases. This research has been done with a customer behaviour focus (Green & Krieger, 1989) or a customer-needs-motivated portfolio (Stone et al., 2008). There is also research with a more offensive strategy, focusing not on the consumer, but on the competition with a view to create product differentiation (Hausman et al., 1994; Heidergott & Leahu, 2010). The use of Game Theory as an analysis tool for Product Portfolio Management, as seen in the research contained in these pages, combines the advantages of these two methodologies to create a model that takes the consumer behaviour and the competition behaviour into consideration.

2.2.2. Product Management

General product design and development textbooks discuss the qualitative and quantitative decision making in product development. For high technology specific issues, the text by McGrath contains a detailed product strategy analysis methodology that is commonly used by product managers (2001). The

product scoring, rating and ranking methods are most popular and are general enough to apply to most any industry (Ulrich & Eppinger, 2004). Both of these methods allow for deeper data driven methodologies to be included in the decision making, while including the qualitative strategy and consumer behaviour concepts; however, these models do not combine together the competitive strategy qualitative concepts with the quantitative market analysis. The model and research done here addresses this same mix of qualitative and quantitative analysis but combines these measures into one model to aid in product decisions and including competitive response dynamics.

Although not discussed directly in this research, the outcome of the Game Theory model would provide valuable insights into the direction of the market that can be utilised to understand the longer term targets of the product Roadmap. Product Roadmaps are where these decisions are unified into a strategic plan. Previously, the leap from the marketing analysis to the Product Roadmap is done by a Product Manager with no explicit tool set. This methodology is laid out in general by many text books, including those mentioned in the previous paragraph, as well as some more detailed methods for specific markets (Vahanitty et al., 2002). The addition of the perspective in a Game Theory model will directly imply the desired long term.

Some research has also been done on the modelling of product innovations and new product development using an agent based model of product innovation (Garcia & Jager, 2011). Although this text was a valuable resources in the analysis of product innovation, the Game Theory model included in our research added more value to the competitive analysis by modelling the competitive reactions and market impact over time.

Some service companies have recently taken to view their services as a product to allow for innovation and attribute management. A company will need a change of structure to view services as a product and manage development in a similar way as traditional product development and management (Meyer & DeTore, 1999), but there are numerous papers discussing the product management of services, most focusing on the methodology aspects alone (Sundbo, 1997; Edgett, 1994; Smith et al., 2007). These papers provide a initial general guide to product management in services, but none address the competitive strategy to follow. A few, more recent publications, discuss the management of services in a more traditional services light but with some product management teaching (Menor et al., 2002; Jaw et al 2010), but this work is early and speculative in nature. The three aforementioned items of research were referenced in analysing the insurance service as a product for the utility analysis done in this research. Thankfully the Motor Insurance Product is presented to customers on the aggregator websites as a service product and not a true service, therefore the representation in the Game Theory model was simpler than some other service industry examples may be.

2.2.3. Portfolio Optimisation

Going beyond a single product involves optimisation of a collection of products, also known as the product portfolio or product line. Introduction of the product line extensions and the impact on pricing in a competitive environment was detailed by Kadiyali (Kadiyali et al., 2010). This paper was an academic analysis of product line extensions and its use in gaining market share and price-setting power. This paper does introduce the idea of competitive reaction to the product line extension, with interesting insights, but does not formally use Game Theory as a method of analysis. The research contained here is a valuable continuation of Kadiyali's line of thinking.

Qualitative analysis for portfolio optimisation is common in marketing and business readings (Tudo & Valeriu, 2011; Yano & Dobson, 1998; Day, 1977). Some of these papers focus more extensively on particular aspects of the product line optimisation, like cannibalisation (Chaney, 1991) and estimated cannibalisation rates (van Heerde et al., 2010), or vertical integration and the effects on a product portfolio (Rothaermel et al., 2006). These theories are valuable to Product Portfolio Management for qualitative measures can clarify otherwise non-tangible attributes and concepts; however, there are limitations to purely qualitative measure, and the research herein provides a more thorough analysis using quantitative methodologies as defined by both quantitative and qualitative measures.

Some work has also been done with more detailed heuristics for portfolio optimisation (Kohli, 1990; Jiao, 2007; Green & Krieger, 1985), inspiring the player utility function in our research model. These later works have driven the development of engineering models with more detailed case studies on product portfolio optimisation; however these models are restrictive in their purely quantitative nature and by the types of products and markets that the models can be applied to. The first well known extension of product line design and optimisation was based on profit optimisation designed by Yano & Dobson (1998). Following on their work, and adding algorithm details like uncertainty and competition (Li & Azarm, 2002) or the customer-engineering interaction (Jiao & Zhang, 2005) were more elaborate and valuable models that could be used to create reliable market models, including the one in this research. All three of these models were used to inspire and develop the player utility functions to be discussed in further details in the Methodology Chapter.

Motor Insurance itself has unique aspects to product development and product issues. The most detailed research specific to insurance is the comparison of ruin theory and utility theory in analysing portfolio optimisation in property-liability (Cummins & Nye, 1981). Ruin theory is a actuarial analysis technique used by insurers to estimate the probability of ruin, or claim (Gerber, 1982). To this same effect, most insurance portfolio optimisation is based on risk management and cost minimisation based

on ruin (Koller, 2011). The concepts of risk is taken into effect in the research here, but it displayed as a portion of the utility with the use of Utility theory in the analysis of the company's utility of the product as purchased by a particular consumer behaviour risk group. These concepts will be addressed in more detail in the methodology and analysis chapters (Chapters 3 & 4).

The Motor Insurance Industry is also unique in services market as it can, due to government regulation requiring the purchase of motor insurance for all automobiles, be seen as a commodity services market. The services market has different marketing and development needs than tangible consumer products (Easingwood, 1986). Work has been done analysing products and product bundling of commodity services in the electricity market (Eakin & Faruqui, 2000) and on new services development in the financial services market (Edgett, 1994). And as Edgett states "unlike tangible new product development practices which have the benefit of extensive research into how successful new products are developed, the service sector has only recently begun to explore ways to ensure the success of new services." The research here utilises the product-like representation to the customer of the insurance service to leverage some traditional product management concepts, as mentioned before. And the competitive commodity nature of the insurance industry is broken down to show the product differentiators using the consumer behaviour surveys, allowing the product to be analysed like a traditional product. These two modifications of view to the insurance industry make the research and model here unique in theory and application.

In summary, this research is embedded in the continued debate on analysing the Product Portfolio for the development of a competitive product strategy. The current research could benefit from the insights provided by Game Theory in combining the qualitative and quantitative measures and highlighting the competitor responses to product decisions in a highly competitive market dynamic.

2.3. Game Theory

Game Theory was initially introduced by Von Neumann and Morgenstern with their book on Theory of Games and Economic Behaviour in 1944. Their ideas have been adopted across almost all research areas including, Biology (Dugatkin & Reeve, 1998) and Operations (Levinson, 2005).

Although valuable and innovative, Game Theory did not come to its full potential until the Nash declaration that there is always an equilibrium (Nash, 1951). From this realisation, the research in Game Theory expanded to new models and new applications, including the research here.

Optimisation algorithms and models used to calculate Nash Equilibrium in complex games were used in this research. The complexity of calculating the Nash Equilibrium (Daskalakis et al., 2006) is a well

researched and continued area of discussion and calculation. There are a number of algorithms and theories being used and developed that ease the time burden of calculating the Nash Equilibrium (Papadimitriou and Roughgarden, 2005; Nisan, 2007; Roughgarden, 2010), and some of these methods were utilised in the development of the model here.

2-player games have been the basis of much of the Noncooperative Game Theory research including bimatrix games, zero-sum games and a sequential game approach (DeMeyer et al. 2010; Lemke, 1964; Nwogugu, 2006; Peters, 2008). Multi-player (3+) games pose a further calculation difficulty. The complexity of calculating the Nash Equilibrium is such that including additional players greatly intensifies the computation time and complexity (Wang & Parlar, 1994). This area has far fewer research contributions, and the research here utilised a combination of qualitative and quantitative methods to simplify the market model and computation to minimise the computation time and effort. As you will read in Chapter 4, a quasi-newton non-linear optimisation algorithm derived from the n-player competitive game Nash Equilibrium calculation of Chatterjee (2009) was utilised to analyse our n-player game.

Given the complexity of calculating the Nash Equilibrium, many algorithms have been developed to estimate the Nash Equilibrium as a best approximation. The most prominent is from the established research by Papadimitriou, including reducibility (Goldberg & Papadimitriou, 2006). At the cutting edge, Goldberg is doing work on learning games (Goldberg, 2014), an extension of Game Theory with applications of Artificial Intelligence (AI) theory. This new methodology was not utilised here, but is discussed in further detail as an area of future research in the concluding chapter (Chapter 6).

The research contained here, provides some minimal contribution to the current debate on computing the Nash Equilibrium in a Game Theory model; However, the main contribution lies in the insights gained by using a Game Theory as an analysis tool to provide perspective into product portfolio strategy development.

2.4. Game Theory in Product Management

Game Theory has been applied to management and marketing research adding value and insights to business decisions. The concept of Game Theory and its use in business strategy was popularised more recently with news and popular business journals articles (Smith, 1996; Oberholzer-Gee & Yao, 2007; Matthews, 2009) and the integration of Game Theory practices into business school curriculums (Polak, 2007). A majority of the academic use of Game Theory is more qualitative business strategy decisions (Arsham, 2009; Wang & Parlar, 1989). Including, evaluating the corporate strategy on investment in

projects in a competitive environment by using different coinciding Game Theory models (Smit & Ankum, 1993).

Alternately, there has been speculation on the false analogy of business and markets as a game and the ethics of making such an analogy (Koehn, 1997). Although this paper has valid arguments to the dangers of comparing business ethics to those of standard games, there is no discussion on the added value in the quantitative analysis of the market using standard Game Theory, which strives not to make analogies, but to model realistic and rational player behaviour. It is with this belief in the value of Game Theory modelling, not comparing to game behaviour, that this research strives to add value to product portfolio decisions.

There are several examples of more in-depth Game Theory analysis of marketing problems or particular marketing or strategy issues that give more quantitative measure. For instance, a Game Theory look at pre-launch marketing announcements (Eliashberg & Robertson, 1988) or market structure in airline markets (Ciliberto & Tamer, 2009). There have also been models that expand on the traditional academic Game Theory market models to develop a model that can express an oligopoly. One such model specifically analyses product life cycle and pricing in an oligopoly (Karnani, 1984). The market under scrutiny in our research is an oligopoly and the model created therefore expands upon the game models represented here.

Industrial Organisation is an area of economic study that uses Game Theory to analyse the dynamics of competitive markets (Belleflamme & Peitz, 2015; Cabral, 2000). This concept has been used to look at why and how companies might expand or contract their product portfolio based on new entrants or new competition (Johnson & Myatt, 2003). The research here does not look at a dynamic case, but does support the theory of expanding the product portfolio when marginal revenue is growing, as seen in the UK Motor Insurance Industry. Industrial Organisation concepts have also been used to analyse the role of the Internet and how it has dramatically altered industry competition (Wang & Zhang, 2015), as seen with the use of Aggregator websites for the UK Motor Insurance Industry.

Specific to insurance there have been a few Game Theory models. Borch developed a Game Theory-like model that analysed the insurance premium equilibrium when studying a competitive market (Borch, 1984). This model built on his previous insurance pricing Game Theory model that analyses the relationship between the insurer and the customer (Borch, 1962). A more recent and very intriguing model is a price sensitivity model for motor insurance in Austria using the Game Theory model of neural networks (Yeo et al., 2001). On the other end, a clean and simple two-player Game Theory model was developed with insurer and customer in a go/no-go strategy game with consideration of risk (Lemaire,

1980). Finally, there has been recorded interest in using Game Theory to analyse the consumption or purchase decisions of customers in the insurance industry (Williams, 1960). Although this market case is not applicable to this research due to the government regulations requiring the purchase of motor insurance, this and the other models were interesting stepping stones into the modelling of insurance products using Game Theory, pricing, and now product portfolios. The research here is unique to many of these models as it analyses the market as a whole rather than focusing on a single relationship dynamic, like that between the company and the customer.

Specifically looking at Product Portfolio Management using Game Theory is a unique combination, and although product pricing (Karnani, 1984) has been analysed, there is only one analysis that has looked specifically at product portfolio management in a competitive market using a Game Theory based model (Sadeghi & Zandieh, 2010). The Sadeghi and Zandieh model is generic enough for modifications; however, the model is also very simple and focuses on a tangible consumer product. Extensive modifications were needed for the model to reliably model the UK Motor Insurance Industry and the unique aspects of this competitive commodity services market. This research added great value to the initial idea raised by Sadeghi and Zandieh by making the model broader to include an oligopoly as well as different product and market types.

2.5. Conclusion

As discussed, the research coverage for Product Portfolio Management and for Game Theory is excellent and feeds together well to deliver a clear case for the value of combining the two areas of study. It is unfortunate that this niche of study of the combination of Product Portfolio Management and Game Theory is so limited. It is with this research that the area is explored in further depth to add to the current academic debate.

The objectives of this research is to demonstrate that Game Theory brings valuable insights to understanding market dynamics for the UK Motor Insurance Industry, and improves upon previous Product Portfolio Management analysis models with the new perspective Game Theory brings to the analysis.

The coming chapters will review and discuss how this combination added value to different levels in the market, including companies, market regulators and academia. And within these levels there are several different areas of interest including product portfolio analysis, market design, modelling and algorithm design.

3.   Methodology

Case Study, Consumer Survey and Computer Modelling

3.1. Introduction

This chapter contains a breakdown of the research methods used to enable the advances and findings detailed in the concluding chapters. The research methods employed include: case study research, a consumer purchase behaviour survey and the computer game model using results from the prior methods.

Research methods were chosen based on the search for an underlying mechanism to human, or market, behaviour (Giddens & Dallmayr, 1982). The methods here will 'dig deeper' (Johnson & Duberley, 2010) to understand these mechanisms, including the use of a market model (Bhaskar, 1989) using computer modelling that will enable more reliable decision making in product portfolio management and design.

Although using mixed-methods (McLennan, 1995) may be more difficult to execute than research utilising a single method, it will enable a more complete picture than case studies alone, for this complicated research question (Yin, 2009). Each methodology was chosen to enlighten an important mechanism or aspect to the industry, enabling a reliable and robust game theory model, and an understanding beyond the simple single methods (Flyvbjerg, 2001). This research considers both quantitative and qualitative issues of decision making; therefore the methods cover both techniques.

For each of the research methods where interaction with respondents is required it is assumed that respondents have been honest and truthful. Truth is a difficult concept for it is often naturally skewed by the perception of the individual. Methods, including outlier removal, were used to avoid becoming a "deaf to human nuance" and alleviate the issues potentially caused by those that may lie to themselves or others (Lewontin, 1995).

This chapter will address each methodology as they were applied in a chronological order of the sequential exploratory design (Creswell, 2009). The first method employed was the case study, followed by the consumer survey. Finally, the game model was derived from previous research and algorithmic methods and the model was generated for the calculation of the Nash Equilibrium.

3.2. Industry Case Study

Case study is the in-depth study of a group or individual when a hypothesis or detailed research question is already in place. The methods employed in case study research differs from the methods used for that of research for a 'teaching case'. A 'teaching case' is primarily used to facilitate classroom discussion and debate, where case study as a research method is a more rigorous study enabling the understanding of complex social and market phenomena (Yin, 2009; Caulley & Dowdy, 1987).

Although some argue that generalisation from a single case is not possible (Flyvbjerg, 2006), and others disagree (Yin, 2009; Creswell, 2009), the goal of this research is to develop a game theory model and utilise this case as a testing ground. Meaning, the value of this case is its single in-depth market understanding. The case study is an important part of the research and can only strengthen the position and suitability of the computer model (Flyvbjerg, 2006). It will also further the understandings of the process and considerations companies make in Product Portfolio Management decisions, also enabling a more informed computer model.

The Case Study method was chosen for the area of product portfolio management and the use of game theory is still theoretically very thin, with only one key journal written on the subject (Sadeghi & Zandieh, 2011). Insurance has been studied and reported on in many areas, but the area of product management has been understudied. Due to the light basis of academic research in this area, the case study method provided an ideal environment for obtaining an in-depth and targeted understanding of the market dynamics or mechanisms (Easton, 2009).

The Case Study research was carried out using the Yin method of six main sources research (Yin, 2009). For this research five sources were gathered. These were: documentation, archival records, interviews, direct observations and physical artefacts. Due to logistical issues, no opportunity was available to become a part of the work at Endsleigh or Zurich, therefore participant-observation was not deemed possible for this case. To reduce impact of the removal of this source, an employee was recruited as a case study team member and briefed on the intentions of the study. He then also reported his findings on all six methods of research. The resources utilised provided perspective of the operations of the case company, their use of product portfolios in the market and the operation of the marketplace, therefore ensuring that the game structure emulates the market and company dynamics.

To clearly define the case research goals and procedure, the type of case needed to be determined. The case could be defined as a descriptive case (Yin, 2009), however, this only describes the output, not the process and research goal types. A better definition of the type of case used here is an exploratory study (Eckstein, 2000). This defines the level of detail required to create the description of the mechanisms in place in the case market and the operations of the case company.

The case study could be viewed in two different ways. First, the case study as an exploratory study (Eckstein, 2000) with the goal to develop an understanding of the industry and company operations enough to construct the game theory model. Second, the case study is to test the use of game theory modelling as a viable decision making tool. Because the key focus of this research is theoretical, and not on the usage of the game theory model in determining the market equilibrium, it was determined that the best course of action was to view the case study as one component of the study as a whole. Therefore, the case study was undertaken as an exploratory study and the output was used to develop the theoretical industry game theory model. For this method, it is assumed that the company chosen is representative or typical of UK Motor Insurance companies.

3.2.1. Choosing the case company

To choose the 'right case', a two-phased approach was undertaken (Yin, 2009) first a list potential markets that are competitive, containing more than two competitors and contain clear market segments was compiled. Then within the chosen markets a list of potential companies, that have a portfolio of products with definable features and market segments, was created. From this reduced list of potential cases each was contacted and interviewed for their willingness to participate as well as their potential for a clear game model. The following qualities, based on the recommendations of Yin and Stake (2006), were analysed in choosing the case company:

- Accessibility to company records, market data, engineering and marketing data

- Experience in a competitive market with multiple products and players

- Existing product portfolio, or in market against companies with extensive portfolios

- Not currently the market leader but has the desire to expand revenue and/or market share

- Consumer product, for greater access to market data

- Company can be assumed to be representative or typical of the industry in question

Each of these criteria ensured that the case provided all the information needed to make quality insights into the consumer purchase behaviour, the product portfolio management process and the game behaviour of the market.

Initial interviews took place with five of the potential cases, and after careful consideration using the criteria above the case study was chosen to be Endsleigh Insurance, a UK subsidiary of Zurich Insurance, specialising in student insurance. For a full list of other companies/markets considered and reasons for their dismissal, please see Appendix A.

Endsleigh Insurance has 50 years in the UK Motor Insurance market with an existing product portfolio similar to that of other motor insurance companies (Gunnels Porter, 2012). They are the market leader in student insurance, but are looking to grow and expand their motor insurance product with students and with other market segments. Endsleigh insurance is a representative company of the UK Motor insurance market for a majority of companies or brands in the market are subsidiaries of a larger insurer with niche market focus (Gunnels Porter, 2012), and their annual sales in motor insurance are near the average in the market (Business Monitor International, 2012).

3.2.2. Case Research Process

The case research process was initialised with market research database and market media searches. Then initial interviews with management were carried out, followed by gathering of company documentation and records. Employee and market observation research was then carried out. Further interviews were carried out for any questions that arose during the observations and/or company investigation.

Designing the case study took place after an initial period of industry research. The initial period of industry research allowed for a greater understanding of how the market operated, allowing for the case study research design to align with the actual market operations. For instance, a standard consumer product would include engineering and manufacturing costs, where being a service, the motor insurance industry does not have these costs, but will have overhead and legal expenses and insurance payouts. This unique dynamic changes the lines of questioning and the search criteria for documentation. The design also clarified the target of the case study research. Initially the case study was focused on a single case of Endsleigh Insurance; however, given the theoretical aspect of the planned game theory research, it was determined that the research is more conducive to a single case study of the UK Motor Insurance industry with the 'embedded case' (Yin, 2009) relating to Endsleigh Insurance.

Before the bulk of the data is collected, a formal approval of the research coverage and plan was agreed upon with the case study company (Gunnels Porter, 2012). A full review of the research questions was also done. There are five levels of questioning in case study research (Yin, 2009). The research questions to be in place for the study, the research patterns, the case study specific questions and finally the planned interview questions.

Finally, the gathered case study data will be analysed in terms of the research questions. More information on the analysis can be found in the Analysis of Data chapter.

3.2.2.1. *Industry research, data and reports*

Before any in-depth interaction with the case company could occur, a thorough understanding of the workings of the market was required (Yin, 2009). The Industry research was first used to familiarise and focus the research on the relevant and industry issues and to gather an understanding of its structure and and workings. Then, after creating the research design, further industry research, data collection and review of reports were analysed for indicators of market structure and dynamic that would be relevant to the game format. The required information was gathered by utilising the market data sources, governing bodies and related media.

The market data was gathered from all available sources, including: Mintel Data Monitor, MarketLine and Business Monitor International. Market reports by consulting firms and related private companies were also reviewed, including: Earnest Young, The Boston Consulting Group and Towers Watson. These market summaries, review documents and market data gave an overview of the market as a whole from a business prospective for their audience is primarily companies operating within the market wanting to gain more insight.

For a clearer prospective from a consumer and economic standpoint the results from surveys and investigations by UK and motor insurance governing bodies were reviewed. These included: Association of British Insurers (ABI) (2008 & 2012), Royal Automobile Club (RAC) foundation (2014), Department for Transport (2014) and the Crown (2009).

Finally, the media coverage of the market was reviewed. Although sources like BBC News and Financial Times were reviewed, a majority of coverage in the industry is done by the insurance market focused publication, the Insurance Times. The Insurance Times also provided great insight through the funded surveys and market investigations they carried out.

With the information gathered from the initial sweep of market data, the case study research design was completed. The design included the study questions and interview and observation questions, and a plan of action for continued research.

A secondary look at market data was more in-depth, targeting the case study company and the study specific questions. The market data was also reviewed for information relevant to understanding the changes in the market that lead to the current state (Yin, 2009) and the particulars of the current state. This review searched for evidence to the 'why' in the market dynamic (Eisenhardt, 1989).

3.2.2.2.   *Interviews and Observation*

Interviews are the most important source of information in case study research (Yin, 2009). Interviews were carried out with senior management, product managers and sales employees to get a full perspective of the dynamics of Endsleigh Insurance, Zurich Insurance and their position in the market.

The question planning from the research design contains the focus of the interviews. Level 1 questions are those to be asked of the interviewees; however, level 2 questions are important to keep in mind when working with the flow and direction of the interview (Yin, 2009).

Interviewing allows for a flow of questioning that targets the study questions as well as allowing for flexibility during the interview if new issues or questions arise (Rubin & Rubin, 2011). All interviews undertaken were classified as shorter case study interviews (Yin, 2009), allow some included follow-up that extended the overall interview time to become classified as a prolonged case study interview. The shorter time was more appealing to the senior and mid-level employees interviewed, for whom time was valuable.

Notes were taken during interviews and compared to the transcriptions recorded after. Interviews were recorded on a digital recorder to enable the transcription within a week of the interview (Blaxter et. al., 2010). Transcriptions and notes were analysed (Gillham 2005), using thematic analysis (Aronson, 1994) for answers to the research questions, including common themes and concerns. Thematic analysis allowed for a clear coding system that highlighted, without bias, the themes, concerns and mechanics discussed during the interviews (Fereday & Muir-Cochrane, 2008).

A codebook was developed a priori, using the initial case study research used to develop the research structure and questions. This codebook was then utilised in the template approach as revealed by Crabtree and Miller (1999). The coded material was then connected to identify themes.

Observation is used to add new dimension to the study above and beyond what an interview can provide (Yin, 2009). Observation of Endsleigh took place in the corporate headquarters, as well as in one meeting and one orientation fair held at UK universities. Universities are a key market segment for Endsleigh and they maintain a close working relationship with the staff and students (Gunnels Porter, 2012). Regular notes were taken during the observation and themes extracted from the notes. These themes were compared to and matched to the themes uncovered during the interview process.

The interviews and observations were analysed, and compared, for detail in the mechanisms in the UK motor insurance market and the product value calculations considered in the company. This analysis will be discussed further in the Analysis of Data chapter.

3.2.2.3. *Company Documentation and Data*

Company documentation regarding the product development and sales process were gathered to highlight any mechanisms not mentioned, and back-up any details given, during interviews. The thematic analysis discussed in the previous section was applied and compared to the results from the interviews and observations.

Sales data was also retrieved to get a typical view of risk, customer purchasing choices of product attributes and customer profiles. This data may have been used as the consumer purchase behaviour data; however, the survey was viewed as a more reliable option for it also would contain branding influence and no bias in the data set. Endsleigh sales data was only for Endsleigh potential customers, creating a volunteer bias in the data, where as the survey data covered a wider collection of respondents. The sales data from Endsleigh was used to verify the results obtained from the survey data. More information regarding this process can be found in the Analysis of Data chapter.

3.2.3. Information Unavailable

As will be discussed later in this chapter, conjoint analysis can be carried out using consumer survey or by using actual sales data. During the case study research, attempts were made to acquire the actual sales data from any of the price comparison websites. Real sales data is viewed by some (Train, 2009), to be more accurate then survey data. Unfortunately due to legal constraints and reluctance on the part of the price comparison websites, the sales data was never made available for the purpose of this research. For this reason, a consumer purchase behaviour survey was undertaken.

3.2.4. Company Confidentiality and Data Protection

A part of gaining access, is to have a professional and trusted relationship with the company (Yin, 2009). During case study research many company sensitive and company private details are revealed to the researcher, therefore data and information security does become relevant. Product Portfolio Management is heavily tied to a companies corporate strategy, and often times projected out 2, 5 or even 10 years. If publicly released, this could have a negative impact on the company and change the dynamic of the competitive market. Therefore, a full understanding of the companies expectations were agreed upon prior to the start of the case study and release of any sensitive information.

Security measures were taken to protect the sensitive company and individual data collected. Password protection was used on every computer and clouds containing the data. Hard copies of any sensitive information were not printed unless in special cases. These printed copies were destroyed via shredding immediately after use (Dench et. al., 2004).

Endsleigh Insurance was notified of all sensitive data gathered. The access and use of this data was agreed upon prior to the study commencing in a project proposal contract (Gunnels Porter, 2011). Included in this contract was the recommended informed consent, privacy protection procedures and confidentiality (Yin, 2009).

3.2.5. Judging Case Study Quality

During the design of the case, four tests were used to test the validity of the case study research: construct validity, internal validity, external validity and reliability (Kidder et. al., 1986). These tests are common to most lines of research, therefore documentation is widely available and may be seen as common knowledge.

Validity was constructed into the case study design in two main ways: multiple sources of evidence and review of case study draft by key informants (Yin, 2009). Multiple sources of evidence were designed into the case study, for instance, complementing the company documentation and observations of product value ideal at Endsleigh, with the questions during interviews pertaining directly to this area. The case study was drafted first as a teaching case and was reviewed by all those involved in the case study research before publication. Furthermore, this dissertation was reviewed by key informants prior to submission.

Internal validity was conducted using explanation building, a form of pattern matching, as described by Yin (2009). A Theoretical Construct Table, summarising evidence for each theoretical construct used in the case study analysis (Eisenhardt & Graebner, 2007) was also generated for the formal analysis of the market mechanisms. The use of addressing rival explanations was considered, unfortunately, due to the lack of academic study in this area, there were no other reliable explanations available for comparison. For more information on this process and the outcome, please read the Analysis of Data chapter.

To verify the assumption that Endsleigh is a typical UK motor insurer, the archival data of the operations of Zurich and Endsleigh before the purchase of Endsleigh was reviewed for common practice of product value calculations and market interaction.

Reliability can be assured through the development and adoption of a case study protocol, that highlights the case study design and focus (Yin, 2009).

3.2.6. Concluding Comments on the Case Study

The case study research was a very useful method to better understand the mechanisms behind the UK Motor Insurance market. The presentation of a mixture of methods and the in-depth nature of case study research (Creswell, 2009) provided the ideal framework to explore the PPM process and UK Motor Insurance market.

These methods gave the research a 'real-life' perceptive of the operations involved in product portfolio design and to highlight the market phenomenon, "unfold in practice" (Flyvbjerg, 2006). It will also illuminated first hand encounters of the decision process for product portfolio design and market viewpoints, a unique quality of case study research (Schramm, 1974).

3.3. Consumer Survey

The Consumer Survey allows for the consumers to be directly addressed and questioned on their buying behaviour and attribute choices. Although it can be argued that recent sales data would provide more realistic results, the survey allows for purchase comparisons that may not be typical in the market to be analysed (Train, 2009). A majority of consumers in the UK Motor Insurance market, use price comparison websites. On these sites, the consumer is first asked the level of insurance they wish to purchase prior to entering the price comparison pages (gocompare.com & confused.com; 2013). Therefore, if real sales data were used from these sites, the insurance level choice detail would not be available, and would be a consumer self-selecting attribute, rather than a purchase comparison choice. The purpose of the survey was to gather the customer perceptions of insurance products, including various insurance levels, as well as providing insights into the attribute factors involved in purchase decisions.; therefore, the survey provided more consumer purchase behaviour information than the real sales data.

To better understand the customer perspective on insurance purchasing, questions will cover attribute value, brand perception, portfolio breadth and product quality. Dillman's 'tailored design method' for internet surveys was employed to create a survey with unbiased and comprehensive questioning, as well as the desired response rate (Dillman, 2007). The survey software used did not enable piping , to integrate previous answers to open-ended questions into follow-up questions (McDaniel and Gates, 2005), but enabling respondents to answer all questions, then filtering of responses after the fact created a similar effect.

3.3.1. Survey Writing

Great care was taken in the survey writing process. The survey was written in two main sections, the demographic questions and the choice-based conjoint analysis choice set questions.

The survey was determined to be no more than 25 questions long, with an expected completion time of no more than 10 minutes, including open-ended questions. This length is seen to be sufficiently short to be more palatable to respondents (Sheehan, 2006). The survey was submitted to consumers in an

electronic format, with a link to an on-line survey using the service Survey Monkey. This tool was easily accessible to respondents and provided an exportable database for the gathered data.

To maintain data integrity and prevent bias, all survey questions were reviewed by multiple parties. The reviewers looked at the four general guidelines: clear wording, non-biased wording, respondent is able to answer the questions and respondent is willing to answer (including question flow) (McDaniel and Gates, 2005). Surveys were be sent out using a web-format to avoid coercion bias (Nosek, et. al.; 2002). Survey respondents were paid a nominal fee through Survey Monkey for completed the survey to encourage a high response rate. The survey was also pretested to look for misinterpretation and respondent reactions (McDaniel and Gates, 2005).

To understand the details of writing the survey, the sections below will detail the considerations taken in choosing the conjoint analysis method and in writing the individual survey questions.

This sub-section will elaborate on the process in writing the survey and survey questions. First, the conjoint question method was considered reviewing a few possible different methods. Once the conjoint analysis and question method was agreed upon, the actual survey writing and question creation was done. This included the writing of the demographic questions, the formulation of the conjoint analysis question-sets and choice-set, and finally the layout and format of the survey and survey questions.

3.3.1.1.   Choice Based Conjoint Questions

Conjoint analysis is the use of survey data where attributes are "considered jointly" (Train, 2009) to derive a function describing the perceived customer value of a product or service (Liew, 2013). The customer behaviour is modelled using a series of product attribute related questions either as direct inquiry regarding the attribute value, or as indirect product choice questions (Chen & Chitturi, 2012; Chrzan & Orme, 2000). The responses are then collated to calculate the customer utility function, which is represented as a regression model based on the product attributes and levels. This linear utility function, or set of utility functions were then used as input to the game theory model to represent consumer purchase probability, and therefore market value, of a given insurance package. Details of the later will be discussed in the Deriving the Game section of this chapter.

Traditional conjoint analysis is also known as stated-choice conjoint analysis or ratings-based conjoint analysis (Elrod et al., 1992). In this model, the consumer is asked to respond to a series of product attribute questions that directly ask for the product attribute value either with the use of a Likert scale of importance (Likert, 1932) of the attribute or by ranking the attributes in order of importance (Murray, 2012). The stated-choice conjoint analysis is simple to develop and easy for the consumer to

follow (Raghavarao et.al., 2010). To enable the survey to remain close to the market mechanisms, as referenced earlier, this method was not used.

Choice-based conjoint analysis is the use of questions where a set of product choices are presented to the respondent. The respondent, or customer, is asked to choose one product they would purchase, if the ones shown in the question were the only ones available on the market.

This method of Choice-based conjoint analysis is argued to be closer to the marketplace setting (Raghavarao et.al., 2010) with consumers choosing a single product from a set of available products. And although the questions are more difficult to develop, the resulting regression model is simpler. The utility function represents consumer choice weights, and in choice-based conjoint questioning, the choices are taking place 'real-time' (Train, 2009).

The choice-based conjoint analysis questions are more difficult to develop, requiring the generation of question choices and the choice-sets (Raghavarao et.al., 2010). These choice-sets and how they were determined will be reviewed in more depth in the conjoint analysis questions subsection of the question creation section below.

For more information on the use of choice-based question responses to achieve the linear regression models of the consumer utility, see the Conjoint Analysis subsection of the Data Analysis section below.

Mixed conjoint analysis combines the use of stated and choice-based conjoint analysis. Few studies have been undertaken to look at the added value and potential risk of using a mixed method. Speculation has been that mixed conjoint analysis won't combine the best of both a stated and choice-based conjoint analysis study. However, it was my concern that asking the stated-choice questions prior to asking the choice-based conjoint analysis questions would be a form of leading, where a question or survey style, leads the consumer to act or think differently than they normally would.

Before initiating the final survey a a small test was run to look at if the use of mixed methods in conjoint analysis would cause a different consumer response. More details on this process can be found in the Survey Testing section below.

3.3.1.2.   Question Creation

The survey consists of two key types of questions: the demographic questions and the conjoint analysis questions. Both question types were written with the process discussed earlier. In this section the question creation considerations and methods will be reviewed.

3.3.1.2.1.   Survey Introduction

The first page of the survey consisted of a welcome introduction to the respondent. In this brief introduction, the subject matter was framed for the reader in a manner that did not interfere with the respondents behaviour (Sapford, 1999).

3.3.1.2.2. *Demographic questions*

The demographic questions were written to gather any identifying information regarding the respondents. The intention was to be able to pinpoint clusters of consumer with similar behaviour that could be identified by one or all of these demographic characteristics.

The demographic questions were chosen based on the general demographic questions asked (gender, age, etc.), general economic identifiers (income, employment status, etc.) and driving behaviour (mileage, driving usage, etc) and current insurance product. For the general and economic questions, the questions were pulled from the Survey Monkey database of approved and verified questions. These questions are those used by large research organisations and have repeatedly been verified in large surveys. For example, the economic question regarding current employment status was previously used in the US Census and comes from the US Census Bureau database of verified questions.

The questions for driving behaviour were created using non-leading voice (Fowler, 2009; Sapsford, 1999) and numbers were chosen based on consumer averages gathered by the RAC foundation. Their statistics are gathered from a range of surveys. For instance, the average household annual mileage was gathered from the National Travel Survey from 2012 gathered by the Department of Transport UK. With this data, customer behavioural clusters could be later categorised for more meaningful clusters, as will be discussed later.

3.3.1.2.3. *Conjoint Analysis questions*

As mentioned earlier the chosen question method for the survey was choice-based conjoint analysis. The product attribute levels were constructed using the three experimental design recommendations as outlined by Train. Each attribute and level is to be tangible and understandable to the consumer, number of levels that provide data accuracy with out over complicating the question and maintaining a distance between quantitive variables that is representative of the market yet small enough for data evaluation (Train, 2009).

To create the question product options, the Design of Experiments (DOE) function for Choice question creation from the JMP 13 (an SAS component) software package was used. When providing the features and feature levels, number of questions and products per question, and the conjoint utility

result (main-effect only or secondary effects), the software would generate the set of choices and question set-up.

A possible range for the number of questions was chosen based on the previous survey studies of Train (2009). From his research he found that more than 8-10 questions would cause the respondent to start to loose interest and the choices would be less reliable. The number of choices for each question was also chosen based on the research of Train (2009). It was found that more than 5 choices left the respondent overwhelmed and unable to make a decision. After this initial understanding of the number of questions and choices, the final numbers were determined by the ability to give a statistical and full utility function from the questions provided. JMP Design of Experiments (DOE) was utilities to find the optimal question set. The DOE utility contains a Choice Design function under the Consumer Studies section. This Choice Design function is specifically designed to create the optimal question and choice sets based on the factors included. For our survey, some of the attributes are predetermined by the market, namely add-ons and insurance level. The factors for add-ons are the set yes/no option and insurance level contained the three factors of Comprehensive, Third Party Theft and Fire and Third Party only. Finally, the number of factors for brand were determined by the strategic competitor analysis. Price was determined based on market prices, but was narrowed from 5 factors to 4 after finding that a survey of reasonable size was not possible given the number of attributes.

After entering the attributes and factors, the number of questions and choices are entered into the model. JMP posts an automatic alert if the number of questions and/or choices per question were not sufficient to provide a statistically significant result, therefore from trial and error, and remaining within the above mentioned parameters, the final survey was generated with 10 questions and 4 products per question. This number of questions and choices is the most efficient choice design providing attribute coverage. The final profile (the set of questions and choices) table is provided in Appendix F.

The question set-up provided from JMP was run several times until one was found to suit the survey's needed. The question options could not have an obvious rational option for every question (Raghavarao et.al., 2010). They should be set up as realistic to the market as possible, meaning competitive and relative (Green & Srinivasan, 1990). Finally, it was desired that one question function as a test question, as discussed below.

3.3.1.2.4.   Test question

A test question (Question 22, Appendix F, Image F.8) was presented as a method to identify and remove malicious or insincere respondents. This test question appeared the same as the other question; however, the options were so extreme that there was only one rational choice to be made. Any

respondent that chose a product other than this obvious choice was removed from the data pool. To check this decision, these respondents were also tested using hypothesis testing to show that they had behaviour so removed from the norm that they could be statistically considered an outlier. Other methods were employed to remove outliers. These are discussed in the Outlier Removal section of this chapter, as well as in the Analysis of Data chapter.

3.3.1.2.5.   Question Appearance

The question's appearance, order and presentation can have an impact on the respondent answers and behaviour (Fowler, 2009). For this reason, the question order, number of questions per page and question appearance were taken into consideration.

The question order was chosen at random from the JMP software, and was the same for each respondent to maintain consistency.

It was revealed during the survey trials and tests that the number of questions per page had a dramatic effect on the respondent behaviour. This is consistent to findings mentioned earlier from Train (2009). It was determined that for demographic questions, the questions would be grouped on a page with questions of a similar topic to ease understanding and flow of topic. The choice-based conjoint analysis, on the other hand, were presented with one question per page to eliminate any confusion of choosing one product per page, versus choosing one product per question (an issue that arose during testing).

The products had a representative brand that fell into the categories of 'Big Insurance Brand', 'Big High Street Brand', 'Big Other Brand' and 'Small and Medium Sized Insurer'. One insurance company was chosen from each category based on similar logo colourings. It has been shown that if one logo differs greatly (i.e. one insurer was light and the others were dark, size etc) there is a bias in the responses (Evans & Mathur, 2005). For this reason, the logos chosen were of a similar colouring and the same size. The following logos were used:

a.   Big Insurance Brand - LV

b.   Big High Street Brand - M&S

c.   Big Other Brand - Nationwide

d.   Small & Medium Sized Insurer - Endsleigh

3.3.2.   Survey Delivery Method

Determining the most reliable and accessible survey delivery method and the considerations of respondent profiles and data security will be considered in this section.

3.3.2.1.   Choosing a Survey Delivery Method

The method of survey delivery was considered at length. Paper surveys sent via mail have proven to be slow and unreliable (Sheehan, 2001). Interviews had shown to provide the most reliable survey data and higher response rates. For this reason, the initial survey design was presented as an electronic survey with responses gathered in person. This would allow for any extra observations to be made on the consumer as well as answering any concerns along the way.

After the survey was designed as discussed in the sections to follow, a test survey was conducted in this manner. The individual gathering survey data observed that this method had a strong volunteer bias. This bias appeared to be even stronger than that seen in other electronic surveys (Dillman, 2007). For, this reason, and due to time pressure, it was decided that the final survey would be conducted using electronic questioners sent out via email. Due to this change, a second survey test was conducted. It was shown that there was no statistically significant difference in the responses between the two survey delivery methods.

Two different electronic survey software packages were tested before deciding to use Survey Monkey. Qualtrics, a popular software package for large corporations and provided by the University, was used for the initial survey test. However, due to contract restrictions and minor layout issues, the survey was transported to Survey Monkey. The colour, layout, images and questions were identical to the Qualtrics package, so no visible difference was detectable between the test and final survey. The great advantage to Survey Monkey was the open availability and the large survey respondent pool available.

3.3.2.2.   Method and Respondents

Audience, the Survey Monkey survey respondent pool, was large and demographically and geographically diverse. This provided an ideal quick way to gather data from a group similar to that of the UK Motor Insurance consumers. The respondents are encouraged to respond by a pay-per-survey scheme where the respondent is paid for their completed surveys. It is shown that a responses are highest when a small monetary payment is offered (Hansen 1980).

The survey ran on Survey Monkey over a period of two days on the 27th and 28th of February 2014. The total cost of the project was £530. This included the necessary upgrade of the survey monkey package, to allow for a greater number of questions and respondents, and the price of using Survey Monkey Audience.

The sampling frame included all potential respondents of age to drive or hold motor insurance in the UK, and members of the Survey Monkey audience. The Survey Monkey audience does contain a

'selection bias' that was assumed to be minor in comparison to other accessible respondent pools. The bias comes from the respondents being technologically familiar enough to be involved in the audience scheme. From the demographics gathered during the survey process, there was not an obvious skew in the representative nature of the respondent pool. Each demographic figure of the sample was compared to the known market demographic from alternate sources. These demographic proportions were within representative tolerance levels and ensured the selection bias was most likely benign. Other potential sampling frames analysed were not as representative (e.g. using University students and staff, face-to-face interviews in two cities).

A target response number of 269 (confidence interval of 90%, margin of error of 5%) respondents was calculated using the statistical validity calculation (Curwin & Slater, 2007). Where ϕ is the desired number of respondents, z is the z-score of 1.65, ϵ is the margin of error and the normal distribution, *p,* is 50%.

$$\phi = \frac{z^2 * p(1-p)}{\epsilon^2}$$

The target number of respondents was not reached, but 186 did, which would give a confidence interval of 90% and a margin of error of approximately 6%. After removal of incomplete or incompatible responses there were 162 respondents. Removing outliers and those from test question, the final number of responses was 115. This number of respondents is still statistically significant with a confidence interval of 90% and a margin of error of just under 7.65%. For more information regarding the number, response rate, data cleansing and quality of respondents, please see the Analysis of Data chapter.

3.3.2.3. *Data Security*

Security and organisation is a big concern where the data may be perceived as private. The EU Socio-Economic Code of Ethics was used as a general guide to handling consumer data and sensitive information (Dench et.al.; 2004). All data was be kept on a secure cloud server, in a SAS database. Access to the cloud is password protected and access known only to the lead researcher. Contact details for the respondents were be kept in a separate database from the actual data and held by Survey Monkey, to reduce the ease of cross-reference. This allowed for follow up, if necessary and permitted by the respondent.

3.3.3. Survey Testing

The survey was tested before the final survey was disseminated. This section will discuss the general design of the survey testing done prior to release and the general findings. Three tests were performed. First, a standard test on the survey reliability and question formatting before release. Second, A more detailed tests of mixed conjoint versus choice-based conjoint survey structure will be also evaluated. And finally, the survey delivery method was changed and a small test was run to ensure reliability of methods.

3.3.3.1.   *General*

The Survey test consisted of 30 respondents with a 100% response rate. Respondents were selected from a group of diverse people of various backgrounds, but all known by the researchers via various contacts. This ensured a high response rate and yet still maintained diverse and reliable responses. A small proportion (5) of the respondents were interviewed in person at a local grocery.

It was found that the interviewing process was slow and response rate rather low. This called into question the value of continuing with this line of questioning for the final survey. Interviewing was not used in the final survey.

The survey invitations were sent as personal e-mails to each individual. The invitations consisted of a thank you, details of the prize draw and a link to the survey. The survey was presented using the on-line software Qualtrics, which provided uniform and easy access to all participants.

The grocery respondents were compared to the remaining responses to ensure consistency. The interviewed surveys were found to be particularly valuable in the feedback regarding the survey set-up and the questions. It was found having more than one choice-set question per page caused confusion with respondents. The responses showed respondents choosing one product per page, rather than one product per choice-set. Standard format was utilised, however, the stated-choice questions were commented as being confusing and difficult to answer. The prices set for the insurance products was commented as being too high. References were consulted to create a more accurate and representative price range.

After the changes were made a small test was run before the final was sent out. This was to ensure consistency and that the changes did not impact the responses.

3.3.3.2.   *Mixed Conjoint versus Choice-based Conjoint*

Minimal research has been done with regard to the differences in Mixed Conjoint and Choice-based Conjoint survey results and the consumer response behaviour. The existing research was discussed in the

Literature Review chapter; however, it was determined that a small test directly related to the UK Motor Insurance market would be a valuable addition to the survey results.

The initial survey test consisted of the two types of conjoint survey questioning: Mixed conjoint and choice-based conjoint. The mixed conjoint questions contained the stated conjoint analysis questions, followed by the choice-based conjoint questions. It was hypothesised that the questioning of stated attribute preferences, prior to market-like choices, would change or sway the way the respondents thought about and answered the choice-based questions.

It should be known that this test can not be considered conclusive, for the survey was small. Further testing regarding this hypothesis is needed and would be very valuable to the market research community.

Groups were selected at random from the test survey respondents. The response rate was 100%, therefore statistical analysis regarding the response rate was not necessary. Hypothesis testing using the student t-test was used to test is the two groups responded differently. All bias with regards to demographics was checked for, and there was no significant bias.

The hypothesis test showed that the two groups did in fact respond differently. The resultant utility functions demonstrated the respondents answered the choice-based questions differently if they were asked the stated-choice questions prior. The reasons for this difference can only be by speculation and warrants further study, but the assumption is that the stated-choice questions initiated the consumer to think more about the attributes in a conscious manner that they may not do in a market setting. Due to these results it was determined that the final survey was to be conducted using choice-based conjoint analysis questioning only.

3.3.3.3.   *Changing Survey Providers*

As discussed in the prior sections, it was determined that an interview survey would not be a viable survey method for the purpose of this research, alternate survey dissemination methods were analysed. The Survey Monkey audience was deemed to be the best option, with a diverse respondent base, cost effective and flexible enough for the needs of the research questions.

This was decided prior to the second small test survey, therefore the consistency checks were not only checking due to the suggested question changes, but also for the format change from Qualtrics software to Survey Monkey software.

It was assumed that this change would have no effect, for the aesthetics of the two software options were virtually identical; however, utilising the second survey test to check for consistency was reassuring for the continuation with the new survey dissemination method.

3.3.4. Data Analysis

Conjoint analysis was used to generate consumer utility values for each of the product attributes. With the use of these, attribute utility values are treated as the results of the survey and are analysed in the following three ways: outlier removal, hypothesis testing and cluster analysis. Each of these are details in the following sections. The target of these forms of analysis will be for a representative set of consumer purchase behaviour, or consumer utility, functions.

This section contains the background and methods utilised during the data analysis. For more information regarding the results from this analysis, please see the Analysis of Data chapter.

3.3.4.1. Conjoint Analysis

The concept of conjoint analysis is derived under the assumption of utility maximisation by the decision maker, or respondent (Thurstone, 1927). This model states that a consumer will chose product i, if the utility of product i is greater than the utility of each and every other product available on the market, including the option to not purchase a product at this time. The overall scale of utility is irrelevant, for it is not a direct measure, but a comparative measure used to estimate probability of purchase (Train, 2009).

From the survey answers, the responses, or chosen product, for each choice-set is programmed into the software and the conjoint analysis is run. The resulting utility part-worths, or attribute coefficients, are estimated using the Firth bias-corrected Maximum Likelihood Estimator (MLE).

Research has shown that the most reliable predictors from conjoint analysis derive from when consumer utility functions represent only economically or behaviourally similar consumer groups. "The accuracy of demand estimates can be improved by identifying unique customer utility functions per market segment, or class of customers to capture systematic preference variations" (Ben-Akiva and Lerman, 1985) Therefore, Each consumer market segment type has a full utility function. The algorithm uses conditional statements to determine the utility function to be used for that consumer segment. This is fitting, for the calculations used in the player utilities where the expected market value is actually calculated segment by segment (or in this case for each cluster).

Following part-worth conjoint analysis, the consumer utility, of the *i*th segment for the *j*th product and the *m*th player, U_{ij}^m, is assumed to be a linear function. Three market segments where $i \in I = \{1, 2, 3\}$ were defined using cluster analysis and hypothesis testing. One of the part-worth binary independent variable is brand, where a player, m, is part of a pre-set brand type (see Definition 2).

For a product, $j \in J$, where J is the full set of 384 possible products (including brand variation) and $\Upsilon \subset J$, where Υ is the set of all 96 possible products per player. Each product, j, is defined by a set of attributes that determine that utility of the product. The attributes for UK Motor Insurance are the Insurance Level, Brand, Price/Rate, and Add-ons. Each attribute has various attribute levels that contribute as the independent variables in the customer utility function.

For more detail on the calculation involved in the conjoint analysis results and the results themselves, please see the Analysis of Data chapter.

3.3.4.2. Outlier Removal

In developing the survey, it was assumed that respondents were honest in their responses; however, with the use of a large sample size and the outlier removal method outlined here, any respondent that was obvious in their deception was removed from the respondent pool.

Outliers create a skew to all of the utility functions calculated (Jolson & Hise, 1973). They also have a very heavy impact on cluster analysis (McDaniel & Gates, 2007).

For the cluster analysis, distance is used to determine the groupings. An individual that is further out from the group may shift the centroid in the calculations, moving the group and changing the dynamics. There are certain cluster analysis techniques developed specifically to minimise the effect of outliers, but no technique will be fully robust to this issue. Ward was chosen as my analysis technique for it is more robust against outliers, especially in high dimensional problems (Everitt et. al., 2001; Ward, 1963). Despite this effort, outlier removal was undertaken to provide a cleaner dataset to work from.

To prevent issues from outliers during cluster analysis three methods were used in removing them from the data: test question, coefficient outliers and cluster analysis.

First, as discussed earlier a test conjoint question was inserted into the survey (Question 22, Appendix F). This question had only one reasonable choice, and anyone answering otherwise can be assumed to be answering questions without forethought or maliciously and considered an outlier.

Second, all individual coefficients were graphed and outliers highlighted. The use of graphing to highlight and remove outliers is widely used in one or two dimensional problems (Hooley & Hussey, 1999). Due to the high dimensionality of this problem, outliers for each individual dimension were analysed. A respondent was deemed an outlier and removed if they proved to have more than half of the dimensions highlighted as an outlier. reason respondent was not removed for fewer outlier dimensions is to avoid removing an individual for simply having a different view on a particular add-on or brand. However if a respondent swayed from the norm in many areas, they were seen as outliers. Those identified as outliers were viewed together by their defining characteristics to see if they had anything in common or could be viewed as a niche cluster.

The individual respondents identified as outliers were compared and contrasted based on demographic information to check for the possibility of niche behaviour. This was not seen to be the case, but further research in the consumer purchase behaviour with a larger sample size would be necessary to confirm.

Finally, Cluster Analysis can be used to identify and remove outliers (Sumathi & Sivanandam, 2006; Tan et.al, 2005; Everett et. all., 2001). The procedure would be to define any 'small' clusters, remove those individuals and re-run the analysis. In my analysis I came across several clusters of only one individual, even when looking at a small number of clusters. I believe it may be best to remove these individuals (possibly one by one), and re-run the analysis. For instance, when going from 3 clusters to 4 clusters, there was a noticeable difference in the distance measures; however the 4th cluster contains only one respondent.

These same 'small' clusters are seen in both the hierarchical Ward's method and the K-means cluster analysis methods. They are even the same respondents. For this reason, the two offending respondents were removed and cluster analysis was run again.

3.3.4.3. *Hypothesis Testing*

Hypothesis testing was used on the survey data to determine differences in consumer groups. For the purpose of these tests, the null hypotheses stated that there was no difference in the data, and a 95% confidence interval was used.

Before performing the demographic differences testing, which will be discussed later, an initial test was run to check data quality and estimation bias. The sample was divided into two using random methods and checked, using hypothesis testing, that the two groups showed the same customer behaviour. This was the case, therefore the sample was viewed as viable for continued testing.

With the use of the demographic questions, the survey population was divided into each of their corresponding group for that question criteria. Using student t-test hypothesis testing was performed on the commonality in purchase behaviour between the groups from that demographic question criteria. These tests were repeated for each demographic question.

Although, this test did not provide clusters or definitive market segments viable for the game model, they did demonstrate clear differences in purchase behaviour between demographic groups and the results were used to verify the findings in the cluster analysis.

The tests were conducted on both the final utility scores and the behavioural coefficients. In some demographic cases these two tests had different results. This difference most likely occurred due to the statistical significance of the factors. Not all behaviour coefficients were deemed as statistically significant, and although this discrepancy was taken into account during the hypothesis testing of the behavioural coefficients, that was not possible with the final utility scores. For this reason, the tests were not used for the mechanism building of the game model. These tests were still useful in showing the validity of the cluster analysis tests for there were notable and understandable differences between certain groups (e.g. High/Low Income).

After the inconclusive nature of the hypothesis testing, cluster analysis was proposed to divide the respondents based on behaviour, then derive the characteristic differences from these clusters.

3.3.4.4.   *Cluster Analysis*

Cluster Analysis is the process of dividing the respondents into groups based on their similarities in purchase behaviour. For the purpose of creating a realistic utility function, it is believed that different utility functions are required for different types of customers (Train, 2009). Analysis was undertaken to test what characteristics made a difference in purchase behaviour.

The JMP 13 software package used for the conjoint analysis, also offers the toolset for cluster analysis producing the utility function coefficients for each individual respondent. These coefficients are used to identify the consumer purchase behaviour, and therefore can be used as the input into the cluster analysis.

The following methods were available for hierarchical cluster analysis in the software package used: Average Linkage, Centroid Method, Ward's, Single Linkage, Complete Linkage and Fast Ward. K-means cluster analysis is also available, as a non-hierarchical alternative. The Ward's method for hierarchical cluster analysis was chosen initially for its greater ability to handle high dimensional problems (Tan et.al, 2005). Hierarchical analysis was the preferred exploratory analysis due to the

unknown resultant number of clusters. Ward is also more robust against outliers (Everitt et al., 2001); however any form of cluster analysis will be sensitive to these.

K-means cluster analysis was run following the hierarchical cluster analysis. The hierarchical analysis defined the expected number of clusters. Then in the secondary analysis the cluster findings and defining characteristics were verified. These two methods complemented each other, verifying the results and ensuring no significant estimation bias was apparent for either method (Johnson & Wichern, 2007).

The hierarchical cluster analysis provided a distance graph that was used to determine the ideal number of clusters and, after cross-referencing, the distinguishing demographic characteristics of these clusters.

3.3.5. Concluding Comments on the Survey

The Survey provided the consumer insight necessary to identify the market segments and their characteristic purchase behaviour. With the used of conjoint analysis methods this purchase behaviour was modelled as consumer utility functions based on the product and product attributes. The result was a set of clearly defined linear utility functions that define the consumer purchase preferences and were a logical addition to the game model.

3.4. Deriving the Game

Based on the theory of Sadeghi-Zandieh (2011) and the research assumptions here, the use of game theory will add a competitive dimension to the analysis of the optimal choice of a product portfolio or a given market. The theory and model played out by Sadeghi-Zandieh was a simple two player game with a small set of potential product portfolios; however, as demonstrated in the case study, the UK Motor Insurance market is far more complex. Representation as a Duopoly with few products is non-representative.

This section will cover the methods used to derive the game model, including: defining the set of players, the set of product portfolio strategies and the game mechanisms.

3.4.1. Defining Players

Given the relatively open nature of the UK Motor Insurance industry, there are upwards of 120+ players in the market. To model this type of complexity would make calculation of a Nash Equilibrium time (and processor) consuming, nearing impossible. For this reason we first looked at Porter's five

competitive forces before using Porter's Competitive Analysis and Strategic Groupings to simplify the problem.

Using Porter's five competitive forces (Porter, 1979) to analyse the UK Motor Insurance market, one can see why primarily internal competition is compared. Entry of new competition was not considered but could contain potential issues. High financial cost to enter, tight governmental regulation and the already highly competitive market are strong deterrents to entry and very few players have entered in the past decade. More likely is spin-off niche brands developed by the big insurers to gather more market share. This issue was not taken into account in the game, but these new company types are covered as a competitive strategic group, as discussed later in this section. The threat of substitution is minimal due to government regulation stipulating that all cars must be insured to be on the road. There are no real substitutions to the motor insurance product, unless considering public transportation, which was not undertaken in this research. The market buyer power has been increasing recently with price comparison websites and is one of the driving factors of this research. This factor is taken into consideration in the consumer purchase behaviour derivations. Supplier Power is unique in this industry, in that there are only a few actual insurers. A majority of 'insurers' are actually brokerage firms that find the right product and pricing, then label it as their own and managing the insurer relationship. This leaves rivalry as the main driver of competition with the sheer number of competitors, little diversity between competitors, lack of actual product differentiation and low buyer switching costs. This analysis and results are the same as those found by MarketLine (2013).

In-depth competitor analysis requires four diagnostic components (Porter, 2004): future goals, current strategy, assumptions and capabilities. When putting the four components together, the competitor response profile, or offensive and defensive probably reactions, can be anticipated (Porter, 2004; Fleisher & Bensoussan, 2007). These reactions define the mechanisms of the players and can be simplified to the positioning of each company (Porter, 1996).

Strategic Groupings are groups of companies defined as playing in a similar fashion based on visible characteristics uncovered using Competitive Analysis (Porter, 1980). When performing the Strategic Competitive Groupings, the positioning of each company are clustered together to form groups with common positioning strategies. Porter (2008) defines player positioning on two-axis: cost and differentiation. In the UK Motor Insurance industry players primarily use Pricing, Brand and Customer targeting to draw in customers. Brand and customer targeting are differentiations factors in this commodity-like market. Using these defining features, we can identify four strategic groups: Large Insurance Brands, Big High Street Brands, Other Big Brands and Small & Medium Sized Insurers.

Larger Insurance companies can undercut the competitor in price in the short run, drawing from their reserves to make up the difference. This makes the Large Insurance companies and brands behave in a different fashion to other groups.

Big High Street Brands and Other Big Brands rely on customer relationships, trust image and other branding techniques to attract customers. They are also attached to convenient locations or sources (i.e. Nissan Insurance can be purchased when purchasing your Nissan automobile). The dividing difference in these two players is the weight of the brand and convenience. High Street brands rely on the everyday relationship held with customers, where as the other big brand rely more on specialist relationship (i.e. car ownership for Nissan or banking and other financial services through Nationwide).

The Small and Medium sized Insurers compete through niche pricing and specialised products targeted at a specific market segment. For instance, Endsleigh Insurance targeting fair pricing and specialised products for Students and Academics.

3.4.2. Defining Player Strategies

If using the structure derived from the Sadeghi-Zandieh model, each player strategy is a possible product portfolio. A product portfolio is a collection of products that are released to the market to create a coherent 'portfolio' of offerings. In the UK Motor Insurance industry and in the game model represented here, each product is defined as an insurance product at a particular price level with a collection of add-on insurance products.

This section will cover how the product portfolio strategies were derived, and then simplified to create a representative set of player strategies that provided a full spectrum of marketable product portfolio strategies but so as not to overwhelm the calculation of the Nash Equilibrium.

3.4.2.1. Product Portfolio Strategies

Using the product definitions used in the survey, for each company (3 insurance level, 1 brands, 4 price levels and 7 insurance add-ons), there are a possible 1,536 ($\binom{3}{1} * \binom{1}{1} * \binom{4}{1} * 2^7$) products available. This would imply there are a possible ($2^{1,536} - 1,536$) product portfolios. If each strategy is a product portfolio, this would be an unreasonable game size to calculate the Nash Equilibrium.

Many of the product insurance add-ons did not have statistically significant values for the customer utilities. Therefore, many of the total number of products would not yield unique results. For this reason, we can narrow down the number of product add-ons to three: Legal Cover, Protected No-Claims

Bonus and Key Cover. This would yield 96 unique products. The total number of product portfolios from this, although significantly smaller, is still unreasonable for calculation purposes ($7.923 * 10^{28}$).

3.4.2.2.   *Game Strategies*

If using product portfolios, rather than just products, there are too many possibilities for calculating using all possible portfolio strategies; Therefore, methods were employed to create a subset of representative product portfolios.

The representative product portfolio strategies, a^m, where $a^m \in A^m$ must demonstrate the full range of possible portfolios. Creating the full range includes from very basic portfolios of just one product, to the full portfolio of all possible products. For the other product portfolios, interviews, market data and rank pricing was used to create a total of 21 possible portfolios.

Based on the interviews and insurance market reporting, many insurance companies create products specifically targeted and offered to a niche group. These product offerings are specialty product portfolios and, to avoid confusion with the game product portfolio strategies, will be referred to as Targeted Portfolios. The interviews also revealed insurance company's desire to have a variety of products available. This was represented using Targeted Portfolios that have more varied collections of products, shifting price points to reflex a shift in the number of add-ons or the insurance level.

Finally, price ranking was used to create portfolios of products that include most all products, but insure consistency in the pricing based on the number of add-ons and the insurance level. Also, it was expressed in the interviews, and demonstrated in market research, that most companies do not provide the 'Third Party Only' Insurance Level Option. For this reason, the price ranked portfolios were also created with 'Comprehensive' and 'Third Party, Theft and Fire' (TPTF) only.

The full list of product strategies are included in Appendix B.

3.4.3. **Defining Player Utility**

The utility function to be utilised in the game theory model is the utility to the player (competitive strategic group) when using a given product portfolio. As discussed in the Literature Review chapter, the game definition is based on the Sadeghi & Zandieh theory of using game theory to optimise product portfolio management (Sadeghi & Zandieh, 2011). In this model the player utility is derived as the expected market value of the portfolio given the consumer purchase preferences. The final player utility values will then be used in the game matrix to enable to calculation of the Nash Equilibrium of the game.

The consumer utility functions for a given product were calculated using choice-based conjoint analysis and can be used to calculate consumer purchase behaviour. Therefore, the utility needs to be transformed from the consumer utility for a single product to the expected market value of a group of products.

This transformation has many forms, each for a different purpose. The general form was first published by Green and Krieger (1985). Since then there have been more specific functions created for engineering (Jiao & Zhang; 2005) and marketing (Yano & Dobson; 1998). There has even been some work in the insurance industry incorporating risk (Li, 1995).

The customer utility functions, are used to determine the market choice probability, P_{ij}^m, for a given market segment, as defined in the Multi-nominal Logit (MNL) model. This is done by comparing the utility of the product over the utility of all other available products in the market (Kamakura & Russell, 1989). Thus:

$$P_{ij}^m = \frac{exp(U_{ij}^m)}{\sum_{m' \in M} \sum_{n \in N_{S_\sigma}} exp(U_{in}^{m'})}$$

Where j is a product released by player m, in the market pure product portfolio strategy combination, S_σ, where there are competing products, $n \in N$, by all other players, m', where $N_{S_\sigma} \subset J$ for N_{S_σ} is a set containing all products released by all players in product portfolio strategy combination S_σ. Therefore, we may represent the set containing all products release by player m in pure product portfolio strategy combination S_σ as $N_{S_\sigma}^m$, where $N_{S_\sigma}^m \subset N_{S_\sigma}$.

For the mth player and a product portfolio strategy, a, the expected market value, E, can be calculated with the following, as adapted from Li (1995):

$$E^m(S_\sigma) = \sum_{i \in I} \sum_{j \in N_{S_\sigma^m}} \alpha_i p_j P_{ij}^m Q_i$$

Where the market pure product portfolio strategy, S_σ, is defined by the player pure product portfolio strategies $a^m \in A^m$, with released products $j \in N_{S_\sigma}^m \subset N_{S_\sigma} \subset J$. Market segments, $i \in I$ and $I = 3$ are adjusted for using market segment size, Q_i, and market segment insurance portfolio risk ratio, α_i. Finally, each product is weighted for its potential profit by inclusion of the product price, p_j.

The ratio value, α_i, is gathered from historical data within the insurance company (Interview: Holiday, Tim; 2014). These values are pivotal to the operations and market advantage of an insurance company, therefore are held as highly sensitive and confidential. For that reason, I was unable to attain detailed risk weighting values; however, it has been verified that students are viewed as incurring a greater risk (Interview: Holiday, Tim; 2014) and in the United States, it has been shown that Higher Income individuals are considered lower risk (Brobeck & Hunter, 2012). It is assumed that similar economic circumstances between the UK and the USA can allow for the information regarding risk for Higher Income individuals in the United States to be extrapolated an applied to those individuals in the UK.

3.4.4. Deriving the Game Structure

A Multi-player Non-cooperative Finite Game is assumed to be a good representation of the UK Motor Insurance market. Discussion regarding the choice of game can be found in the Literature Review chapter, and discuss on the development of potentially more accurate game models can be found in the Conclusion chapter.

This section will detail the formulation of the consumer and player utility functions and the formulation of the calculating of the Nash Equilibrium (Nash Equilibrium) for the UK Motor Insurance game model.

As mentioned in the Player Utility Section, the player utility is defined as the Expected market value of a given strategy, a^m, with the products released by the player m, $j \in N_{S_\sigma}^m \subset N_{S_\sigma}$, against a release of competing products $n \in N_{S_\sigma}$ (as seen in the P_{ij}^m definition in the Player Utility Function section).

$$E^m(S_\sigma) = \sum_{i \in I} \sum_{j \in N_{S_\sigma}} \alpha_i p_j P_{ij}^m Q_i$$

If we define the UK Motor Insurance market as a finite noncooperative nonzero-sum game, the game may be represented by the tuple:

$$\Gamma = (M, \{A^m\}_{m \in M}, \{E^m\}_{m \in M})$$

where M is the finite set of players, and A^m is the set of all pure product strategies for player m and E^m is the expected market value, or payoff function, of player m.

3.4.5. Concluding Comments on the Game Model

After the building of the utilities of consumers and players based on surveys, conjoint analysis and expected market value theories by Train (2009) and Li (1995), respectively; the Nash Equilibrium of the finite multi-player non-cooperative game could be solved using a nonlinear programming solution derived from the computer model optimisation formulation by Chatterjee(2009).

3.5. Computer Modelling

The finale of my research is the mathematical computer model demonstrating use in a realistic case, including a multiple-player market and real customer and engineering values. The model was also designed such that it may be modified by a company, in the ways described in my research, to make more informed product decisions.

Extensive research and study was done to decide upon the best mathematical and computation methods to utilise in the model. It was expected that the model find a solution in 'reasonable time'. The value of what would be deemed 'reasonable time' was be determined during the company interviews and case study research, as 12 hours, as it can run over night on a company computer if permitted by Information Technology systems. A computer simulation model was chosen for it effectiveness as a tool for discovering surprising consequences of simple assumptions, in contrast to both induction and deduction (Axelrod, 1997).

3.5.1. Calculation of Player Utilities

The Player's utilities for strategy combinations is calculated by the payoff calculation. The player utility function (eq 1.a) is dependent on the customer utility functions, the market products identified and the defined player strategies. The player utilities are calculated by taking the sum of the expected market values for each products and each market segment.

The expected market value is computed for each market strategy combination, for the given player and market segment. A market strategy combination is a set of player strategies released at the same time in the market. It is, also, in this function that the α and Q_i values are defined.

The Expected Market Value (EMV) (eq. 1.a) is defined by the customer purchase probability (eq 1.b). After reducing the customer purchase probability (P_{ij}^m) in the EMV for a single market segment, i (eq. 1.c) it is clear that the parts of the EMV dependent on product (not just market segment) can be calculated in two parts: the Numerator, η_{ij}, (eq. 3) and the Denominator, δ_{in} (eq.4). In the Denominator, n is defined as all competing products in the market product strategy combination. After the calculation

of the Numerator and Denominator the α and Q_i factors of the market segment are included to create a computation representation of the expected market value (eq. 2).

$$E^m(S_\sigma) = \sum_{i \in I} \sum_{j \in N_{S_\sigma^m}} \alpha_i p_j P_{ij}^m Q_i \qquad (1.a)$$

$$P_{ij}^m = \frac{exp(U_{ij}^m)}{\sum_{m' \in M} \sum_{n \in N_{S_\sigma^{m'}}} exp(U_{in}^{m'})} \qquad (1.b)$$

$$E_i^m(S_\sigma) = \alpha_i Q_i \frac{\sum_{j \in N_{S_\sigma^m}} exp(U_{ij}^m)}{\sum_{m' \in M} \sum_{n \in N_{S_\sigma^{m'}}} exp(U_{in}^{m'})} \qquad (1.c)$$

$$E_i^m(S_\sigma) = \alpha_i Q_i \frac{\eta_{ij}}{\delta_{in}} \qquad (2)$$

$$\eta_{ij} = \sum_{j \in N_{S_\sigma}^m} p_j exp(U_{ij}^m) \qquad (3)$$

$$\delta_{in} = \sum_{m' \in M} \sum_{n \in N_{S_\sigma^{m'}}} exp(U_{in}^m) \qquad (4)$$

Where, E_i^m is the expected market value for player, m, and market segment, i. And, $j \in J$ where J is the set of products in the product portfolio released by player m for market pure product strategy combination, S_σ, and n is the total set of products released to market in the market pure product strategy combination S_σ, by all players in the game.

Finally, the expected market values for player m for each market segment i, E_i^m could be summed to achieve the expected market value for player m.

$$E^m(S_\sigma) = \sum_{i=1}^{3} E_i^m(S_\sigma)$$

3.5.2. Finding Nash Equilibrium

The Market Equilibrium point can be calculated using the Nash Equilibrium of the m-player game (Nash, 1951). And the Expected Market Value, as discussed above, can be used as the player utilities for each product strategy (Sadeghi and Zandieh, 2011).

The game first should be checked for a dominant strategy for each player. Even a complex game can reveal a simple market dominant strategy for an equilibrium. For further details on the game analysis, see the Analysis chapter.

If the game does not reveal of dominant strategy the Nash Equilibrium could be calculated using available optimisation methods, including that theorised by Chatterjee (2009). These methods can be

used based on the theorem that the Nash Equilibrium is equivalent to the solution point of the optimisation of the player's expected market value at a strategy combination, or the minimisation of the difference between a player's expected market value at a market's mixed product strategy and optimal player payoff.

3.6. Conclusion

The methodologies used to research the use of game theory modelling for insurance product portfolio management in the UK Motor Insurance industry consisted of a mix of case study research, consumer purchase behaviour surveys and computer modelling of the game model. This mixed research method, although complex, is consistent with complex nature of the research question and industry.

The mixed methods performed in this sequential exploratory design was ideal for this research where an instrument was being developed "because existing instruments are inadequate" (Creswell & Plano Clark, 2007). This method is also described as suited to testing elements of an emergent theory from resulting from the qualitative phase (Morgan, 1998). Morgan also suggests this design may be used in further research where the qualitative research (case study) is applied to different samples (markets).

With the use of sound and diverse research methods, working together to provide and demonstrate market mechanisms that will provide reliable market insights, as well as theoretical advances in game theory and product portfolio management. Data Analysis process and the results will be discussed in the following chapter. Discussion on further research plans and recommendations, including alternate game models, computation methods and other consumer markets, will be discussed in the Conclusion chapter.

4. Data Analysis

Consumer Purchase Behaviour and Nash Equilibrium

4.1. Introduction

Data analysis, for the purpose of this research, spans over a wide range of techniques and types. Due to the research mixed methods, the data collected range from the qualitative to the quantitative, and from the the theoretical to the concrete (Yin, 2009).

This chapter will discuss the process and outcome of all data analysis up to the details of the game model outcome. Data from each research method led to understandings and development in their own right, as well as use in the next research method. The analysis was initiated in the UK Motor Insurance industry case study, followed by the consumer purchase behaviour survey and finished with the computation of the Nash Equilibrium using a computer game model.

The industry case study analysis will be detailed, and all outcomes from the research will be reviewed. The application of the outcomes will also be discussed for the data for the industry case study was used heavily in the construction of the the later research mechanisms. The industry case study consisted of primarily qualitative data that was used to define the content of the consumer behaviour survey and the structure of the game model.

The analysis of the consumer behaviour survey data will be discussed in detail including how and why data cleaning and cluster analysis were performed. The results of the consumer behaviour survey will be reviewed for its use in the game theory model. This analysis pulled from many standard statistical analysis tools used in academia and in standard marketing practice. Some advanced techniques were used as well as one transformation unique to this research.

Finally, the game theory model computation will be reviewed, including software and computation techniques utilised to minimise computation time and complexity. The results of the game theory model will be briefly introduced. All in-depth analysis of the game model results will be in the Industry Impact chapter.

4.2. Industry Case Study

The Goal of the Case Study was to gather a greater in-depth understanding of the mechanisms and drivers in the UK Motor Insurance Market. The market had a large amount of background research that was useful to gain a general understanding after analysed and brought together into a coherent 'story' (Eisenhardt, 1989). With the added use of the company interviews, observations and data, the specific research questions regarding modelling the market became more apparent.

This section will discuss the process of analysing the data gathered during the case study research. First, the case study quality will be reviewed, covering the use of research questions and the use of multiple sources and draft reviews. Next, the case study analysis process will be revealed, with sections detailing specifics to how the case study results were applied to the survey research and the game model.

4.2.1. Summary of Case Study Company

The Case Study focuses on Endsleigh Insurance and their UK Motor Insurance Line. Endsleigh Insurance started solely in student possessions insurance working with university student union organisations. They quickly started to stand as the broker to all insurance that a student may need. And although today, they handle all types of insurance for all markets, their core market target is the best interest of the students and gaining quality and price competitive insurance products for students and university staff.

Endsleigh operates in three business areas: Endsleigh Personal Insurance Service, Endsleigh Financial Services and Endsleigh Business Insurance Services. For Financial Services Endsleigh provides searches and advice on mortgage, life insurance, investments and pensions. And for Business Insurance Services, Endsleigh provides insurance options for businesses.

Endsleigh Personal Insurance Service is the customer-focused insurance intermediary, providing insurance for "career people". Starting with a strong relationship with students and the universities, Endsleigh has extended into products for those students after graduation as well as education professionals. Endsleigh has formed partnerships with the National Association of Schoolmasters, the Union of Women Teachers, and the Association of University Teachers. Endsleigh even used a university student competition to facilitate the 2009 branding changes.

Unique among brokers and intermediaries, Endsleigh keeps all claims handling and paperwork in Endsleigh control. This allows for greater commitment to customer service and facilitates greater customer loyalty, but has not been without it's issues. There are high demands on the Information Technology (Holiday, 2014) services and diligence is required when representing outside firms in claims handling (Barker & East, 2012)

Endsleigh receives hundreds of thousands of quote requests per day, and a large majority of which are from price comparison web sites. Furthermore, the product and price transparency created through price comparison sites has created a need for nimble market reaction. Price and product updates are required quickly and frequently to maintain market position. Endsleigh has an in house software team continuously working on these "real-time" changes, while also improving upon the existing services.

Zurich acquired Endsleigh back in 2007, and until recently, left Endsleigh and its operations unchanged. But with the changes in the market, restructuring, reorganisation and process improvements have been trickling through the business. These changes made way for Zurich to transfer some of their personal lines insurance to the Endsleigh brand as of May 2012.

4.2.2. Case Study Quality Analysis

The case study quality was analysed in every phase of the research process. Validity checks were designed into the research process. The research questions and protocols ensured the validity carried through the more detailed research and data gathering. Lastly, the use of standard models in the analysis phase continued the reliability into the detailed data analysis. It is assumed that these four design testing methods and the results convey a quality researched case study analysis.

Construct Validity was designed into the case study process in two ways. Multiple sources of evidence were designed into the case to aid validity. Key informants involved in the case were used to review case study drafts to ensure the messages were not biased during analysis. More information on these methods is available in the Methodology chapter.

Reliability can be assured through the development and adoption of a case study protocol, that highlights the case study design and focus (Yin, 2009). The protocol consisted of four parts. First, an overview of the case study, conveying the research purpose and setting. Second, the data collection procedures, detailing the major tasks in collecting data, including access, schedule and backup protocol in a environment change. Third, the development of the data collection questions, or research questions. The research questions are developed in five levels, each level is specific to a research area. These areas are: interviewees, case, pattern finding, study, and conclusions (Yin, 2009). Each level ensures consistency throughout the case and allows for a template in the case analysis. In particular, the level 2 and 3 questions specific to the case and patterns, are the questions used to set-up the analysis phase of the research. A table of the questions for all 5 levels can be found in Appendix C. The final case study protocol details the outline, format and audience for the case study report. This protocol was written in two parts, for the research is presented in two parts. First a teaching case was released for use by the

Warwick Business School. Second, the case was used for this research, and dissertation as detailed in these pages.

Internal validity was undertaken during the analysis phase and is discussed in detail in the following section. The validity was conducted in two phases: Explanation building and a Theoretical Construct Table. Both of these items will be discussed in more detail below.

Explanation building is the narration of the 'how' and 'why' of the mechanisms in question. Causal links found in the UK Motor Insurance market can be seen as complex and difficult to measure (Gunnels Porter, 2011), therefore this method is the starting point for the following two sets of analysis. The narrative is also undertaken in several iterations, to ensure it is refined by each set and type of data, therefore removing bias so the narrative develops, as long as the protocol is consulted regularly to avoid unwanted selection bias (Yin, 2009). The results of this narrative were used to refine the survey and game model portions of this research. A summary narrative can also be found in details in the Industry Review section of the Introduction chapter.

Theoretical Construct table was utilised to organise the findings from the data analysis. This method clarifies the results and allows for a one-to-one comparison to the research goals and protocol (Eisenhardt & Graebner, 2007; Graebner, 2004). The complete theoretical construct table is contained in Appendix D.

For the purpose of this research, the case study results were used to generate a more general market model. For this reason, it was deemed necessary to verify the assumption that Endsleigh, and Zurich, can represent a typical UK motor insurer. The 'typical' insurer was defined on the following criteria: Size, Relationship to Insurer, Branding, Annual Sales, Product Portfolio Available and Profitability. These are all measures available for a majority of insurers and brands in the insurance market. Based on the aforementioned criteria, Endsleigh and Zurich were found to be 'typical' Insurers within 2 standard deviations from the norm. These measures were re-evaluated against the competitive strategic groups devised in during the game formulation, and again, Endsleigh and Zurich were found to be 'typical insurers in their respective competitive strategic groups (Medium to Small Insurer and Big Insurance Company, respectively).

4.2.3. Case Study Analysis and Results

This section will detail the analysis of the case study data collected and results that relate to the design of other research methods included in this research. First, the thematic analysis methodology used to analyse the vast quantity of data from interviews, documentation and observations, and the

compilation process, including the theoretical contract tables, will be outlined. Next the applications of the case study findings to the research design of the survey and game model will be covered in more detail.

4.2.3.1.   *Data Analysis*

The case study research resulted in a large amount of qualitative and quantitative data from a wide variety of sources. This section will outline the analysis done on the data, including the organisation and presentation of the results. The use of the results will be discussed in more detail in the Application subsections below.

The data collected from interviews, media, market research, company documentation, and observations were compiled into a common database. All documentation was broken down into paragraphs and all information gathered was labeled with source details, including contact, time and location. The thematic analysis methodology as detailed by Aronson (1996) was utilised to code the qualitative data into relevant themes. The quantitative data was entered into a separate database, categorised and used in defining the game players as was discussed in Chapter 3, section 3.4.1.

Thematic analysis was used to analyse interviews, media, observation notes and documents. A codebook was developed during the case study design and protocol writing and is included in Appendix E. The codebook was developed such that the codes were directly related to the research questions posed in the case design protocol. Therefore, the resultant themes and supporting, or disagreeing, data were already poised to answer the case study research questions.

The database with all qualitative data and their respective coding was organised according to the codes and the themes were compiled into a common message or mechanism, to reveal the answers to the case study research questions. Some of the quantitative data was also used to answer the more specific research questions that were either covered in previous market research (Market Line, 2014; Datamonitor 2014; Department for Transport, 2014; Association of British Insurers, 2012 & 2014; Insurance Times, 2011), or were easily calculated from previous research results (e.g. Bacchus et al., 2004; Webb & Pettigrew, 1999; McDonald and Wren, 2009).

Finally the results from the thematic analysis were combined into a Theoretical Construct table. This exercise allowed the results to be checked again for coverage of case study research goal coverage and for unwanted bias or extraneous information. The Theoretical Construct table also provides a clear presentation of the case study research results for presentation in research documentation, including contained here (Appendix D).

4.2.3.2.   *Application to the survey*

The consumer survey was conducted after the completion of most of the case study research. Some of the case study research results were aimed at understanding the market and the company product portfolio process. Part of the product portfolio process is understanding the consumer behaviour and the market competition. These results are also relevant to the development of a valid survey. To get viable consumer behaviour values, the survey must clearly represent the market purchase questioning. This can only be done with the case study results. The results were utilised in the following survey sections: demographic and product selection questions.

The demographic questions in the consumer survey were used to represent the risk criteria gathered by insurance companies (e.g. job and age), as well as the consumer behaviour that may influence purchase behaviour (e.g. miles drive per annum). The case study revealed the risk criteria used during the insurance purchase process. The criteria used on pricing of insurance product and later in this research, will be used to determine market segments. There are other demographic questions, that were previously part of the risk criteria, but have recently been deemed illegal by European Parliament (Financial Times, 2011). These demographics (e.g. sex) were still included, for it was indicated during interviews that the market segmentation is still valuable for marketing purposes. Finally, the demographic questions requested details pertaining to the customer behaviour that may, or may not, be included in the insurance purchase process. These behaviours were potential markers for market segments that may be marketed to, even if not directly identifiable by the insurance application process.

The case study revealed the product choices available to consumers, some identifiable questions in how consumers chose insurance products, and the types of product comparisons customer made.

A list of potential product attribute and attribute levels was obtained from case study research, including: interviews (Blackwell, 2011 & 2012; Holiday, 2014), company sales data and sales listings off of the price comparison websites (Gunnels Porter, 2013). These attributes were included into the product definitions of the choice-based conjoint analysis for the calculation of the product question choice-sets.

Given the quick change to the price comparison sites as a tangible market, the companies involved in the case study did not have any research to back up assumptions regarding the consumers purchase preferences and behaviour on these sites. These questions helped to identify the product attributes that were to be addressed in the choice-based conjoint analysis questions. The main question remained around the consumer-perceived value of the different insurance levels (Franken et al., 2010) and the value of the add-ons to the product as a whole. The product attribute and levels were therefore chosen to ensure these questions were addressed. Every add-on was included in the choice-sets to get a full picture

of which add-on held tangible value to customers, and the insurance level was also included in the product definitions. The inclusion of the insurance level in the choice-sets is different from the market environment in question. On price comparison websites, the consumer specifies the insurance level prior to entering the pricing and set of available products. This self selection is not part of the survey, because the utility value of the insurance levels was a desired measure, and this could only be measured if available within the choice-sets against the other insurance levels. No survey methods are available to calculate the consumer utility of product not directly compared; however future research should be undertaken to develop a survey method that may address these consumer utility values while staying closer to the price comparison website format, and therefore closer to the consumer/market interaction under review.

The results of the case study also provided details on what a product question choice-set should look like. The set of choices must be a 'reasonable' representation of available combinations in the marketplace (Flyvbjerg, 2006). During the case study research it was determined that the each product in the choice-set should be representative when displayed within the set. For instance, it would not be reasonable to have a choice-set where a high specification product (i.e. comprehensive insurance will all add-ons included) were priced at the lowest price point, and the alternate products be low specification products (i.e. third party only with few or no add-ons) at the highest price points. This type of question not only contains an obvious choice point, but does not represent products that would be available together in the market. Although, one such question was utilised in the survey as a test question to eliminate malicious or ill attentive respondents.

Although, not formally considered part of the case study research, this section is the most appropriate place to address the use of the results from the competitive strategic groupings within the survey. As discussed in the Methodology Chapter, the competitive strategic groupings analysis for the UK Motor Insurance market defined four groups of competitors. For the survey choice-based conjoint analysis questions, these four groups were the set attribute levels for the brand attribute. It was only through the results of the case study, that fed into the competitive strategic groupings research, that allowed these attributes to be reliably used in the survey question choice-sets.

The completed survey with questions covering the above mentioned concepts can be seen in Appendix F.

For the survey results, and therefore the consumer utility functions, to be reliable enough for the game model, the survey needed to represent the consumer/market dynamic as well as cover all consumer behaviour questions required to understand the consumer utility of different insurance products. Only

through the case study research could the necessary depth of understanding of these issues, and proper question coverage required, be fully understood.

4.2.3.3.   *Application to the game*

The primary goal of the case study research was the adaptation of a game model to adequately predict the UK Motor Insurance industry market equilibrium. The case data was used to define the players, possible player strategies and to define game mechanisms.

The cases study data was initially used in the competitive strategic groupings research to determine the number of players and the defining features of those players. The database with competitor quantitative data was used in cluster analysis to determine the potential different types of players. The clusters were defined by market share, marketing expenditure and profits. Both a k-means and a hierarchical cluster analysis was run to check the defined clusters and eliminate estimation bias. After the clusters had been defined the qualitative data was used to label the clusters and to again, verify the cluster groupings. For further details on the results of the Competitive Strategic Groupings analysis and the use of Porter's Five Forces to verify the findings, see the Methodology chapter.

As mentioned earlier, the results from the case study research revealed the product attributes and attribute levels, from this the number of potential products, and therefore potential number of product portfolios was found. Unfortunately this number was deemed 'unreasonable' due to computation time for the Nash Equilibrium. For this reason, the number of product portfolios needed to be reduced to a number that would allow for a 'reasonable' computation time for the Nash Equilibrium. The initial idea for this number was 30. With the use of qualitative case study data, a set of 28 product portfolio strategies were compiled. The strategies consisted of three levels of strategies, then in each level there were between 6-10 strategies. The three levels were: basic products, niche product portfolios and full portfolio sets. The basic product portfolios consisted on one to three products of simple products available to the market. These strategies were similar to those used by some insurers as a tactic to get listed as a low price insurance option on the price comparison site, then add-ons were sold after the fact (an issue that is under current scrutiny from government regulators (Gray & Sharman, 2014; East, 2012)). The second group of product portfolios was those set for niche markets. The optimal product for each market segment was set forth and combined in several formats to make this group. This is a common strategy among insurers (East, 2012; Insurance Times, 2011). The final product portfolio strategy group is the full portfolios. These were sets of all products available from the insurer, some were set to have pricing more consistent to the market, but one was simply the absolute full possible product portfolio. After a follow-up interview covering this issue and remaining risk calculation questions, this product portfolio set was reduced further to the final 21 pure product portfolio strategies

seen in Appendix B. For an introduction on the definition of the product portfolio strategies see the Methodology chapter.

The case study research aided in the definition of the game mechanism, including: competitive nature, non-atomic vs. n-player and finite vs. sequential. The case study research research revealed that the UK Motor Insurance industry is a competitive commodity industry as defined by Porter (2008) where although big insurers own many different insurance brands, cooperation among the insurers is minimal and in most cases banned by government regulators (European Commission, 2003). The most appropriate game mechanism in this case is a non-cooperative game. The number of players in the market was high, but given the unique behaviour of different player types, it was deemed not representative to set-up the game as a non-atomic game (Peters, 2008). After the competitive strategic groupings analysis and the number of players was defined as 4, the game could then be defined as an n-player game. Finally, from the findings in the media, market data and the interviews it was determined that the game does not occur in regular states for most insurers. Although some insurers, perform their product portfolio and pricing updates on a standard regular basis (e.g. quarterly, monthly), the big insurers can run these updates on a daily or hourly basis (Blackwell, 2011). Due to this staggering of stages in the game, it was determined that a single finite game representation would provide the best detail to find the target market equilibrium.

4.2.4. *Additional Required Research*

After the case study research was completed, some subjects were revisited for clarity or issues that came to light. These issues include: computation of market segment specific risk factors, clarity on the product portfolios to be analysed, market updates and the reasoning for Nash Equilibrium findings.

The case study research was used to determine the company defined risk factor value for each market segment (α_i). Unfortunately the risk factor values utilised by companies are considered highly sensitive information and determines market profits and derived from years of market data collection (Gunnels Porter, 2012; Holiday, 2014). For this reason, the actual risk factors were not shared by the case companies for this research. Estimated values were gathered from interview discussion. Of particular interest is the calculation of risk factoring for 'high-income' customers. The income of a customer is not allowed to be questioned during the insurance application process; however, can ben derived from other questions asked (e.g. car and job type), a follow- up interview was conducted with Zurich and Endsleigh executives to specifically address this questions (Holiday, 2014). The responses were as expected, so it was found near impossible to calculate a reasonable risk factor. However, research done in this area in the United States pointed as a trend from insurers to calculate 'high-income' earners as a lower risk factor, therefore providing reduced insurance pricing (Brobeck & Hunter, 2012). Due to the similar

nature of the U.S. and UK insurance markets (The Economist, 2014), it was assumed that a similar practice is in place in the UK market. To this effect, the risk factor was estimated as 10% lower than the rest of the population, for the sake of the game player utility calculations.

Product portfolios are defined by each individual company for research into the market. Through interviews and media coverage, it was determined that companies follow three distinct strategies: low cost offering, niche product offerings, and full portfolio release (Blackwell, 2011; Insurance Times, 2014). As discussed earlier, this determined the initial product portfolio strategies for the game model. However to narrow down these strategies to the final 21, a follow-up interview was conducted with the marketing manager at Endsleigh, finding that a few of the strategies initially created were extraneous or repetitive in the eyes of the game analysis.

This research was conducted over a period of three years. Due to the changing nature and growth of the insurance market, some initial market research was repeated after the survey and the game analysis. This provided an up-to-date setting for the results analysis (Yin, 2009). Most updates were simple quantitative updates to the competitors profits and the market size, but the changes in government regulations had the greatest impact to the conclusions made based on the Nash Equilibrium findings. These issues will be discussed in more detail in the Industry Impact chapter.

A follow-up interview was also conducted with an Endsleigh Insurance sales executive regarding the Nash Equilibrium findings. There was found to be some shock in why some companies maintain the other two strategy types, when the Nash Equilibrium clearly demonstrated the dominance of one product portfolio strategy. For more information the Nash Equilibrium results and data analysis, see section 4.4.2 and for further details on the results and insights provided for the market see the Industry Impact chapter.

4.2.5. Concluding Comments on Case Research Analysis

The case results were highly beneficial to the development of the survey and game model. The insights gathered during the case study research enabled the survey and game model to better represent the consumer and market dynamic. This effort ensured the game model results were applicable to the current market. Details specific to the meaning of the results including the use in interpreting the Nash Equilibrium will be included in the the Industry Impact Chapter.

4.3. Consumer Purchase Behaviour

This section includes details on the analysis of the survey data for the purpose of discovering a linear model representing the consumer purchase behaviour of motor insurance in the UK. This purchase

behaviour can then demonstrate the market value of a given product or product portfolio that may be released by a game/market player.

As will be described in the following subsections, the data was first cleaned using the methods described below, then a final conjoint analysis was run with the remaining data points, and finally, the data was broken down into market segment clusters based on the consumer behaviour.

4.3.1. Survey data cleansing

There were a total of 186 respondents and 22 survey questions (12 demographic questions and 10 choice-based conjoint analysis questions). Data was collected and demographics analysed at the completion of survey response collection, as well as two mid-points at 5 and 12 hours after the release of the survey. This was to ensure that no trends or bias existed in the response times. With the use of hypothesis testing using student t-test, the data showed no difference from the remainder of the collected responses and those collected earlier in the survey release time.

The data was analysed and cleaned prior to data analysis in 3 ways: removing incomplete surveys, employing a relevance and test question filter and outlier removal.

First respondents that did not complete the survey were removed. Incomplete surveys would not provide statistically significant results for that individual, therefore making inclusion in the cluster analysis counter productive. This left 162 respondents.

To ensure that provided responses were relevant and represent consumers only respondents that have participated in, or are looking to participate in, the UK Motor Insurance purchase process were included in the analysis data-points. Therefore, for analysis purposes those that responded that they have or plan to purchase insurance in the corresponding demographic question, were included. It is assumed that these respondents would have a more reliable understanding and realistic market behaviour representing the actual consumer base. This left 130 respondents and of these 121 had completed the survey. Incomplete surveys were also removed for a more reliable conjoint analysis. Partial responses could have been implemented; however, it was believed that they would potentially show up as outliers due to undo attention to question responses (Fowler, 2009).

Respondents were analysed and removed based on their response to the test question (Sapsford, 1999). As mentioned before, a test question was placed in the survey where only one response could be considered the rational choice. Any respondent that did not reply with this choice was considered to either be irrational, or responding to the survey without due attention or in a malicious manner. Remaining responses were analysed using more technical methods mentioned below.

A secondary method of cluster analysis to remove remaining outliers (Tan et al., 2005; Liew, 2013) was employed to remove any possible selection bias. Clusters of one, or "small" clusters, were defined as outliers and removed then the analysis re-run. This procedure was done in a step-wise manner: removing the first "small" cluster of one, then running the cluster analysis again before removing another. For instance, when going from 3 clusters to 4 clusters, there is noticeable difference in the distance graph; however the 4th cluster contains only one respondent. The clusters of one were the same for both hierarchical and k-mean analysis and removing them ensured clearer and more reliable clusters (Sullivan, 2012; Everitt et al., 2001). To ensure these clusters of one were not just potential niche markets (Sumathi & Sivanandam, 2006), the demographics were compared to other clusters. This did not appear to be the case, but only with a large scale survey of this nature could this be confirmed. A hierarchical distance graph demonstrating these clusters can be seen in Appendix G.

Discussion on the cluster analysis performed on the remaining respondents and the resultant clusters can be found below in the Consumer Utility Functions subsection.

Finally, respondent purchase weightings were charted for each product attribute and respondents that exhibited high number of outlier data points were eliminated. This method did not reveal any new outlier respondents; however did verify the outcome of the cluster analysis results.

The final number of respondents used after all cleansing was 115.

4.3.2. Conjoint Analysis

This section reviews the design of the discrete choice questions for use in the survey and the use of conjoint analysis in determining the consumer purchase behaviour or utility functions.

To determine the choice sets for the discrete choice questions, the JMP software required the number and levels of product attributes, the number of choices per choice set, the number of choice sets per survey and the expected number of respondents. With these values, the JMP software first determines if the desired format can accommodate choice sets that will reveal a reliable design of experiments (DOE), or if one of the above factors requires changing to allow for greater reliability. For instance, to calculate the main effects only (no attribute interactions) with the product attributes and levels determined in the case study, the survey was required to have at minimum 7 questions to provide a reliable set of options to calculate the linear regression with the expected number of 50 respondents. The number of respondents was chosen to be low at this phase to ensure the final survey was of adequate design for reliable regression modelling.

The final response data, that was determined to be reliable based on the cleansing analysis mentioned in the previous section, was run through the JMP 13 conjoint analysis to get purchase weightings/ tendencies for each product attribute. The set-up window can be seen in Appendix J, Image J.1. The conjoint analysis uses the choice responses from each respondents to analyse how the respondent came to that product choice, based on the attributes of the product chosen, and the attributes of those products not chosen. The conjoint analysis model used by JMP is form of conditional logistic regression (SAS Institute Inc., 2013) as pioneered by McFadden (1974). Specifically, it uses the Firth bias-corrected maximum likelihood estimators model. This model is the default and is deemed more accurate than the standard maximum likelihood estimators. Likelihood criterion tests are run on the alternative models during the analysis, including: Akaike's Information Criterion, Bayesian Information Criterion, -2*LogLikelihood and -2*Firth Loglikelihood (SAS Institute Inc., 2013). This tests did confirm that for these survey results, the Firth bias-corrected maximum likelihood estimators model was indeed the best fit. The resulting parameters are the 'part-worths', or coefficients of utility associated with that attribute.

The base-line used for regression model were: Third Party Only, Small/Medium Size Brand, High Price Point and No Add-ons. This allows for each of the attribute levels to be represented in a binary fashion. For example, if the insurance level is comprehensive (one of the three levels), the variable l_{1j}^m (Comprehensive) is set to 1, and l_{2j}^m (Third Party, Theft & Fire) is set to 0, where l_{0j}^m is defined as Third Party Only. For the three segments the following binary independent variables, or attribute levels, are defined as follows:

l_{1j}^m - Comprehensive Insurance Level

l_{2j}^m - Third Party, Theft and Fire Insurance Level

b_{1j}^m - Big Insurer Brand

b_{2j}^m - High Street Insurer Brand

b_{3j}^m - Other Big Brand

r_{1j}^m - Low Price

r_{2j}^m - Mid Low Price

r_{3j}^m - Mid High Price

d_j^m - Breakdown Cover Included

g_j^m - Legal Cover Included

y_j^m - Personal Injury Cover Included

h_j^m - Hire Car Included

c_j^m - Protected No-Claims Bonus Included

k_j^m - Key Cover Included

e_j^m - Excess Cover Included

These attributes are used to define the customer utility with utility weighting

values, $V \in \{v_1, v_2, v_3 \ldots v_{15}\}$ of the product from a given player, as follows:

$$U_j^m = v_1 l_{1j}^m + v_2 l_{2j}^m + v_3 b_{1j}^m + v_4 b_{2j}^m + v_5 b_{3j}^m + v_6 r_{1j}^m + v_7 r_{2j}^m + v_8 r_{3j}^m + v_9 d_j^m + v_{10} g_j^m + v_{11} y_j^m + v_{12} h_j^m + v_{13} c_j^m + v_{14} k_j^m + v_{15} e_j^m$$

For each product number, j, there is a set defined for the binary attributes listed above for the

insurance level (l_{1j}^m, l_{2j}^m or none), price (r_{1j}^m, r_{2j}^m, r_{3j}^m or none) and which add-on attributes are

included (d_j^m, g_j^m, y_j^m, h_j^m, c_j^m, k_j^m, e_j^m or none). Appendix H, contains a table with the product

number and the associated product attributes, including price indicator and the included add-ons. For

example, product number 65 has all binary attributes set at zero except for l_{1j}^m, this would give a

comprehensive product, set at the high price level, from a small/medium sized brand with no additional

attributes. These product definitions are used to define the variable values when calculating the consumer

utility of that given product, presented by that brand/player.

The player, m, defines the brand attribute value. The player's strategic grouping is primarily defined

by their branding type, therefore the player number defines the brand for the purpose of the regression

model. For instance, player 1 is defined as Small/Medium Sized Insurer. For this player, all brand

variables, b_{1j}^m (Big Insurer Brand), b_{2j}^m (High Street Brand) and b_{3j}^m (Other Big Brand) would be set to 0.

The linear regression is provided for the full respondent data when the conjoint analysis is complete.

The equation for the entire set of valid survey respondent data was calculated as:

$$U_j^m = 1.37 l_1 - 0.48 l_2 + 1.17 r_1 + 0.97 r_2 - 0.69 r_3 + 0.30g + 0.48c + 0.32k$$

The product attributes listed in the final utility function for the entire survey respondent sample above

are only those that were determined to be statistically significant based on the survey responses. It is

interesting to note that brand (or to be later known as the game model player) was not determined to be

statistically significant for the survey sample as a whole; however, you will see that there is a clear brand

preference for certain market segments. Also, Personal Injury Cover is noted as statistically significant

when the survey sample as a whole is used, but none of the market segments identified contained a

statistically significant response to the Personal Injury Cover attribute. This second note of interest is

most likely due to the size of the market segments vs. the size of the survey data as a whole. If the

survey is run again on a larger scale, it will most likely be seen that at least one of the market segments

also has a statistically significant preference for the Personal Injury Cover product attribute. Some of the

other add-ons did not provide a positive or negative consumer utility change that was statistically

significant. These include: Breakdown Cover (d_j^m), Hire Car (h_j^m) and Excess Cover (e_j^m).

Although this consumer utility function is statically significant and reveals interesting consumer

purchase behaviour, breaking down the utility function into identifiable market segments furthermore

creates a more reliable full market profile of consumer purchase behaviour (Tan, et al., 2005).

4.3.3.   Consumer Utility Functions

The consumer utility function revealed from the Discrete Choice Conjoint analysis, although it was

determined that the characteristic of the consumer behaviour of the market as a whole could be refined

further into market segment behaviour. The use of market segments also allows for refinement through

the use of cost factors, in particular the risk factors, specific to each market segments to be included in

the expected market value calculations, as will be discussed in the later section on the calculation of the

player utilities.

This section contains the details of the cluster analysis used to determine the market segment specific

consumer utility functions, and if these utility functions do indeed create a more detailed representation

of the consumer market purchase behaviour. The cluster analysis will be discussed in details, as well as

further discussion on the resultant utility functions.

4.3.3.1.   *Cluster Analysis*

Cluster analysis is the use of distance between data points to create groupings or clusters that have

similar results. Cluster analysis is the foremost recognised way to identify market segments in market

research data (Everitt et at., 2001). This subsection details the methods explored and used in determining

the market segments in the UK consumer motor insurance market based on the consumer purchase

behaviour findings from the survey and discrete choice conjoint analysis performed for this research.

The data used was the individual respondent weightings provided by the conjoint analysis. The

option is labelled "Save Gradients by Subject" in JMP 13 and will save the weightings for each

respondent in the response table. The cluster analysis was done only using the variables that were found

to be statistically significant for the full respondent sample.

The first method employed was the hierarchical cluster analysis and the graphical representations

provided by the analysis software. K-means analysis was also used to aid in the verification of the

clusters discovered from the hierarchical cluster analysis. There was also a unique discovery uncovered

in the data when comparing the clusters to their demographic identifiers, that will be discussed in more details in final sub-section of this portion.

4.3.3.1.1. *Hierarchical Analysis Clusters*

The hierarchical distance graphic included in Appendix G graphically demonstrates the clusters and the distances between each cluster centre. Ward's method was utilised to avoid biased and uneven clustering (Burns & Burns, 2008).

Using Ward's hierarchical cluster analysis method, the obvious jumps in distance are at two, four, and five clusters. After that the distance improvements level off. For this reason, an initial analysis of the five clusters was done.

The second stage of the analysis consists of graphing the demographic answers for the respondents in each cluster to determine if there is a noticeable demographic marker to that group.

In the analysis of the five cluster groups, four of the clusters demonstrated a clear difference in 3 of the stated respondent characteristics (sex, employment status and age). The remaining characteristics did not show significant weight in any one cluster. Unfortunately cluster 3 was almost twice as large as the other clusters and with analysis this cluster contained no clear respondent characteristic that could reliably identify the cluster. This cluster may have been identifiable by an unreported demographic characteristic (e.g. location), or may represent the general population.

The analysis was run again for the set of two, three and four clusters, with similar issues. It was decided that a second cluster analysis technique was to be employed to check the current results and possibly refine the results.

4.3.3.1.2. *K-means Analysis Clusters*

K-means cluster analysis is considered a more reliable clustering method when the number of resultant clusters is known (Burns & Burns, 2008). Since, the number of clusters was not known this method was not used, in favour of the Ward's hierarchical analysis method. Once the number of clusters was estimated with Wards, the more reliable k-means method was used to check the reliability of the clusters as well as generate more reliable clusters. This proved to be a successful technique, and is frequently seen in academic and professional market segmentation studies (Burns & Burns, 2008).

Using the number of clusters from the hierarchical cluster analysis the k-means clustering method was employed. Three, four & five clusters were used and the analysis was stepped until the clusters were stable. It was apparent that the same "small" clusters were occurring, that were not seen in the Ward's method. Therefor the cluster analysis method of outlier removal was used to eliminate these respondents

and the analysis was run with the remaining data set, leaving a final number of reliable respondents as 115. This final value does leave a margin error of 8.3% with a confidence interval of 90% or if a confidence interval of 95% is used, the margin of error is 10%.

In the final K-means analysis, three, four and five clusters were run once more and it was apparent that 4 clusters was the most efficient set. This is the same result as the hierarchical analysis, with the new refined data set, and the respondents in each cluster are almost identical.

4.3.3.1.3.   Cluster with in a Cluster

The resultant clusters were defined by the demographic characteristics gathered in the survey. The desired outcome was four clear clusters that could be defined by one or more of these demographic measures.

Following the hierarchical cluster analysis, this was not the case and this was the point at which a secondary cluster analysis method was proposed. After the initial K-means analysis the characteristics of the clusters was apparent.

The simple method of pie charts, or histograms, was used to show the bias of one characteristic over the others. After analysing each characteristic for each cluster the proportions were seen as displayed in Appendix I.

It was coming to light that there were four clusters. Two general clusters could be defined/divided based on mileage driven on an annual basis (one low mileage; one high mileage). One cluster was a 'niche' cluster of High-Income earners. The final cluster was not clearly definable, however, it was noticeable that all students respondents were in this same cluster. It was decided to try and treat this as a cluster-within-a-cluster.

To explore this potential, all student responses were removed and the cluster analysis was run once more. The full analysis was run including the hierarchical Ward's method to determine the number of clusters followed by K-means to determine clusters. This proved very successful. There was a shift in the clusters and once the characteristics were graphed, there were three very clear clusters remaining (excluding the newly defined "student" cluster). These clusters remained consistent with the previous findings only with greater clarity.

The student cluster was graphed and tested using cluster analysis, centroid method (Romesburg, 2004) and hypothesis testing to ensure that they were indeed distanced as such that they could reliably be identified as an individual unique cluster.

4.3.3.2.   Resultant Clusters

Based on the above process, the following clusters have been defined by the following identifying characteristics: Students, High-Income customers, High annual mileage driven and Low annual mileage driven.

The third and fourth clusters were initially considered; however, the cluster standard deviation was such that the division between these two clusters could not be considered statistically significant to the 95% confidence interval used in this research study. Therefore, the two clusters were combined to represent the remained of the consumer market that did not fall in one of the two 'niche' markets. However, it is believed that these cluster definitions should be reexamined with a larger survey sample. These high and low mileage segments may prove helpful for customer targeted marketing.

It is believed that there are a greater number of market segments; however, a much higher sample size is needed to enable a clearer picture of the clusters. This is due to the complex nature of the small differences in the purchase behaviour and the diverse consumer base.

Another reason for the lack of more market segments is the difference in the statistically significant coefficients between the demographic groups. As seen in Appendix J, the coefficients that are significant vary from group to group. Most groups show either none or very few differences (one or two); however, the demographic groups of students and high-income earners have very different product characteristics that determine purchase behaviour. Again, a larger survey sample may refine these results so that cluster differences, and purchase behaviour markers, could be more clearly divided. Appendix J also contains tables demonstrating the statistical significance and coefficient of variance for each of the final three clusters.

Since these groupings are similar to those hinted at in the cluster analysis, they were marked as market segments and assigned a unique utility function.

With all analysis complete and all calculations of statistical significance taken into account, the final three market segments were considered for use in the game model: Students, High Income Earners and the remaining consumer market. There were a total of nine, seven and 99 in each cluster, respectively.

4.3.3.3.   *Resultant Functions*

Following part-worth conjoint analysis, the consumer utility, of the *i*th segment for the *j*th product and the *m*th player, U_{ij}^m, is assumed to be a linear function. Three market segments, $i \in \{1, 2, 3\}$, were defined using cluster analysis and hypothesis testing. One of the part-worth binary independent variable

is brand, where a player, *m*, where is part of a pre-set brand type as defined by binary attributes, b_{1j}^m,

b_{2j}^m, b_{3j}^m and empty.

For a product, *j*, there is a set defined group of attributes that determine that utility of the product. These attributes are represented in a binary fashion with the variables as defined in section 4.3.2, and a full set of the defined products, *j*, can be found in Appendix H. The attributes for UK Motor Insurance are the Insurance Level, Brand, Price, and Add-ons. Each attribute has various attribute levels that contribute as the independent variables in the customer utility function.

From the conjoint analysis of each market segment, using JMP conjoint analysis, it was found that not all segments have the same utility function. Each has a different set of product attributes that contribute in a statistically significant way to the utility of the product. The base-line used for regression and conjoint analysis were: Third Party Only, Small/Medium Size Brand, High Price Point and No Add-ons.

The brand is defined by the player brand group (Big Insurance, High Street, Small/Medium Size and Other). Therefore, The brand attribute is a variable in the market, but not within a player strategy. The product, and its attributes, presented by the player, determines the final utility.

For the three segments the following binary independent variables, or attribute levels, are defined as follows:

High-Income Earners:

$$U_{1j}^m = 0.52r_{1j}^m + 0.29r_{2j}^m - 0.37r_{3j}^m + 0.34g_j^m$$

Students:

$$U_{2j}^m = 1.04l_{1j}^m - 0.25l_{2j}^m + 0.13b_{1j}^m - 0.57b_{2j}^m + 0.76b_{3j}^m - 0.24r_{1j}^m + 1.17r_{2j}^m + 0.28r_{3j}^m + 0.79c_j^m$$

Remaining Population:

$$U_{3j}^m = 1.71l_1 - 0.63l_2 + 1.48r_1 + 1.14r_2 - 0.85r_3 + 0.19g + 0.62c + 0.46k$$

The Consumer Utility Functions are the regressive linear functions derived from the conjoint analysis. There is one linear function for each market segment discovered during the cluster analysis. Not all consumer utility functions contain the same independent variables. This demonstrates that clusters differ in their purchase behaviour and product attributes that impact the purchase choice of one

market segment, may have no impact on another. The size market segments was found to be fairly represented in the respondent data. In the data there are 7 high income respondents, 9 students and 99 from the remaining population. Significance analysis of the coefficients for each of these market segments, as well as all respondent data, can be found in Appendix J (Images J.1-J.4). It can be said to be remarkable that such small numbers of respondents could have several statistically significant coefficients, but with the use of DOE for the conjoint choice analysis and common economic markers of these market segments it is expected that the differentiation between data points would be small, allowing for a raised significance with a small sample (Burns & Burns, 2008).

High Income Earners are unique in that they do not appear to have a brand or insurance level preference and have only a notable desire for the legal cover add-on. The price preference profile for the High Income Earners is unlike the other groups in that their is no dislike for the lowest price point. It can actually be seen that the lowest price point is the highest preference with the mid-high price point being the point of disinterest. This is most likely due to the customer perception that a higher price point would provide greater value beyond what may be obvious. This behaviour is frequently seen in many food markets and a point of debate in new product management (Krishnan, et al., 1999).

The student market segment can be seen to have a reliable brand preference. Specifically there is a preference for the Other brands category (Car manufacturers, Banks etc.) and yet are noticably against purchasing from the High Street Brands (M&S, WHSmith etc). The students have a dislike, or distrust, for the lowest price point, and demonstrate the strongest preference for the second to lowest price point. The students have a statistically significant preference for the Protected No-Claims Bonus Cover add-on. This add-on protests the insurers No-Claims Bonus from incidents where the other driver is uninsured or it is a "hit-and-run" or a similar type incident. This is an understandable preference for individuals in this student category given their usual age and driving experience, where there would be a dramatic increase in insurance premiums if they needed to claim on insurance.

The behaviour model of the remaining population shows a very strong preference for the lower price point and then a sudden dislike for the next to highest price point. This market segment demonstrates a similar preference to insurance levels as the Student population as well as the No-Claims Bonus Protections add-on. This group, however, contains statistically significant preferences for a greater list of add-ons than the other two groups. The add-ons include the Protected No-Claims Bonus, as seen with the Students, the Legal Cover as seen with the High Income Earners, but also includes a preference for Key Cover. The Key Cover option is the inclusion of insurance for the loss or theft of the car's electronic key fab. This is a surprisingly pricy item to replace. The larger number of add-ons included

as statistically significant could be due to size of sample, for the coefficients are not very high and the larger sample sizes create more accurate results (Jolson & Hise, 1973).

4.3.4. *Concluding remarks on Consumer Behaviour*

The consumer utility functions defining the consumer purchase behaviour is a necessary entity to understanding and calculating the market worth of a given product or product portfolio. The discrete choice conjoint analysis survey and calculations provided a reliable and easily understandable analysis of the market behaviour. Although, this calculation could benefit further research to refine the model to the understanding of other potential market segments, the resultant functions from this research were considered reliable for the purposes of the game model.

The consumer utility functions will be used to calculate the player utilities based on the players brand characteristics, along with the product attributes for each market segment. This process will be discussed in greater detail in the following section.

4.4. Nash Equilibrium Computation and Analysis

The game model chosen was a n-player non-cooperative finite game. For this purpose, the question of interest is where the market is heading and what product portfolio would be the most profitable in the long-term. The Nash Equilibrium is the method of choice for finding this market equilibrium in a given non-cooperative game. According to his definitive paper in 1951, Nash concluded that an Equilibrium always exists in such cases.

This section will review how the player utility function was created from previous information and subsequently how an Nash Equilibrium was calculated using non-linear optimisation.

4.4.1. Player Utility Function

The player utility functions were created from the previous information gathered from the case study and the consumer purchase behaviour survey. This section will detail how that information was put together into a single player utility function and how this function was computed in the computer model.

4.4.1.1.   *Deriving the Function*

As discussed in the methodology chapter, the player utility function was chosen to be the equivalent to the expected market value, E, similar to the method employed by Sadeghi and Zandieh (2011). The expected market value calculation in a commodity services market, like insurance, is vastly different than

the expected market value calculation for an physical consumer product like that represented in the Sadegh and Zandieh study. Therefore, a new algorithm was devised and adapted from the Li (1995) model for insurance portfolio optimisation. The calculation is as follows:

For the *m*th player and a product portfolio strategy, a, the expected market value, E, can be calculated with the following, as adapted from Li (1995):

$$E^m(S_\sigma) = \sum_{i \in I} \sum_{j \in N_{S_\sigma}} \alpha_i p_j P_{ij}^m Q_i$$

Where player m, with a product portfolio strategy, a, and the market pure product portfolio strategy, S_σ, can determine the expected market value. The pure product portfolio strategy is defined by the player pure product portfolio strategies $a^m \in A^m$, with released products $j \in N_{S_\sigma}^m \subset N_{S_\sigma} \subset J$. The market segment size, Q_i, and risk ratio, α_i, are adjusted for each market segment, $i \in I$, where $I = 3$. Finally, each product is also weighted for its potential profit by inclusion of the product price, p_j.

The risk ratio value and market segment sizes were gathered during the case study and the probability of purchase value, P_{ij}^m, was calculated from the consumer purchase behaviour algorithms, as discussed in the methodology chapter.

Given the number of potential product portfolios and players, although a linear order calculation, the calculation of the expected market value is not a trivial task.

4.4.1.2.   Calculating Utilities

To minimise the computation time the player utilities, or expected market value, the calculations were broken down into parts. First, the consumer probability of purchase was calculated for each market pure product strategy combination, S_σ, for a given player, m, and market segment, i.

The customer probability of purchase, P_{ij}^m, is the calculated from each of the consumer product utilities. The consumer product utilities can be seen in the previous section. The calculation of the consumer purchase probability, as seen in the methodology chapter, is:

$$P_{ij}^m = \frac{exp(U_{ij}^m)}{\sum_{m' \in M} \sum_{n \in N_{S_\sigma^m}} exp(U_{in}^{m'})}$$

Where j is a product released by player m, in the market pure product portfolio strategy combination, S_σ, where there are competing products, $n \in N$, by all other players, m', where $N_{S_\sigma} \subset J$ for N_{S_σ} is a set containing all products released by all players in product portfolio

strategy combination S_σ. Therefore, we may represent the set containing all products release by player m in pure product portfolio strategy combination S_σ as $N_{S_\sigma}^m$, where $N_{S_\sigma}^m \subset N_{S_\sigma}$.

The consumer purchase utilities, U_{ij}^m, as seen in the previous chapter, is defined by a set of three linear regression models. Each linear regression equation is defined by the market segment, i. A coded algorithm in the game used if-then-else statements to determine the utility function to be used for that consumer segment.

This division was also beneficial to the optimisation of the computation, for the calculations used in the player utilities where summed over each of the market segments individually, taking into account the risk factors.

For the full calculation of the expected market value (equation 1.a), the probability of purchase (equation 1.b) was also broken down into the two parts of the numerator (equation 3) and the denominator (equation 4). This allowed for the minimum number of calculation loops required for the necessary sum, and easier inclusion of the price, p_j, risk factor, α_i, and market segment size, Q_i, items for the final expected market value calculation. The breakdown of the calculations are listed in section 3.5.1 leading to the computation representation of the expected market value.

Where, E_i^m is the expected market value for player, m, and market segment, i. Where, $j \in J$ and J is the set of products in the product portfolio released by player m for market pure product strategy combination, S_σ, and n is the total set of products released to market in the market pure product strategy combination S_σ, by all players in the game. Also, μ_{ij} were defined as the numerator values of the expected market value equation and β_{in} was the denominator, used to simplify the computation of the final expected market values.

Finally, the expected market values for player m for each market segment i, E_i^m could be summed to achieve the expected market value for player m.

$$E^m(S_\sigma) = \sum_{i=1}^{3} E_i^m(S_\sigma)$$

This value stands are the player utility function to be used in the determination of the Nash Equilibrium.

4.4.2. Nash Equilibrium

The Nash Equilibrium will represent the market equilibrium, or the point to which the market will settle towards in the long-term, if all market conditions continue in their current condition.

If the UK Motor Insurance market is defined as a finite noncooperative matrix game, the game may be represented as:

$$\Gamma = (M, \{A^m\}_{m \in M}, \{E^m\}_{m \in M})$$

where M is the finite set of players, and A^m is the set of all pure product strategies for player m and E^m is the expected market value, or payoff function, of player m .

Before endeavouring on a full scale model, a check was run for a dominant strategy for each player. This was set up as a 2-player non-cooperative game (matrix game) that could be solved using a spreadsheet (see Appendix K for example). This game was calculated for each market player playing as player 1, and all remaining players playing as player 2. For each of these four matrices it was shown that the dominant strategy for the players was indeed a full product strategy (strategy 21). Attempts were also made to find a mix of market strategies that would lead to an alternate strategy; however, tests showed that indeed a full product strategy (strategy 21) is the dominant strategy for all players.

If the game was not found to have a dominant strategy plans were in place to find the Nash Equilibrium using a nonlinear programming solution derived from the computer model optimisation formulation like that of Chatterjee (2009), as discussed in the methodologies chapter.

4.4.2.1. *Results*

The Nash Equilibrium found in this model is the market equilibrium (Nash, 1951) for the UK Motor Insurance industry if no significant changes occur in the marketplace. A mixed Nash Equilibrium would refer to either a single company taking a mixed product portfolio approach, or a mix of the companies in the brand category specified would take on the different product portfolio strategies.

The Nash Equilibrium calculated for the full case of 21 possible pure product portfolio strategies and four player types was a pure Nash Equilibrium consisting of the full product portfolio strategy for all four player types. This would imply that all companies in the UK Motor Insurance industry market will strive toward a fully diversified product portfolio over time. Further details on the market impact can be found in the Market Impact chapter.

4.4.3. Concluding remarks on the Nash Equilibrium

The Nash Equilibrium found in the model is as expected; however, there is some skepticism regarding the current state of the market and why so many niche product portfolio players are seen. With more work detailing the consumer, player and market behaviour, this may become more apparent. Or it may be a temporary state of the market due to market entry barriers. These niche players are usually new

and smaller insurers in the market. For more information on the results found here and how they pertain to the UK Motor Insurance market, please see the chapter on the Impact on Market.

4.5. Conclusion

The analysis of the gathered data proved valuable in their own right as well as the development of the research methods and game model and the interpretation of the results. Further research in all areas of this study could add value to the understanding of the model, the research methods and the market impact.

The mixed research methods allowed for a wide range of analysis techniques and types to be utilised in this research. Each analysis method met the needs of that research area and focused the data into tangible results that could be utilised by the next research area.

The industry case study data analysis was complex and thorough, providing a reliable basis for the content of the consumer behaviour research and the game model structure. The resultant information from the case study also proved invaluable in the analysis on the meaning and implications of the game theory model results, or the Nash Equilibrium. This topic will be covered in greater detail in the Industry Impact chapter.

The analysis of the consumer behaviour survey, although pulled from standard academic and market practice, was both standard and innovative. Further research should be undertaken on the theory of a cluster with-in a cluster. This new information could prove invaluable to industry practitioners in the discovery of hidden niche markets or provide added insight into target marketing and understanding consumer behaviour.

The game model analysis could be reviewed on many levels. The development and analysis of the player utilities added insights into how the consumer perception, market dynamic and product attributes shape the market potential to each player. Then the final Nash Equilibrium really highlights the market drivers for each player type. When analysing the player unities as the Nash Equilibrium discovered further economic drivers and potential arise.

Some companies may not care to wait to calculate an exact Nash Equilibrium, therefore an estimate derived from other multi-player calculation methods that are much faster, may prove effective. For instance, learning game-theoretic equilibrium would provide a learning estimate of the market progress toward the Nash Equilibrium. This has been done utilising query protocols and viewing the game as a "black box" (Goldberg, 2014) This may also prove insightful in how the market developed over time to come to the final Nash Equilibrium calculated.

The research methods of discrete choice conjoint analysis is undergoing a more recent surge in advancement (Liew, 2013), and these new techniques may be worth investigating in the understanding of the consumer purchase behaviour.

Overall, the data analysis conducted proved fruitful and beneficial to the further understanding of how the UK Motor Insurance industry operates and how the market economy and company strategy can be influenced by product and product portfolio offerings. Further discussion on the interpretation of the results and insights on the market regulation can be found in the following Industry Impact chapter.

5. Industry Impact

Interpretation of the Results in the Case Study Context

5.1. Introduction

This chapter contains a discussion on the meaning of the results, as well as a review of the techniques found in this dissertation and how they may be used by companies interested in product portfolio analysis. The results in terms of their impact on the market and government regulators, and on the companies participating in the UK Motor Insurance Market.

The game model results will be discussed through out this chapter, but they will also be placed into the context of the market and company operations with the use of the case study data and the consumer survey results. This chapter will also discuss some of the implications to the market and companies from the findings directly uncovered in the case study research and the consumer survey.

Overall, this chapter will look at the results and their impact on companies and the market. Finally it will discuss how to use these methodologies and apply them to alternate markets and game models.

5.2. Market Interpretations

The game model results can be used for market insights by government regulators and industry experts to aid in the development of a more profitable and reputable market. This section discusses the game model results and how they may be used to aid decisions regarding the maximisation of consumer value and market value.

5.2.1. Maximising Consumer Value

Maximisation of consumer value was not the research question being optimised in the game model presented here. In this section we will hold off initially on discussing the game model results directly and discuss the market findings on consumer value in product innovation and regulation. These topics will also aid in further understanding the market maximisation results to be discussed in the next section.

The case study revealed very interesting findings that relate to the consumer value and the game model results, that would be considered valuable to the company and their product and operational decisions.

Consumer advocacy is important in any industry including motor insurance. Product innovation can increase the value of the insurance product to the consumer with little, or no, added cost to them. Additionally, regulation and policy set up by independent government bodies are designed to protect the consumer from exploitation (Barker, 2012).

5.2.1.1.   *Product Innovation*

Product innovation that is customer centric can make the customer's process and relationship with the insurer easier. Easier process is also thought to increase the reliability and consistency of claims (Littlewood, 1978; Pattman, 2015).

Innovations that increase customer value differentiate a company and their service/product; however, the heavy weight to price as a purchase innovation in this market is slow. Price competitions keeps profits low and with continuous fear of regulation on new products, new development is low. Stimulating innovations that maximise consumer value would benefit not only the consumer and the companies in the insurance industry but the market as a whole. The total market value increases as innovation and product portfolio diversity increase, therefore new insurance add-ons and other consumer centric products increase market value.

Although not related in the game theory model, back office innovation is also beneficial to the consumer, company and market. With effectively designed back office reporting and technology, company overhead can be decreased allowing for lower prices or higher profits. The reporting systems can also be designed to aid in the consumer purchase process to reduce risk of miss-selling issues and fines or litigation. Finally, if the back office innovations provide for a better consumer experience, the overall reputation of the market may increase.

Further research is necessary to understand which innovative add-ons and how innovations beyond add-ons would maximise consumer value. The game model presented here is that of maximisation of the market value in terms of profits. The problem of consumer value rather than profits is a very interesting and inherently different game that if simulated could add valuable insights to regulator decisions.

5.2.1.2.   *Regulation and Policy*

As of June 2011, the motor insurance product is a requirement for the ownership and operation of a motor vehicle (BIBA, 2010), and for most individuals the use of a motor vehicle is required for work or personal reasons (Office for National Statistics, 2013). These requirements could allow for exploitation of the market value. For this reason, government regulators are in place to ensure there is healthy competition and to serve the greater good, not just company profits.

The increased regulations also have grave implications for the motor insurance market. Continued regulation and threats of fines and litigation have stifled innovation in new product development (Barker, 2012). This reduces the overall value of the motor insurance market and the unique added value products available to customers. Regulators should be aware of maintaining a balance so as to not damage the market development.

Unique added value products sold as add-ons are valuable to some customers; however, with promise of profits, a hard sell can mean consumers are purchasing these products when for them it is false value. Government regulators are the key to protecting the consumer against false value and ensuring communications between the consumer and the company mean that consumers know and understand the product they are purchasing (Leftly, 2012). Unlike physical consumer products, services are less easily defined and the risk of misrepresentation or misunderstanding can cause great friction and cost to both parties.

Although not revealed from the game model simulation, from case study readings it is our opinion that policy makers should revise their strategy in handling new product innovation in the motor insurance industry. The current process of "cracking down" on miss-selling after an accumulation of complaints of the product in place has grave implications on company costs and reputation. Instead a managed process for the review of new products prior to release, that may include consumer feedback, would cut down on the cost to the companies, and government regulators.

5.2.2. Maximising Market Value

The game model included in our research, as mentioned before, was designed to optimise the individual company profits. At each strategy cross-point there is an estimated market value. The Nash Equilibrium point was not the point of maximum market potential. It is, however, important to ensure a strong market value to reduce the number of companies and competition being lost along with jobs, and keep economic contributions up.

This section will review the product innovation, market and comparison site implications as interpreted from the game model and other research included here.

5.2.2.1.   Product Innovation

Product innovation is valuable by aiding increased market value and market competition. To stimulate product innovation in the market, funding, regulatory cooperation and consumer desire will be required.

Preventing degradation of innovation due to regulation and litigation, is the first goal in market innovation. Current problem products need to be re-worked, with the help of government regulators to meet the needs of the market and consumer. Then modifying the relationship and communication channels between the government regulators and companies will allow innovation to thrive while ensuring the products are beneficial to customers.

In the current market, companies are barely making a profit, therefore funds are not going back into innovation and Research & Development. Initiatives by the government regulators to work with the companies by communicating prior to innovation and providing advice and funding would be beneficial to all parties.

Communication to the consumer regarding innovation is not strong, as is evident from the lack of knowledge and understanding of the telematics technology and other add-on products (Newsdesk, 2015). Further marketing and communications to the consumer that provide more valuable and informative information would boost consumer interest in the products and their value. This added interest would then act as a market "pull" (Porter, 1979) to innovation in the market.

5.2.2.2.   *Market Potential*

The maximum market potential is the maximum profit value for the market as a whole. It is not necessarily the Nash Equilibrium point, for this is the point where each company maximises there individual profit with relation to each other. And in this case, the Nash Equilibrium is indeed not the potential market maximum. Dependent on the government regulator goals, it may be desired that the Nash Equilibrium of the market game bring forth a greater market potential, closer to that of the maximum market potential. The regulators would need to, therefore, modify the market dynamics to create a market that fosters this type of potential.

The maximum market potential shows a balance of large companies with large and expensive portfolios and small niche companies with targeted niche insurance products. This market mix is closer to the current view of the market and may demonstrate a mid-point product mix as the market moves towards equilibrium. Further research and dynamic game modelling would be necessary to validate this point. More research is needed, but the current market position may also be a conditionally dominated strategy in this dynamic market game. The model developed was not a sequential dynamic game due to the complexity and speed of market changes.

Based on the case study research, some qualitative reasons for this market dynamic became apparent (Blackwell, 2011). As new insurers enter the market, the easiest way to gain market share is to target a niche market with a targeted product and marketing message. Entrants do not start at equilibrium due to

expense, and therefore place the market as a whole on a point outside of the market equilibrium. As the new companies grow in size and their ability to manage and understand market risk, their product portfolio expands towards the market equilibrium. With the use of strong marketing, differentiation, under pricing and other marketing methods, the larger companies are keeping an edge in this competitive market, slowing the shift to market equilibrium. This produces the current market condition as described earlier.

The market dynamic has been greatly impacted by insurance comparison websites. These market places have changed the visibility of the product features and prices allowing consumers to make a more informed decisions, driving down product prices. This change has made the insurance market behave more like a differentiated "commodity" market (McDonald & Wren, 2012). This dynamic change may accelerate the market shift to equilibrium; however, there are market outliers that do not participate in the comparison website market. These companies are continuing to thrive and further research is needed to analyse how these companies effect the dynamic of the insurance market as a whole.

5.2.3. Market Conclusions

Ensuring positive consumer value adds value to the market as well as to the consumer. The reputation of the industry plays an important role in the consumer relationship (Blackman, 2012) and a positive relationship increases customer utility.

The government regulators and market leaders will determine where the benefit balance will lie, between maximising market potential and maximising consumer value. It is assumed that the ideal situation would be a market design that contains a Nash Equilibrium that maximises both.

According to our findings, Government regulators and market leaders will need to work together to move the market forward to enable the maximisation of the market and the consumer value. In this relationship, communication must remain open to enable innovation rather than stifling it with regulation and litigation.

The current state of the market is not that of the Nash Equilibrium. This means the market is not at equilibrium of a static game and the market may still be adjusting or learning (Goldberg, 2014), or the market is on the equilibrium path in a dynamic game (Meza & Webb, 2001). Further research is required to better understand the current state of the market versus the Nash Equilibrium and the sub-game stages it may undertake as it reaches market equilibrium.

5.3. Company Interpretations

The results from the game model and their meaning provides insights on how a company could conduct their business and form their product portfolio to maximise their market potential in the large term. This section will discuss the analysis conclusions as they pertain to the company operations and strategy.

As a side, the consumer utility function contained specific to price sensitivity and behaviour that was not intuitively obvious and was a very interesting finding. Further research on the logic behind this behaviour would be intriguing or an expanded survey study may prove beneficial.

5.3.1. Innovation

With the insurance add-on market valued at £1bn a year (FCA, 2014), and telematics slowly picking up pace in interest (Jones, 2015) it is clear that innovation in necessary in the UK Motor Insurance industry.

Although add-on insurance products are defined by their insurance coverage offering, this and other less tangible aspects in a service based industry, like insurance, are not protected from quick adoption by competitors by patents. Copyright law may cover some aspects of the product, but has limited coverage. This leaves a short lead time for a company to profit from their product portfolio advances, and emphasises the need for constant innovation in the product portfolio.

In the game model addressed here, the product portfolio was defined as the available product offerings of bundled insurance with various add-on coverage. In this section, first, the value of innovation in the add-on product offerings is discussed. Then, other aspects of the insurance 'product' that were either indirectly or not addressed in the game model, are reviewed, namely: consumer services and physical technology.

5.3.1.1.   Diversification of Add-ons

An insurance add-on is defined as an additional insurance coverage item that may be added to the customers base insurance product. For example, when purchasing comprehensive auto insurance, the consumer also bundles three add-ons: legal cover, breakdown cover and protected no-claims bonus cover.

The results from the Nash Equilibrium calculated in this research show that all brand types should have a full product portfolio to maximise profits at the market equilibrium; however, the current market does not display market equilibrium characteristics as discussed in the previous section.

Although it is obvious that the market is not currently at equilibrium based on the common usage of targeted products by niche players, but it is clear that innovation in products will help a company to maintain ahead of the curve in profits and marketshare.

As mentioned previously, the Nash Equilibrium results of the model shows that a full portfolio for all players will be the market equilibrium. It could be implied from this result that greater portfolio options would extend the boundaries of the game, and the market Nash Equilibrium would extend as well. This would mean that continued innovation towards a more extensive product portfolio would further maximise the companies position in the market.

5.3.1.2.   *Consumer Services*

As discussed in the previous section, customer services increase the consumer value of the services; however, they also have added value to the companies and should be considered as part of the company's strategy. Although not represented in the game theory model here, these products or attributes are related to the findings.

This section will address recommendations on company action regarding consumer services, as they relate to the research findings. These consumer services include: Reputation/Brand ID, Process Management (consumer and back-office), Consumer Management (relationships, relationship building etc).

Research from Insurance Times shows a stronger bias to brands with good customer service reputations than that shown in our survey (Insurance Times, 2011). One reason is our survey placed brand in context with the product attributes and price, where the IT survey asked using direct questioning about customer service preferences. It has been discussed that choice-based conjoint analysis gathers a more truthful insight into the attribute values over direct questioning outside of context (Train, 2009).

Although not addressed in the game model, it is apparent through the case research that unique products and consumer services that maintain a relationship beyond claims, would increase customer retention which is low and problematic in the industry (Newsdesk, 2011). Differentiation is, also, highly beneficial in a highly competitive commodity services market like the UK Motor Insurance industry (Eakin & Faruqui, 2000; Porter, 2008), and some insurers and brokers have been using consumer services to add value to their core product. Innovations in the form of easy to use websites and apps for mobile devices.

5.3.1.3.   *Physical Technology*

Diversification of Risk across market segments is not a new concept, and is discussed in the Literature Review. That section includes details regarding Insurance portfolio optimisation and risk management.

5.3.3. Comparison Site Use and Recommendations

The use of comparison websites has become common place for consumers (Insurance Times, 2011). While there are companies that do not participate in this market place, most companies choose to provide products through these markets. The market is specially beneficial to new entrants that may have highly competitive pricing for targeted niche customers.

Large insurance companies can easily take advantage of the marketplace to gain large portions of the marketshare with competitive pricing and innovative products, especially if they have a positive brand reputation. This was demonstrated in the consumer behaviour research with brands having a positive impact on the perceived value of a product, along with price and add-on products.

The game model demonstrates that a highly varied product portfolio will dominate at the market equilibrium. It is also a beneficial strategy on the comparison sites. If priced competitively, a number of product offerings could be included in the first page of results for a customer's insurance product search. The first page of results are generally the only ones reviewed by the customer and covering more real estate on that first page will push competitors past this important threshold (McDonald & Wren, 2012; Blackwell, 2011).

The impact on profits and marketshare from page rankings and "Priority listings" on comparison sites needs more research, and preferably data from comparison sites to understand the impact of these methods on consumer purchase behaviour.

5.3.4. Regulation Changes and Litigation

Although innovation and expanding the add-on insurance product promised further profits and competitiveness in the market, increased government regulation means control of portfolio offerings to ensure good practice. The regulation increases the risk factor of the product due to the possibility of fines and decreased reputation from mis-selling or misrepresentation.

The risk of litigation from mis-selling or mis-representing a product was not included in the game model but should be considered as this risk becomes more prominent.

5.3.5. Company Conclusions

The research clearly shows that a diverse product portfolio is the market equilibrium and the strongest strategic decision in the long run. More research is needed to clarify this position, and it is recommended that a company undertake their own research and model creation to take into consideration any specific strategic goals, market targets and risk analysis data.

For a game model that answers specific questions regarding market or company positions, read next section to create a model better suited to specifications.

5.4. Company Usage

As discussed in the introduction, the value of this research not only lies in the theoretical developments, but in the practical usage of these methods for product portfolio analysis with in companies.

The following sections will discuss how a company may use these findings to develop their own models and interrupt the results, including conducting research, modifying the model and potential constraints.

Even those with years of experience in a market can overlook detail or become out of touch with the current market dynamics (Blackwell, 2011). As seen in this dissertation, extensive research is required to enable the development of a reliable game model, and even some of the industry "experts" interviewed had opinions that were contradicted by market research and the game model results. It is important to undergo a full investigation as recommended in these coming sections.

5.4.1. Defining The Game

This section details the recommended process a company may undertake to define the structure of their game model and the parts therein. These recommendations are based on methodology experience from this research (see Chapter 3 for more detail), resource questions covered during the case study research (Day, 2011; Blackwell, 2011; Holiday, 2014) and feedback from the case company during the findings presentation (Day & Holiday, 2015).

To ensure continuity and reliability in the model, it is recommended that the model be designed in a top-down fashion (Roberts, 2008) after defining research questions based on the company or product strategic goals. The steps to undertake are:

a.   Understand the company goals/questions

b.   Define the market dynamic

     c.   Analyse the competition and customer behaviour

5.4.1.1.   Company Strategic Goals

Before undertaking this research a clear understanding is first needed on the research questions or goals of this project. These research goals will be based on your company strategy, branding and the product portfolio goals.

In the UK Motor insurance industry there are a number of typical company strategies, including: Mergers & Acquisitions, Niche Marketing, Risk Reduction, Large Marketshare and Brand Diversification (Blackwell, 2011; Insurance Times, 2014). Each of these company strategies would change the format of the game model, primarily the player utility functions. The player utility, as mentioned earlier, defines the value (perceived or actual) of a given product portfolio. The strategy will change the factors of the player utility to include both quantitative factors (profits, costs, risk, growth, marketshare etc) and qualitative (good will, brand image etc). Corporate messaging is the first source for company strategy measures, else directly from management or the marketing department.

Branding and the branding strategy can have an impact on the choice in product portfolio strategy, and should be taken into account when developing the game model. The product portfolio would not be a strategic fit if the pricing is high and the branding message is as a low cost provider, or visa-versa. When developing the player utility, this strategy can be accounted for as a qualitative measure or you can simply remove those potential product strategies from your player strategies; however, do not remove these strategies from your competitors, for this would misrepresent the market dynamic.

Although it may seem obvious that maximising the product portfolio, within the corporate strategy, is the goal, there maybe a more detailed goal around how this portfolio is maximised, or acceptable modifications that would be non-optimal. For instance, product cannibalisation with in the portfolio. Normally the goal is to minimise the product cannibalisation to maximise the portfolio potential (van Heerde, 2010); however, cannibalisation may be accepted if the portfolio achieves other objectives. Ensure all product and corporate targets are included in the player utility function to ensure the product portfolio is optimised to meet the company's specific needs.

The company market goals will also change the type of game applicable to the research questions, as well as the player utility function. As discussed earlier, the player utility function should represent all of the qualitative and quantitative items of value to the company in releasing a given product strategy. The game model used may also be changed to represent the research question. If the market goals are to maximise profits, the game model would be a general game. Whereas, if the market goals are to maximise marketshare, a better fit to gain product insights would be the zero-sum game model.

5.4.1.2.   Market Dynamic

This section will address the design of the game model based on the specific target market dynamic.

Primary research on the market dynamics, competition and consumer positioning is required. There are several professional frameworks that were utilised in this research that would be useful in a company setting. The extensive case study research is more than is required for most company applications.

The game model is based on the dynamics of the market in question, therefore a clear and unbiased understanding of this is required. Porter's five forces (Porter, 1979) is a simple first level framework that would highlight the primary mechanisms and clarify where further research may be necessary. During this process the following three questions would help define the type of game model necessary:

       a.   Who are the players and what are the player types?

       b.   How is the market moving?

       c.   What are the product or competitor alternatives?

Question 1: Who are the Players and what are the Player Types?

The first question to address when designing the game model is the type of player and dynamic that is of interest. For the research done here, the UK Motor Industry market was the target mechanism to be modelled. However, in the research done by Lemaire and Borch (Borch, 1962; Lemaire, 1980) , the games were modelling the interaction between the insurance company and the customer. Finally, the main research question may be related to the cooperative nature of internal product portfolio.

Competitive market research is required to understand the competition and their behaviour, strategies and relationship with the market, customer and competitors. For a model focusing on the market mechanisms, as seen in this research on the UK Motor Insurance Industry, the players are the companies, or company groups, that are involved in the market. In most competitive markets, there are multiple players that operate in a purely competitive manner, competing over profits or marketshare, each with a unique product strategy. However, there are markets with a more complicated company interaction with cooperation as well as competition. For instance in the computer gaming industry, console makers develop game product portfolios against competitor game developers. This is a competitive environment, however, the availability of more games for the console users increases sales of the consoles, creating a semi-cooperative relationship (Frick, 2013). A purely competitive market can be modelled in the format used for the UK Motor Industry; however, markets that include a cooperative element need to evaluate is this dynamic can be included in the player utility function, or if a cooperative game model is required. The cooperative element in the UK Motor Insurance Industry could also be modelled. For example,

consider relationships between Endsleigh and Zurich Personal lines (parent companies and partnerships), or between the panel of insurers for which Endsleigh is a broker.

If it is found that the market is highly competitive with many smaller competitors, it may be possible that a non-atomic game model would be better suited to the company's needs. This model type was not research here, but resources are available regarding this model type and can, in some cases, be easier to compute the market equilibrium than a multi-player

An alternative view of the game model is to focus on the dynamic between the customer and the company. Depending on the market, this dynamic may be complicated enough that the added insights from a game model could help the company to anticipate the long term needs of the customer and how that relationship cam be fostered. There are existing models for the customer and company two-player game. This is far easier to model and would allow the company to focus primarily on understanding the customer behaviour, product attribute values and purchase interaction. Researching the customer behaviour is also required if the game model in question is of a competitive market; however, it is recommended that the depth of this research be more intense when analysing this intimate customer and company relationship.

A company may wish to focus on their own product and brand portfolio. In the UK Motor Insurance Industry it is common for large insurance companies to maintain a portfolio of brands that target specific markets or have different product strategies. To analyse the maximisation of this dynamic a Cooperative Game Model may be used to represent the competitive nature of the relationship alongside the mutual corporate profit or marketshare goals.

In short, the game model must be adapted to best suit the company's research question. It may be the 2-player zero-sum game of the customer vs. the company, the n-player competitive game of the product marketplace, or the cooperative game of inter-company brand and product portfolio optimisation.

Question 2: How is the Market moving?

The speed at which a competitors can adapt to new product portfolios, or customers can change in purchase behaviour (dramatic changes in the market type), would determine how the market is modelled. In the UK Motor Insurance Industry research, the rate of change for pricing and product development was quick and did not maintain a pattern, therefore it was the single move with the long-term view of market equilibrium that best fit our research question. For complex consumer products, a company may release a product and then months or years later a competitor will release a competing product. This slower pace, where first mover advantage (Porter, 1979) and temporary monopoly of a market could be

modelled using a sequential game model (Polak, 2007). This would more honestly demonstrate the short and long-term benefits of a give product strategy.

Question 3: What are the Product and Competitor Alternatives?

Using Porter's Five Forces, the product alternatives, competition and threat of new entrants would be analysed. This question looks at how these factors would effect the game model dynamic.

If the barriers to entry into the market are low, it would be advantageous to include a player that represents the entry of a new competitor or product. This player could be a catch all for product strategies that could impact the profits or marketshare of the company.

Product alternatives should be included in the player utility function, unless the game model in question is the customer vs. company dynamic. If this is the case, the product alternatives could be added as a player purchase strategy for the customer.

Player reputation and goodwill should also be accounted for, if it is a strong influencer on market product decisions. Prisoners Dilemma in a repeated game setting and International Trade Treaties are good game model examples (Watson, 2013) that include this qualitative factor that takes the players view of future plays into consideration.

Finally, the competitors and competitor alternatives can be represented as different players in the game. As seen in the UK Motor Insurance Industry research, these competitors can be grouped together into strategic groups to reduce the number of players computed in the model. But, for some companies, the company or product strategy may focus on their own products against a single competitor. This may be the case in a simple duopoly market where there are only two major leaders, and the company in question is only interested in chasing the large market leader, or a monopoly market with product alternatives that threaten profits or marketshare. These scenarios simplify the game model to a 2-player game. This model is far easier to represent and software tools are in place to quickly and simply calculate the Nash Equilibrium.

5.4.1.3. *Competitor and Customer Behaviour*

This section will discuss the competitor and consumer behaviour as they relate to developing the game model. From the previous section, the market dynamics provide the initial insights into what research is needed here. The competition, consumer purchase behaviour, product strategies and risk research questions are covered here.

If looking at the customer vs company game the research questions here would only include competition information pertaining the company's utility and the customer purchase utility. These utilities are to include both quantitative and qualitative decision factors.

An understanding of the consumer purchase dynamic is required prior to developing the research plan, including: Purchase channels, Purchase decision factors and Product attributes. These factors will then each be used to funnel into the consumer research and plan, to develop consumer utility function.

The company strategies will define where the focus would lie. Using the player utility functions, the game model can focus on individual companies trying to maximise these different strategies, including: product portfolios, market segment target portfolios, or brand portfolios. The product portfolio is the traditional product optimisation model, and the one seen in this UK Motor Insurance Industry model. Market segment targeting and portfolio optimisation can be accounted for in the player utility function where target markets are weighted with a qualitative factor and with more detailed consumer data. The branding optimisation strategy for the company focuses on a portfolio of brands provided by the company versus the brands provided by competing big companies. This model is useful when balancing multiple competing brands in the same market segment (insurance, food products etc).

If too little information is known regarding the strategies, moves or dynamics of the market, the company should analyse if the results would still be valuable. However, keep in mind that games of imperfect information (Watson, 2013) can still contain great insight into the dynamic of the market and the competition.

Risk

Risk analysis is unique to some markets, specifically insurance and other financial services.

Risk analysis for the defined market segments still remains as the top determination for product portfolio pricing, but should also be included in the analysis of portfolio offerings as a key cost driver. The risk calculations performed in this dissertation were rudimentary because of the lack of data from the case company, due to the highly sensitive nature of this data. However, with a company's access to their own risk analysis data and priorities, the risk based on market segments can be clearly defined and integrated into the player utility function.

Market segments are defined by the characteristics of the individuals in the behavioural cluster seen during the customer behaviour analysis research; however, these market segments may not be defined in ways that attribute directly to the risk assessments available. To avoid this issue, customer demographics that are not analysed by the company's current risk analysis should not be used for the consumer behaviour research. If however, it is found that these new demographics are very revealing to the

consumer behaviour, further discussion may be required in the company to address either an adjustment to the risk analysis taken place, or an underlying common correlated factor (Sumathia & Sivanandam, 2006) may be utilised to estimate the risk factor.

There is also risk from Government Regulation and Litigation, that is more universal to all consumer markets. These factors can be accounted for in the cost analysis as risk of fines or litigation, or return product costs, or bad product or sales procedures.

5.4.2. Research Requirements

Once the game type is understood and the research goals have been identified based on this initial analysis, the research can begin. This section details the types of research a company should employ to ensure a reliable and informative game model.

The company goals and targets have already been discussed in the previous section. One should also have a full understanding of the company's current and explorative strategies. These will define the company utility function. The Company utility is fined in two parts: Benefits and Costs.

The utility benefits will include any positive factors for a given product strategy, including: profits, qualitative weightings and future related sales profits. The profits are calculated using the consumer utility functions. The consumer utility functions are created based on the consumer behaviour research, including consumer purchase process, decision factors and product attribute preferences. The consumer purchase process is used to define the research on the decision factors and product attribute preferences, including defining the utility function factors. The decision factors and product attribute preferences are both qualitative and quantitative behaviour features and should be researched accordingly. There are a number of research methods, including those employed here for the UK Motor Insurance Industry which included a customer survey using discrete choice conjoint analysis, followed by cluster analysis. The survey and data mining methods used should be investigated and the chosen based on their fit to the company culture and research question.

The utility costs include tradeoffs for each product strategy. These could be as easily quantifiable as manufacturing costs, R&D expenditure or engineering costs. Or these may be qualitative factors based on company risks or sacrifices like time or branding relations risks.

The player utility function for the company may be different from the competition's utility function, and through the market research these differences can be included in their utility functions. Market research is necessary to qualify the player utility functions for competitors. This research is similar to that addressed in the previous section; however, it should be looking to extrapolate or theorise what the

competition's strategies and decision factors may be. The goal is to design a realistic utility function for the competitor. Primary sources for this information include publicly release information regarding company strategy, culture, branding and products. Secondary sources may include customer surveys or exploratory interviews.

5.4.3. Computation

For this market case, the Nash Equilibrium was found using a simple search for a dominant strategy using a spreadsheet and mini-maxi checks. However, due to the PPAD-complete nature of the computation of the Nash Equilibrium, it can take seconds or years for fully exploratory models. For this reason, compromises may be needed to enable the calculation of valuable results that are available in time for them to be of value. Basically, a balance must be struck between model design and question requirements, with the computation time required.

5.4.4. Interpretation of Results

The game model results are interpreted based on three factors: equilibrium/optimisation result, game type, and market dynamic.

The equilibrium result is the strategy for each player that is optimal in the market circumstances. For the Nash Equilibrium, this is the market equilibrium point at which every player can do no better by changing strategies. However, in dynamic market environment, like most competitive product markets, the market does not reach equilibrium. Comparing the Nash Equilibrium to the current market environment with the aid of insights from the market and consumer research will provide clarity to where in the game the market is, compared to the market target future of the Nash Equilibrium.

To map the Nash Equilibrium to an actual market view, first document the strategies for each player at the Nash Equilibrium. These strategies will define the products that would be released by these companies at the ideal market equilibrium. Then document the current strategies for each of these companies. The value lies in the changes from the current to the equilibrium. Analyse the differences and the potential timescale for making these changes. Then calculate the company's utility functions between the current and future product portfolio strategy. This mapping will highlight the optimal strategy steps to make as the market strives for equilibrium and will minimise the company re-work or lag time in product development.

5.4.5. Usage Conclusions

In conclusion, the usage of the game model techniques as seen and outlined in this research will rely on the company commitment to human and computer resources in calculating this highly insightful addition to marketing knowledge.

The product management team would require an understanding of research questions and requirements, consumers, competitors and market. They would also need access to the resources and ability to code and compute the game model results. And, finally, they would need the insight to map the results back to the research in a meaningful manner. These insights will allow product managers to create a more efficient and profitable product roadmap, allowing a company to focus R&D efforts effectively and maximise profits.

5.5. Conclusion

In this chapter, the value of the game model and other research results were realised for the market and the company. The market feedback includes using government regulation to help change the state of the market to maximise the consumer value and facilitating quality innovation in the insurance market. For company's, the game model delivers a strong message to deliver a full portfolio of quality innovation to a wide consumer base. Also, through the case study and consumer research, the details of implementing this strategy were clarified to reduce rework and issue.

The model and research performed can be adapted for different markets and company requirements. Through the methods presented here, a company may learn and adapt the game model format and utility functions to meet their needs. These adaptations can be made based on different markets and different product types from physical consumer products to B2B services. This method will give companies the power to understand the dynamic of their individual market and back up product strategies with a reliable market model. Furthermore, the UK Motor Insurance market is highly unique, but the on-line price comparison market format is rising in popularity in other industries and markets, and use of this model may behove companies in these markets.

Despite the theoretical advances put forth by the research done here on the UK Motor Insurance Industry, some of the adaptations a company may desire to make would require further research. The theoretical advances made and the suggested future research is discussed in further details in the concluding chapter (Chapter 6).

6.   Limitations

Research and Model Limitations

6.1. Introduction

This chapter will briefly list and discuss the limitations of the approach presented in this dissertation, including limitations to the utility function content and analysis, and the game model structure.

6.2. Limitations to Utility Function

One of the aspects of limitation to the model was the utility function construction and the data available. The following section will discuss the limitations found in the survey data, risk calculations, cost calculations and the product pricing style used.

6.2.1.   Survey Data

As mentioned in the Methodologies and Analysis chapters the customer survey provided a limited number of respondents. Although statistical significance was found, the validity from a small number of data points is not a high as it could be. Greater detail in the product attribute utility variables, market segments and demographics would present itself if a larger scale survey with a greater number of respondents was available. Based on the calculation mentioned in the methodology chapter, a respondent base of at least 1,600 would be ideal, accounting for: a possible respondent rate of 50%; a loss of a further 50% of responses based on demographic needs; malicious responses; and the need for a final number of valid responses of 400. This would give a confidence interval of 90% and a margin of error of ± 5%. The respondent rate is based on information from Survey Monkey while setting up the survey with their audience participants in the UK. The loss of 50% based on demographic needs and malicious responses is based (with rounding up) on the loss rate from the survey contained here in this dissertation.

A larger survey would benefit a company or market regularly greatly, given the extended clarity in behaviour and granularity of market segments, giving a more in-depth and accurate utility function. Although this is valuable and important, the contribution to knowledge of this dissertation does not focus solely on the survey and utility function, but in the application and viability study of the use of game theory to analyse product portfolio strategies in a market.

6.2.2.   Risk Calculation

Due to the importance of the risk factor in the calculation of the player utility, its inclusion is justified; however to to the absence (and confidentiality of the data, a plausible estimate was utilised. The risk factor simply extrapolated from accident rates for the given market segments as reported by the Motor Insurance Regularity body (National Travel Survey 2014, 2014), as well as from qualitative commentary during interviews regarding the market segments (Gunnels, 2011). A company using this model would be able use their actual risk calculations that may represent more closely the reality of their cost of insurance. Also, extrapolation should be used for estimation of the competitor's risk rates. This extrapolation still proves as a limitation of the model accuracy.

6.2.3. Costs

The cost involved in insurance risk was also limited in how it was calculated in this model's formulation. The risk factor used was simply a percentage of return for each market segments; however, the actual cost is equal to the payout if an accident occurs. The use of the average accident cost for each market segment multiplied by the risk factor would provide a more reliable cost basis. Furthermore, this cost should be included in such a way that the utility reflects any negative value to a product presented to a given segment. For instance, the risk factor may be as high as 0.65 (e.g. for the student market segment); however the average cost of an accident is high enough that with that risk factor, selling an insurance product at the lower price point (i.e. 300 GBP per year) would actually yield a negative player utility for that product in that market segment. Therefore, the risk cost calculation used in this dissertation is limited, and it is suggest that a more accurate model be utilised in the future.

Other costs not included in the model include overhead and legal and insurer negotiation costs to setting up a new product attribute. These were assumed to be close to equal across all the players, therefore was kept out of the utility function. However, this is a limitation to the model and the reality may display that the larger big brand insurers have lower overhead of set-up costs than some of the smaller niche players, or visa versa. Further investigation is required to understand the extent of this limitation and if these costs should be included in the model for further accuracy.

6.2.4. Product Pricing

As mentioned in the risk and cost sections risk and pricing calculations were limited in this model. A majority of insurance companies base the cost presented to a customer based on their individual risk (i.e. based on demographic and behavioural markers). However, the price is treated as a exogenous product attribute in the model presented here.

This limited view of pricing did simplify the model calculation; however, it reduces the inferences that can be made regarding the degree of price competition, especially in the new price comparison market environment.   The model would greatly benefit modification to include more detailed pricing and risk calculations closer to those used in the actuarial environment of the insurance companies. These model additions would provide greater accuracy and further insights into price competitiveness.

6.3. Limitations to the Game Model

As there were limitations to the utility functions that fed into the game model, there were also limitations to the game model itself. This section will discuss the limitations found in the model with respect to market dynamics and market equilibrium.

6.3.1.   Market Dynamics

In reality the market is dynamic, but an attempt here was made to map a long term market equilibrium in a static game. This approach is limited in its scope and view of the market dynamics. As mentioned in the industry impact chapter, a dynamic game may be more appropriate for certain markets. The reasoning for choosing the static game was discussed in the methodology chapter; however, it should be stated here that the use of the static game does have limitations.

A more detailed interpretation and view of the market may be available it a dynamic game was used. For instance, it was clear from the results that the market is not at market equilibrium, but a follow up with a dynamic game may bring to light more details regarding the current state of the market and possible strategy paths that may lead to the market equilibrium as the game is played.

6.3.2.   Multiple Equilibria

Another limitation of the use of a static game is the possibility of the existence of multiple equilibria. What this means for the player and how a mixed strategy is played is not clear. If each strategy was a single product, then a mixed strategy would mean a mixed portfolio; however, when each strategy is a portfolio, it is not necessarily clear what it would mean to have a strategy of multiple portfolios, or swapping between portfolios.

A dynamic game may provide more details on this position, but the application will most likely depend on the market and the product involved, and on how a company may interpret and work with a mixed strategy solution.

6.4. Conclusion

In summary, there are limitations to this research, allowing for continued improvement and development of more accurate and market models. Although these limitations are apparent, the contribution to knowledge of this dissertation is still valid in the application and viability study of the game theory to analyse product portfolios in a competitive market.

7.   Conclusion

Research Impact and Future Research

7.1. Introduction

This chapter contains a summary of the research contained in these pages, including the academic and theoretical value of the research and suggestions for further research in the area of game theory and product portfolio management.

7.2. Contributions to Knowledge

The academic value of this research extends to several different areas. Some impact is greater than others, but the impact does pertain to: methodology, current Game Theory & Product Portfolio Management research and the market insights. The first two subjects are addressed here; however, the concluding findings and recommendations regarding the market insights can be found in Chapter 5.

Methodological advances were made in the usage of discrete choice conjoint analysis for the study of a service product. This study is unique in utilising the consumer behaviour study method of discrete choice conjoint analysis for understanding customer utility values for a service product such as insurance. The combination of viewing the service as a product by mapping the add-ons as a product attribute allowed the use of discrete choice conjoint analysis to create a valuable consumer product preference utility model to be used in the Game Theory Model.

Great strides were made in this research in the use of Game Theory for Product Portfolio strategy analysis. In particular, by defining a unique player utility function. The utility function found here, although based on a number of utility functions from leading academics, was market and player specific based on the behaviour findings in the case study and consumer behaviour research performed. Although the use of this type of player utility function in a Game Theory framework was outlined by Sadeghi & Zandieh (2011), the modification to apply to a commodity service product and the inclusion of customer behaviour segmentation was a valuable asset to the validity of this Game Theory model.

Furthermore, the use of competitive strategic grouping to analyse and group market players, thus reducing the number of game model players to a manageable number of strategic player groups, provided a unique and valuable method. Since the companies in these strategic groups maintain the same fundamental strategic behaviour, and customers respond to their products in a similar fashion, the

grouping maintained the integrity of a full Game Theory model. This manipulation has never been done before and proved extremely valuable in facilitating the computation of the Nash Equilibrium in the suitable computation window acceptable to the product companies.

Finally, this research demonstrated that Game Theory provides a valuable perspective when used to analyse a Product Portfolio Management case in this particular commodity services market.

7.3. Future Research

This research is a step forward towards the development of Game Theory models for competitive market modelling with valuable insights for a product or product portfolio manager. Given the numerous dimensions of the product portfolio manager's scope, this area has room for improvement from the application to other industries and industry types, to advances in the utility functions and the game model. This section will introduce suggested areas for future research in this area.

7.3.1. Industries

Possibly the most obvious extension of this research that could be undertaken, is the application to other industries. The commodity services industry of the UK Motor Insurance industry has many unique aspects that do not translate to other industries. For instance, there is some work in utilising utility functions for other services industries, extending on that research and utilising Game Theory modelling could provide valuable market and academic insights into those industries and new models.

Along these same lines, an extension to the unique company competitive behaviour in Business-to-Business (B2B) product strategies. Both physical products and services in B2B have proven more difficult to understand then traditional consumer products. The development of a Game Theory model and performing a similar study to this for these markets could prove valuable to the market and in furthering academic understanding of B2B markets.

Finally, a highly interesting industry application would be to consumer products. Although, this would be a more direct extension of the work already done by Sadeghi & Zandieh (2011), one could utilise their existing player utility function, but extend to multi-player using the methodology used here. However, this simpler extension would still benefit the expansion of understanding the applications of Game Theory in Product Portfolio Management, and this application may prove the most valuable in the competitive market applications.

7.3.2. Game Model

Given this research comes at a time early in development of Game Theory used for Product Portfolio Management, there are several areas where research can expand upon these learnings and model, including the model calculation methods and the model types used to define the market and player dynamics.

7.3.2.1.   *Calculations*

A more definite Nash Equilibrium calculation algorithm may be preferable. In the interest of computation time, most Nash Equilibrium computation models look for a single possible Nash Equilibrium, not necessarily a definitive list of Nash Equilibrium(s). One new computation technique that could be very interesting in this, and other competitive market applications, is the learning games as proposed by Goldberg (2014). This technique is proposed as a new method for calculating the Nash Equilibrium faster and with more reliability; however, this learning behaviour is similar to the learning behaviour that markets may experience with these new market types are introduced to an existing industry market, like that in the price comparison website markets. So not only could this application aid in faster Nash Equilibrium computation, but the intermediary steps to calculation may imitate market dynamics more closely.

7.3.2.2.   *Model Types*

Most of the changes to the model type would be dependent on a change in the underlying research question, company goals or market dynamics. For instance, looking at market share instead of profits or analysing the consumer-versus-insurer game. Some of these concepts were introduced in the Methodology chapter when discussion the model chosen; however, this section focuses on the future potential of research with these other model types and more recent model computation concepts.

Some industries have an interesting dynamic where there is both a cooperative and competitive dynamic between players. For instance a single company that maintains a portfolio of brands and with in these brands a portfolio of products. This portfolio of brands may have a common corporate goal that requires a degree of cooperative behaviour. To this respect a cooperative game model would be an interesting additive to investigate.

One Game Theory dynamic that has been performed relating to insurance is the 2-player dynamic between the customer and the company. This dynamic provides valuable insights into the risk assessment and behavioural analysis of the customer. This model type could be applied to other industries or the insights of this model and the model contained here combined to gain more detailed understanding of the customer behaviour dynamic.

One key topic in Product Management that is of keen interest is new product launches and their effects on the market. Research on the art of market signalling through the use of pre-product-launch marketing (Eliashberg & Robertson, 1988), is an excellent start to potentially introducing incomplete information or signalling Game Theory models. There has also been discussion on the competitor response time to new product releases (Bowman & Gatignon, 1995) and could be an interesting dynamic to introduce to a Game Theory model and the use of game moves, where the competitors or players take turns in their moves in the market.

7.4. Conclusion

In conclusion, the research contained here extends on the research already done in both Product Portfolio Management and Game Theory. Through careful use of sound research methods and analysis, this research has provided a valuable Game Theory model for use by Product Portfolio Management in the UK Motor Insurance industry. The use of a game model provided an additional perspective into the future state of the market and, in turn, the expected competitor and market response to specific product strategies. The case company involved found the results insightful and aided their business case for continued product innovation, and are investigating inclusion of Game Theory in future product portfolio analysis and operations. The Association of British Insurers also found the modelling insights valuable in highlighting the impact new regulations place on market dynamics. Thus demonstrating that the use of Game Theory as a tool to analyse a Product Portfolio Management case brings valuable business and regulatory insights.

Future research is expected to take place by continuing on with this research to perform a validation study with the UK Motor Insurance industry. This added research requires more time than was available for this initial study and it is anticipated that seeing the model in use by a company or market regulator could provide further insights into the model mechanism and how it may be improved upon.

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Appendices

Appendix A: List of Considered Companies

Company Target List (reason not chosen to case study):

K2 - Skies and other winter sport equipment (no response)

LINE - Niche Ski equipment company (too few products with little range)

New Balance - Running shoes and athletic apparel (many qualitative factors, and just fit)

Saucony - Running shoes and athletic apparel (qualitative factors and "fit")

Concept II - Rowing Machines and training equipment (no response)

Endsleigh & Zurich - Insurance

Artisan Software Tools - Software design tools (pricing is negotiated with top customers)

Bose - Sound Systems including Noise Cancellation technology (no response)

Jeep - Niche Automotive (direct competition and definition of "market" unclear)

Appendix B: Portfolio Strategy Definitions

This list defines the products that are included in each defined strategy. The core motor insurance product is either Third Party Only, Third Party, Theft & Fire (TPTF) or Comprehensive, followed by the add-ons defined to be included and the price point.

Strategy Number	Details	Product Number					
1	Third Party Only @ Price low	25					
2	TPTF @ Price Mid Low	49					
3	Comprehensive @ Price Mid High	73					
4	TPTF @ Price Mid High	41					
5	Comprehensive @ Price High	70					
6	TPTF, All Add-ons @ Price Mid Low	56					
7	TPTF, All Add-ons @ Price Mid High	48					
8	Comprehensive, All Add-ons @ Price Mid High	80					
9	Comprehensive, All Add-ons @ Price High	72					
10	TPTF @ Price Mid Low; Comprehensive @Price Mid-High	49	73				
11	TPTF, All Add-ons @ Price Mid High; Comprehensive, All Add-ons @ Price High	48	72				
12	Other @ Low; Student @ Mid Low; High-Income @ Mid High	96	83	77			
13	Other @ Mid Low; Student @ Mid High; High-Income @ High	88	75	37			
14	Other+ @ Mid Low; Student+ @ Mid High; High-Income+ @ High	88	76	69			
15	Other @ Low; Student @ Mid Low; High-Income @ Mid High; Other+ @ Mid Low; Student+ @ Mid High; High-Income+ @ High	96	83	77	88	76	69
16	Other @ Mid Low; Student @ Mid High; High-Income @ High; Other- @ Low; Student- @ Mid Low; High-Income- @ Mid High	88	75	37	95	81	41
17	Other @ Mid Low; Other - @ Low; Other + @ Mid High; Student @ Mid High; Student- @ Mid Low; Student + @ High; High-Income @ High; High-Income- @ Mid High; High-Income + @ High;	88	75	37	80	68	69
		95	81	41			
18	Full set of all reasonably priced products excluding Third Party (=14; removing for example Comprehensive with all add-ons at Low price point)	57	58	59	61	54	55
		48	81	74	75	76	77
		78	72				

Strategy Number	Details	Product Number					
19	Full set of all reasonably priced products (=24; removing for example Comprehensive with all add-ons at Low price point)	25	26	27	29	20	22
		23	24	49	50	51	53
		44	46	47	48	73	74
		75	77	68	70	71	72
20	Full set of all products, excluding Third Party (=64)	33	34	35	36	37	38
		39	40	41	42	43	44
		45	46	47	48	49	50
		51	52	53	54	55	56
		57	58	59	60	61	62
		63	64	65	66	67	68
		69	70	71	72	73	74
		75	76	77	78	79	80
		81	82	83	84	85	86
		87	88	89	90	91	92
		93	94	95	96		
21	Full set of all possible 96 products	All					

Appendix C: Case Questions

Table C.1: Case Question Level Definitions

Level	Description
1	Interview Questions
2	Individual Case Questions
3	Pattern across Cases Questions
4	Study Questions
5	Normative Questions and Conclusion Questions

Table C.2: Case Questions

Level	Questions
1	Consumer Questions: Preferred Product Attributes
1	Consumer Questions: Demographics for Market Segment Understanding
1	Company Questions: What analysis techniques does your company use for Product, Product Strategy and Product Portfolio Analysis?
1	Company Questions: Does your product analysis use historical data only?
1	Company Questions: What do you see as the market segments or niches?
1	Company Questions: How does your company respond to price comparison websites?
1	Company Questions: How does your company go about pricing a product?
1	Company Questions: How does your company calculate risk?
1	Company Questions: What is your company's COR?
1	Company Questions: How does your company innovate?
1	Company Questions: What technology does your company leverage or develop related to your products?
2	How is the company product strategy developed?
2	What attributes help define the company strategy?
2	Is regulation impacting the product strategy?
3	How does the customer make purchase decisions?
3	What are the different Product Strategies in the market?
3	What are the competitive strategic groups?
4	Are regulator effecting the company strategies?
4	What are the company strategy decision drivers?
4	What are the customer purchase decision drivers?
4	How do the brands within big companies interact?
5	Does knowledge of a potential Market Equilibrium add insight into product strategy decisions?
5	Does knowledge of a potential Market Equilibrium add insight into regulatory decisions?

Appendix D: Theoretical Construct Table

Table D.1: Theoretical Construct Table

Symbol	Construct	Description	Measures
i	Market Segment	(1) Niche (2) Cluster (3) Risk Grouping	Cluster Analysis and market segments identified in company interviews
m	Player	(1) Insurance Company (2) Competitive Strategic Group (3) Brand	Brand Spending and Brand Strategy Identifiers
a^m	Strategy	(1) Product Portfolio (2) Product Strategy (3) Pricing Strategy (4) Add-on Strategy	Strategies identified in interviews and market articles Portfolios maximised based on segment preferences in survey
j	Product	(1) Insurance Level (2) Add-ons (3) Pricing	Combinations of all insurance levels, prices and add-on options

Appendix E: Case Codebook

Table F.1: Case Codebook Assignments

Word/phrase	code value	related words/phrases
actuaries	1	
add-ons	2	
aggregators	3	comparison websites
brand	4	
breakdown cover	5	add-ons
combined ration	6	technical cost
comparison websites	7	aggregators
comprehensive	8	
excess	9	
excess cover	10	add-ons
fees	11	
fines	12	
FSA	13	regulators
fully comped	14	comprehensive
gps	15	technology
high street	16	
innovation	17	new products
insurance	18	
key cover	19	add-ons
legal cover	20	add-ons
losses	21	
market	22	
modeling	23	
new products	24	innovation
niche	25	
no-claims bonus cover	26	add-ons
overhead cost	27	technical cost
personal injury cover	28	add-ons
policies	29	
premium	30	price
price	31	
product analysis	32	

Word/phrase	code value	related words/phrases
product management	33	
product strategy	34	
rankings	35	price, aggregators, comparison websites
regulation	36	
regulators	37	FSA
rental car cover	38	add-ons
risk	39	
segments	40	
software	41	
students	42	young drivers
technical cost	43	overhead
technology	44	gps
third party only	45	
third party theft and fire	46	
transition	47	
underwriting	48	
uninsured	49	
young drivers	50	students

Appendix F: Survey

Table F.1: Choice Profiles: Design of Experiment Results

	Choice Set	Choice ID	Insurance Level	Brand	Price	Breakdown Cover	Legal Cover	Personal Injury Cover	Hire Car	Protected No-claims Bonus	Key Cover	Excess Cover
1	1	1	Third Party Only	Big High Street Brand	100	No	No	No	No	Yes	Yes	Yes
2	1	2	Third Party, Theft & Fire	Other Big Brand	300	Yes	No	Yes	No	Yes	Yes	Yes
3	1	3	Third Party Only	Big Insurer	100	No	No	No	No	Yes	Yes	No
4	1	4	Comprehensive	Small/Medium Insurer	500	Yes	Yes	Yes	No	Yes	Yes	No
5	2	1	Comprehensive	Small/Medium Insurer	300	No	No	No	No	Yes	No	No
6	2	2	Third Party, Theft & Fire	Other Big Brand	800	Yes	Yes	No	Yes	Yes	No	No
7	2	3	Third Party, Theft & Fire	Big Insurer	800	Yes	Yes	No	Yes	Yes	Yes	Yes
8	2	4	Comprehensive	Small/Medium Insurer	500	No	No	No	No	Yes	Yes	Yes
9	3	1	Third Party Only	Small/Medium Insurer	500	No	Yes	No	Yes	No	No	No
10	3	2	Third Party, Theft & Fire	Other Big Brand	100	Yes	No	No	No	Yes	Yes	No
11	3	3	Comprehensive	Small/Medium Insurer	300	No	Yes	Yes	No	No	No	Yes
12	3	4	Comprehensive	Big High Street Brand	800	No	Yes	No	No	No	No	No
13	4	1	Comprehensive	Big Insurer	100	Yes	No	No	Yes	No	Yes	No
14	4	2	Comprehensive	Other Big Brand	100	Yes	No	No	No	Yes	Yes	No
15	4	3	Third Party, Theft & Fire	Big High Street Brand	300	No	Yes	No	Yes	Yes	Yes	No
16	4	4	Third Party Only	Big High Street Brand	800	No	Yes	Yes	Yes	Yes	Yes	No
17	5	1	Third Party, Theft & Fire	Small/Medium Insurer	300	Yes	Yes	No	Yes	Yes	Yes	Yes
18	5	2	Comprehensive	Big Insurer	800	No	Yes	No	Yes	Yes	Yes	Yes
19	5	3	Third Party Only	Other Big Brand	500	No	No	Yes	No	No	Yes	Yes
20	5	4	Third Party Only	Big High Street Brand	500	Yes	No	Yes	No	No	No	Yes
21	6	1	Third Party, Theft & Fire	Small/Medium Insurer	500	Yes	No	No	No	Yes	No	Yes
22	6	2	Comprehensive	Other Big Brand	100	No	Yes	Yes	Yes	No	No	No
23	6	3	Third Party Only	Big High Street Brand	300	Yes	Yes	Yes	Yes	Yes	No	Yes
24	6	4	Third Party, Theft & Fire	Small/Medium Insurer	800	Yes	No	Yes	No	Yes	Yes	No
25	7	1	Third Party, Theft & Fire	Big Insurer	500	No	No	Yes	Yes	Yes	Yes	No
26	7	2	Comprehensive	Big High Street Brand	300	No	No	Yes	Yes	Yes	Yes	No
27	7	3	Comprehensive	Other Big Brand	800	No	No	Yes	Yes	Yes	Yes	No
28	7	4	Third Party Only	Small/Medium Insurer	800	Yes	Yes	No	No	No	Yes	No
29	8	1	Third Party Only	Other Big Brand	300	No	No	No	No	No	No	Yes
30	8	2	Third Party Only	Big High Street Brand	500	No	No	No	No	Yes	Yes	No
31	8	3	Comprehensive	Big Insurer	100	Yes	Yes	Yes	Yes	Yes	No	Yes
32	8	4	Third Party, Theft & Fire	Big High Street Brand	800	No	No	No	No	No	No	Yes
33	9	1	Third Party, Theft & Fire	Small/Medium Insurer	100	No	No	Yes	Yes	No	Yes	No
34	9	2	Comprehensive	Big High Street Brand	500	Yes	No	Yes	Yes	No	Yes	No
35	9	3	Third Party, Theft & Fire	Other Big Brand	100	No	Yes	No	No	No	Yes	No
36	9	4	Comprehensive	Big Insurer	300	Yes	Yes	Yes	No	No	Yes	No
37	10	1	Comprehensive	Other Big Brand	300	Yes	No	No	Yes	No	Yes	No
38	10	2	Comprehensive	Small/Medium Insurer	800	Yes	No	No	Yes	Yes	No	Yes
39	10	3	Third Party, Theft & Fire	Big High Street Brand	100	No	Yes	Yes	No	No	Yes	No
40	10	4	Third Party, Theft & Fire	Big Insurer	500	No	Yes	Yes	No	Yes	Yes	Yes

Image F.1: Page 1

Motor Insurance Discrete Choice Survey

1. What is your gender?

◯ Female

◯ Male

2. What is your age?

3. Which of the following best describes your current relationship status?

◯ Married

◯ Widowed

◯ Divorced

◯ Separated

◯ Single, but cohabiting with a significant other

◯ Single, never married

Next

**Image F.2:
Page 2**

**Image F.3:
Page 3**

**Image F.4:
Page 4**

Motor Insurance Discrete Choice Survey

11. Do you hold a current driving license?
- ⚪ Yes
- ⚪ No

12. Approximately how many years driving experience do you have?
[⬍]

13. For what purpose do you currently use your vehicle?
- ⚪ Social, Domestic & Pleasure
- ⚪ Commuting, Social, Domestic & Pleasure
- ⚪ Business (with or without Social, Domestic & Pleasure)
- ⚪ Commercial (with or without Social, Domestic & Pleasure)
- ⚪ N/A

14. Approprimately how many miles do you drive in a year?
[⬍]

[Prev] [Next]

**Image F.5:
Page 5**

Motor Insurance Discrete Choice Survey

15. If these were the only motor insurance products available to you, which one would you purchase?

⚪ M&S	⚪ Nationwide	⚪ LV=	⚪ endsleigh Insurance
£100	£300	£100	£500
Third Party Only	Third Party, Theft & Fire	Third Party Only	Comprehensive
Protected No-claims Bonus	Breakdown Cover	Protected No-claims Bonus	Breakdown Cover
Key Cover	Personal Injury Cover	Key Cover	Legal Cover
Excess Cover	Protected No-Claims Bonus		Personal Injury Cover
	Key Cover		Protected No-claims Bonus
	Excess Cover		Key Cover

16. If these were the only motor insurance products available to you, which one would you purchase?

⚪ endsleigh Insurance	⚪ Nationwide	⚪ LV=	⚪ endsleigh Insurance
£300	£800	£800	£500
Comprehensive	Third Party, Theft & Fire	Third Party, Theft & Fire	Comprehensive
Protected No-claims Bonus	Breakdown Cover	Breakdown Cover	Protected No-claims Bonus
	Legal Cover	Legal Cover	Key Cover
	Hire Car	Hire Car	Excess Cover
	Protected No-claims Bonus	Protected No-claims Bonus	
		Key Cover	
		Excess Cover	

[Prev] [Next]

Image F.6:
Page 6

Motor Insurance Discrete Choice Survey

17. If these were the only motor insurance products available to you, which one would you purchase?

○ endsleigh Insurance	○ Nationwide	○ endsleigh Insurance	○ M&S
£500	£100	£300	£800
Third Party Only	Third Party, Theft	Comprehensive	Comprehensive
Legal Cover	& Fire	Legal Cover	Legal Cover
Hire Car	Breakdown Cover	Personal Injury	
	Protected No-	Cover	
	claims Bonus	Excess Cover	
	Key Cover		

18. If these were the only motor insurance products available to you, which one would you purchase?

○ LV= LIVERPOOL VICTORIA	○ Nationwide	○ M&S	○ M&S
£100	£100	£300	£800
Comprehensive	Comprehensive	Third Party, Theft	Third Party Only
Breakdown Cover	Breakdown Cover	& Fire	Legal Cover
Hire Car	Protected No-	Legal Cover	Personal Injury
Key Cover	claims Bonus	Hire Car	Cover
	Key Cover	Protected No-	Hire Car
		claims Bonus	Protected No-
		Key Cover	claims Bonus
			Key Cover

Prev   Next

Image F.7:
Page 7

Motor Insurance Discrete Choice Survey

19. If these were the only motor insurance products available to you, which one would you purchase?

○ endsleigh Insurance	○ LV= LIVERPOOL VICTORIA	○ Nationwide	○ M&S
£300	£800	£500	£500
Third Party, Theft	Comprehensive	Third Party Only	Third Party Only
& Fire	Legal Cover	Personal Injury	Breakdown Cover
Breakdown Cover	Hire Car	Cover	Personal Injury
Legal Cover	Protected No-	Key Cover	Cover
Hire Car	claims Bonus	Excess Cover	Excess Cover
Protected No-	Key Cover		
claims Bonus	Excess Cover		
Key Cover			
Excess Cover			

20. If these were the only motor insurance products available to you, which one would you purchase?

○ endsleigh Insurance	○ Nationwide	○ M&S	○ endsleigh Insurance
£500	£100	£300	£800
Third Party, Theft	Comprehensive	Third Party Only	Third Party, Theft
& Fire	Legal Cover	Breakdown Cover	& Fire
Breakdown Cover	Personal Injury	Legal Cover	Breakdown Cover
Protected No-	Cover	Personal Injury	Personal Injury
claims Bonus	Hire Car	Cover	Cover
Excess Cover		Hire Car	Protected No-
		Protected No-	claims Bonus
		claims Bonus	Key Cover
		Excess Cover	

Prev   Next

**Image F.8:
Page 8**

wbs

Motor Insurance Discrete Choice Survey

21. If these were the only motor insurance products available to you, which one would you purchase?

LV= LIVERPOOL VICTORIA	M&S	Nationwide	endsleigh Insurance
£500	£300	£800	£800
Third Party, Theft & Fire	Comprehensive	Comprehensive	Third Party Only
Personal Injury Cover	Personal Injury Cover	Personal Injury Cover	Breakdown Cover
Hire Car	Hire Car	Hire Car	Legal Cover
Protected No-claims Bonus	Protected No-claims Bonus	Protected No-claims Bonus	Key Cover
Key Cover	Key Cover	Key Cover	

22. If these were the only motor insurance products available to you, which one would you purchase?

Nationwide	M&S	LV= LIVERPOOL VICTORIA	M&S
£300	£500	£100	£800
Third Party Only	Third Party Only	Comprehensive	Third Party, Theft & Fire
Excess Cover	Protected No-claims Bonus	Breakdown Cover	Excess Cover
	Key Cover	Legal Cover	
		Personal Injury Cover	
		Hire Car	
		Protected No-claims Bonus	
		Excess Cover	

Prev   Next

**Image F.9:
Page 9**

wbs

Motor Insurance Discrete Choice Survey

23. If these were the only motor insurance products available to you, which one would you purchase?

endsleigh Insurance	M&S	Nationwide	LV= LIVERPOOL VICTORIA
£100	£500	£100	£300
Third Party, Theft & Fire	Comprehensive	Third Party, Theft & Fire	Comprehensive
Personal Injury Cover	Breakdown Cover	Legal Cover	Breakdown Cover
Hire Car	Personal Injury Cover	Key Cover	Legal Cover
Key Cover	Hire Car		Personal Injury Cover
	Key Cover		Key Cover

24. If these were the only motor insurance products available to you, which one would you purchase?

Nationwide	endsleigh Insurance	M&S	LV= LIVERPOOL VICTORIA
£300	£800	£100	£500
Comprehensive	Comprehensive	Third Party, Theft & Fire	Third Party, Theft & Fire
Breakdown Cover	Breakdown Cover	Legal Cover	Legal Cover
Hire Car	Hire Car	Personal Injury Cover	Personal Injury Cover
Key Cover	Protected No-claims Bonus	Cover	Cover
	Excess Cover	Key Cover	Protected No-claims Bonus
			Key Cover
			Excess Cover

Prev   Done

Appendix G: Hierarchical distance graphs

Image G.1: Hierarchical distance chart with clusters coloured (left)
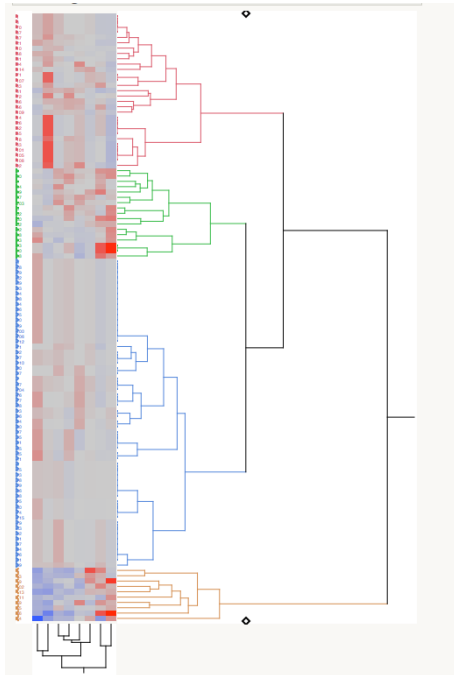
Image G.2: Distance graph with line showing 4 clusters (below)
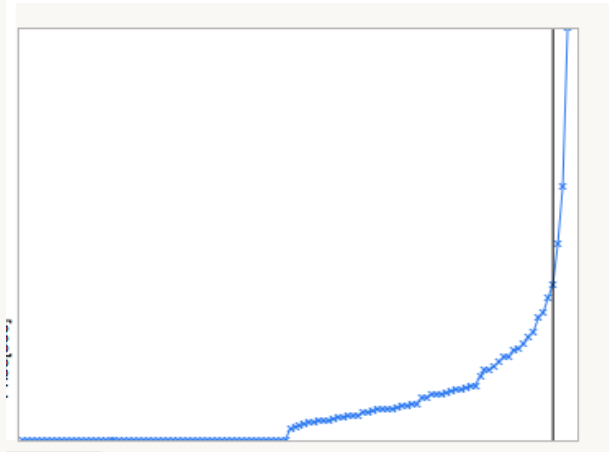
Image G.3: K-means analysis

Iterative Clustering

Cluster Comparison

Method	NCluster	CCC	Best
K-Means Clustering	3	-2.5333	
K-Means Clustering	4	-2.3764	
K-Means Clustering	5	-0.406	Optimal CCC
K-Means Clustering	6	-1.0087	

Columns Scaled Individually

K Means NCluster=5

Columns have common scale

Cluster Summary

Cluster	Count	Step	Criterion
1	6	3	0
2	1		
3	99		
4	1		
5	8		

Cluster Means

Cluster	Insurance Level[Comprehensive]	Insurance Level[Third Party, Theft & Fire]	Price[100]	Price[300]	Price[500]	Legal Cover[Yes]	Protected No-claims Bonus[Yes]	Key Cover[Yes]
1	-0.0007911	0.00209943	-0.0021704	-0.000651	0.00223929	-0.0007791	-0.0003139	-0.000843
2	-0.0051541	0.00147043	-0.0056072	-0.0017859	0.01046043	-0.0007653	-0.0011422	-0.0036881
3	0.00041555	-0.0001585	0.00041831	0.0001996	-0.0003263	-1.074e-5	0.00016605	0.00017532
4	-0.0072932	-0.0039675	-0.0036665	-0.0019419	0.00146524	0.00091816	-0.0020282	-1.3152e-5
5	-0.0027269	0.00058799	-0.0020987	-0.001352	0.00073821	0.00078839	-0.0012854	-0.0010248

Cluster Standard Deviations

Appendix H: Product Definitions

Table H.1: Product Definitions: Product Number with binary attribute definitions

	b_1	b_2	b_3	l_1	l_2	r_1	r_2	r_3	g	y	k
1	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	1
3	0	0	0	0	0	0	0	0	0	1	0
4	0	0	0	0	0	0	0	0	0	1	1
5	0	0	0	0	0	0	0	0	1	0	0
6	0	0	0	0	0	0	0	0	1	0	1
7	0	0	0	0	0	0	0	0	1	1	0
8	0	0	0	0	0	0	0	0	1	1	1
9	0	0	0	0	0	0	0	1	0	0	0
10	0	0	0	0	0	0	0	1	0	0	1
11	0	0	0	0	0	0	0	1	0	1	0
12	0	0	0	0	0	0	0	1	0	1	1
13	0	0	0	0	0	0	0	1	1	0	0
14	0	0	0	0	0	0	0	1	1	0	1
15	0	0	0	0	0	0	0	1	1	1	0
16	0	0	0	0	0	0	0	1	1	1	1
17	0	0	0	0	0	0	1	0	0	0	0
18	0	0	0	0	0	0	1	0	0	0	1
19	0	0	0	0	0	0	1	0	0	1	0
20	0	0	0	0	0	0	1	0	0	1	1
21	0	0	0	0	0	0	1	0	1	0	0
22	0	0	0	0	0	0	1	0	1	0	1
23	0	0	0	0	0	0	1	0	1	1	0
24	0	0	0	0	0	0	1	0	1	1	1
25	0	0	0	0	0	1	0	0	0	0	0
26	0	0	0	0	0	1	0	0	0	0	1
27	0	0	0	0	0	1	0	0	0	1	0
28	0	0	0	0	0	1	0	0	0	1	1
29	0	0	0	0	0	1	0	0	1	0	0

	b_1	b_2	b_3	l_1	l_2	r_1	r_2	r_3	g	y	k
30	0	0	0	0	0	1	0	0	1	0	1
31	0	0	0	0	0	1	0	0	1	1	0
32	0	0	0	0	0	1	0	0	1	1	1
33	0	0	0	0	1	0	0	0	0	0	0
34	0	0	0	0	1	0	0	0	0	0	1
35	0	0	0	0	1	0	0	0	0	1	0
36	0	0	0	0	1	0	0	0	0	1	1
37	0	0	0	0	1	0	0	0	1	0	0
38	0	0	0	0	1	0	0	0	1	0	1
39	0	0	0	0	1	0	0	0	1	1	0
40	0	0	0	0	1	0	0	0	1	1	1
41	0	0	0	0	1	0	0	1	0	0	0
42	0	0	0	0	1	0	0	1	0	0	1
43	0	0	0	0	1	0	0	1	0	1	0
44	0	0	0	0	1	0	0	1	0	1	1
45	0	0	0	0	1	0	0	1	1	0	0
46	0	0	0	0	1	0	0	1	1	0	1
47	0	0	0	0	1	0	0	1	1	1	0
48	0	0	0	0	1	0	0	1	1	1	1
49	0	0	0	0	1	0	1	0	0	0	0
50	0	0	0	0	1	0	1	0	0	0	1
51	0	0	0	0	1	0	1	0	0	1	0
52	0	0	0	0	1	0	1	0	0	1	1
53	0	0	0	0	1	0	1	0	1	0	0
54	0	0	0	0	1	0	1	0	1	0	1
55	0	0	0	0	1	0	1	0	1	1	0
56	0	0	0	0	1	0	1	0	1	1	1
57	0	0	0	0	1	1	0	0	0	0	0
58	0	0	0	0	1	1	0	0	0	0	1
59	0	0	0	0	1	1	0	0	0	1	0
60	0	0	0	0	1	1	0	0	0	1	1
61	0	0	0	0	1	1	0	0	1	0	0

	b_1	b_2	b_3	l_1	l_2	r_1	r_2	r_3	g	y	k
62	0	0	0	0	1	1	0	0	1	0	1
63	0	0	0	0	1	1	0	0	1	1	0
64	0	0	0	0	1	1	0	0	1	1	1
65	0	0	0	1	0	0	0	0	0	0	0
66	0	0	0	1	0	0	0	0	0	0	1
67	0	0	0	1	0	0	0	0	0	1	0
68	0	0	0	1	0	0	0	0	0	1	1
69	0	0	0	1	0	0	0	0	1	0	0
70	0	0	0	1	0	0	0	0	1	0	1
71	0	0	0	1	0	0	0	0	1	1	0
72	0	0	0	1	0	0	0	0	1	1	1
73	0	0	0	1	0	0	0	1	0	0	0
74	0	0	0	1	0	0	0	1	0	0	1
75	0	0	0	1	0	0	0	1	0	1	0
76	0	0	0	1	0	0	0	1	0	1	1
77	0	0	0	1	0	0	0	1	1	0	0
78	0	0	0	1	0	0	0	1	1	0	1
79	0	0	0	1	0	0	0	1	1	1	0
80	0	0	0	1	0	0	0	1	1	1	1
81	0	0	0	1	0	0	1	0	0	0	0
82	0	0	0	1	0	0	1	0	0	0	1
83	0	0	0	1	0	0	1	0	0	1	0
84	0	0	0	1	0	0	1	0	0	1	1
85	0	0	0	1	0	0	1	0	1	0	0
86	0	0	0	1	0	0	1	0	1	0	1
87	0	0	0	1	0	0	1	0	1	1	0
88	0	0	0	1	0	0	1	0	1	1	1
89	0	0	0	1	0	1	0	0	0	0	0
90	0	0	0	1	0	1	0	0	0	0	1
91	0	0	0	1	0	1	0	0	0	1	0
92	0	0	0	1	0	1	0	0	0	1	1
93	0	0	0	1	0	1	0	0	1	0	0

	b_1	b_2	b_3	l_1	l_2	r_1	r_2	r_3	g	y	k
94	0	0	0	1	0	1	0	0	1	0	1
95	0	0	0	1	0	1	0	0	1	1	0
96	0	0	0	1	0	1	0	0	1	1	1

Appendix I: Cluster Pie Charts

Image I.1: Cluster Pie Charts with 4 clusters

Cluster Characteristics graphed after the initial K-means analysis. The clusters can be defined as:

1. Low Mileage
2. High Mileage (all Students in this group)
3. High Mileage potentially
4. High Income
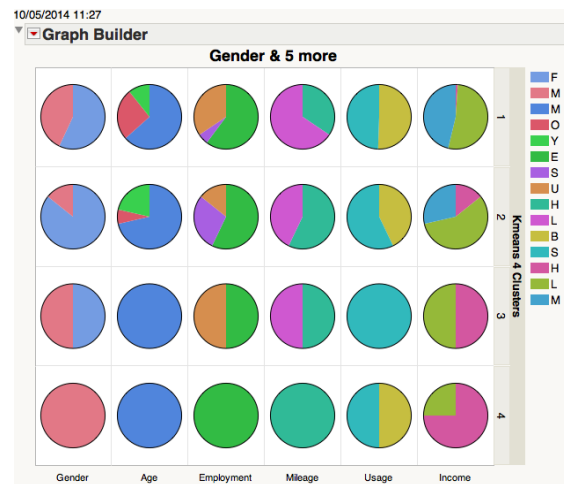
Image I.2: Cluster Pie Charts after removing students from data pool

After removing the students from the data pool and running the clusters again. The following clusters can be defined by the following (chart below):

1. Undefined w/ 2 respondents
2. High-Mileage
3. Low-Mileage
4. High-Income
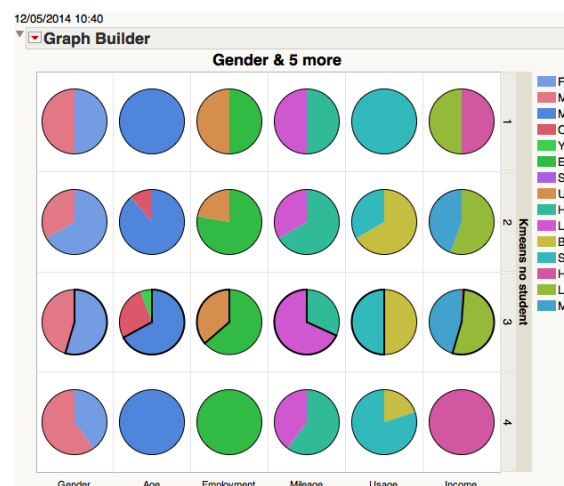
Appendix J: Cluster Coefficients

The tables below show the for the conjoint analysis runs for each of the defined market segments.

Image J.1: Example of Set-up of Conjoint Analysis

Table J.1: Results Conjoint for All Respondents

Table J.2: Results Conjoint for High Income Respondents

▼ Choice Model

▼ Effect Summary

Source	LogWorth		PValue
Price	1.616		0.02418
Legal Cover	1.542		0.02873
Protected No-claims Bonus	1.157		0.06964
Breakdown Cover	1.036		0.09209
Insurance Level	1.004		0.09907
Brand	0.854		0.13996
Hire Car	0.656		0.22098
Personal Injury Cover	0.536		0.29077
Excess Cover	0.208		0.61992
Key Cover	0.000		1.00000

Remove Add Profile Effect Add Subject Effect ☐ FDR

▼ Parameter Estimates

Term	Estimate	Std Error	Lower 95%	Upper 95%
Insurance Level[Comprehensive]	0.359830887	0.2344723411	-0.080063	0.8265
Insurance Level[Third Party, Theft & Fire]	0.208712493	0.2165868555	-0.208382	0.6163572
Brand[Big Insurer]	-0.176816177	0.3075573934	-0.799047	0.380594
Brand[Big High Street Brand]	0.450470504	0.2788692229	-0.085261	0.9928195
Brand[Other Big Brand]	0.198644455	0.2520085203	-0.281404	0.6782379
Price[100]	0.518025934	0.2507586371	0.0513893	0.9934668
Price[300]	0.290472138	0.2245917016	-0.140466	0.710754
Price[500]	-0.368149147	0.3205875272	-1.010241	0.2342194
Breakdown Cover[Yes]	0.242275372	0.1497259165	-0.038944	0.5317658
Legal Cover[Yes]	0.341443273	0.1705426337	0.0239655	0.6805142
Personal Injury Cover[Yes]	-0.182957854	0.1912221889	-0.571274	0.1689625
Hire Car[Yes]	-0.208707336	0.1839028001	-0.580349	0.1309402
Protected No-claims Bonus[Yes]	0.332567722	0.2058134465	-0.042753	0.7406449
Key Cover[Yes]	-0.031163160	0.2418231779	-0.496016	0.4317031
Excess Cover[Yes]	0.094510611	0.2043250127	-0.293152	0.4900534

AICc	196.95332
BIC	221.79186
-2*LogLikelihood	158.06443
-2*Firth LogLikelihood	109.57193

Converged in Gradient
Firth Bias-Adjusted Estimates

▼ Likelihood Ratio Tests

Source	L-R ChiSquare	DF	Prob>ChiSq	
Insurance Level	4.624	2	0.0991	
Brand	5.478	3	0.1400	
Price	9.421	3	0.0242*	
Breakdown Cover	2.837	1	0.0921	
Legal Cover	4.784	1	0.0287*	
Personal Injury Cover	1.116	1	0.2908	
Hire Car	1.498	1	0.2210	
Protected No-claims Bonus	3.291	1	0.0696	
Key Cover	0.000	1	1.0000	
Excess Cover	0.246	1	0.6199	

Table J.3: Results Conjoint for Student Respondents

▼ ▣ Choice Model

▼ Effect Summary

Source	LogWorth		PValue
Price	8.652		0.00000
Insurance Level	4.813		0.00002
Protected No-claims Bonus	2.996		0.00101
Brand	1.315		0.04843
Hire Car	1.222		0.05995
Legal Cover	0.800		0.15837
Breakdown Cover	0.285		0.51911
Excess Cover	0.250		0.56196
Personal Injury Cover	0.117		0.76450
Key Cover	0.000		1.00000

Remove   Add Profile Effect   Add Subject Effect   ☐ FDR

▼ Parameter Estimates

Term	Estimate	Std Error
Insurance Level[Comprehensive]	1.04050496	0.2871348225
Insurance Level[Third Party, Theft & Fire]	-0.25441889	0.2839856421
Brand[Big Insurer]	0.13025684	0.3271950782
Brand[Big High Street Brand]	-0.56829745	0.4525657384
Brand[Other Big Brand]	0.75511377	0.3543708265
Price[100]	-0.24175653	0.4420308243
Price[300]	1.16596326	0.2495528469
Price[500]	0.28297943	0.3882197827
Breakdown Cover[Yes]	0.15792691	0.1810031985
Legal Cover[Yes]	0.30461796	0.2128653715
Personal Injury Cover[Yes]	0.28379768	0.3056837959
Hire Car[Yes]	0.43132701	0.2667892577
Protected No-claims Bonus[Yes]	0.79490687	0.3085556791
Key Cover[Yes]	0.17886858	0.2865320985
Excess Cover[Yes]	0.13482595	0.2142474645

AICc	175.04996
BIC	206.06061
-2*LogLikelihood	138.56347
-2*Firth LogLikelihood	94.786691

Converged in Gradient
Firth Bias-Adjusted Estimates

▼ Likelihood Ratio Tests

Source	L-R ChiSquare	DF	Prob>ChiSq	
Insurance Level	22.165	2	<.0001*	
Brand	7.886	3	0.0484*	
Price	43.203	3	<.0001*	
Breakdown Cover	0.416	1	0.5191	
Legal Cover	1.990	1	0.1584	
Personal Injury Cover	0.090	1	0.7645	
Hire Car	3.539	1	0.0600	
Protected No-claims Bonus	10.809	1	0.0010*	
Key Cover	0.000	1	1.0000	
Excess Cover	0.336	1	0.5620	

Table J.4: Results Conjoint for all remaining Respondents

Choice Model

Effect Summary

Source	LogWorth		PValue
Price	131.854		0.00000
Insurance Level	99.865		0.00000
Protected No-claims Bonus	11.539		0.00000
Key Cover	3.774		0.00017
Legal Cover	1.644		0.02268
Excess Cover	1.062		0.08669
Personal Injury Cover	1.055		0.08805
Hire Car	0.883		0.13082
Brand	0.804		0.15698
Breakdown Cover	0.269		0.53844

Remove Add Profile Effect Add Subject Effect ☐ FDR

Parameter Estimates

Term	Estimate	Std Error	Lower 95%	Upper 95%
Insurance Level[Comprehensive]	1.71225261	0.1267718784	1.4751668	1.9826733
Insurance Level[Third Party, Theft & Fire]	-0.63346217	0.1152639169	-0.865916	-0.410009
Brand[Big Insurer]	-0.01378343	0.1033853129	-0.221505	0.1855629
Brand[Big High Street Brand]	-0.12159232	0.1288063234	-0.377583	0.1307505
Brand[Other Big Brand]	-0.14108961	0.1139949362	-0.369392	0.0862794
Price[100]	1.48467390	0.1376348994	1.2271732	1.7770415
Price[300]	1.13816061	0.0907251495	0.9643731	1.3236252
Price[500]	-0.84946337	0.1569616469	-1.175417	-0.54761
Breakdown Cover[Yes]	-0.04421507	0.0694181119	-0.181563	0.0931057
Legal Cover[Yes]	0.18944350	0.0843503014	0.021869	0.3584182
Personal Injury Cover[Yes]	0.17445252	0.1031800661	-0.025763	0.3850018
Hire Car[Yes]	0.11583444	0.0837110561	-0.044668	0.2917896
Protected No-claims Bonus[Yes]	0.62317195	0.0990488359	0.4328318	0.826652
Key Cover[Yes]	0.46314278	0.1213821189	0.2222443	0.7059719
Excess Cover[Yes]	0.10935367	0.0670022068	-0.021982	0.2423217

AICc	1375.4285
BIC	1448.4169
-2*LogLikelihood	1344.9362
-2*Firth LogLikelihood	1269.8949

Converged in Gradient
Firth Bias-Adjusted Estimates

Likelihood Ratio Tests

Source	L-R ChiSquare	DF	Prob>ChiSq	
Insurance Level	459.897	2	<.0001*	
Brand	5.211	3	0.1570	
Price	613.181	3	<.0001*	
Breakdown Cover	0.378	1	0.5384	
Legal Cover	5.193	1	0.0227*	
Personal Injury Cover	2.910	1	0.0881	
Hire Car	2.283	1	0.1308	
Protected No-claims Bonus	48.761	1	<.0001*	
Key Cover	14.157	1	0.0002*	
Excess Cover	2.935	1	0.0867	

Appendix K: Dominant Strategy Check

The table below shows an example of the spreadsheet run to check for a dominant strategy. This example is broken into three tables for ease of formatting (strategies 1-7, 8-14 and 15-21 for players 2-4 on separate tables).

Table K.1: Dominant Strategy Search (Player 1 across/first, Player 2-4 down/second)

	1		2		3		4		5		6		7	
1	0.036	2.238	0.028	5.116	0.015	4.572	0.014	32.623	0.023	2.379	0.041	1.773	0.020	9.685
2	0.045	1.501	0.034	2.735	0.019	3.332	0.017	13.651	0.031	2.015	0.052	1.259	0.024	4.737
3	0.078	2.001	0.061	3.743	0.033	4.405	0.031	19.345	0.049	2.628	0.088	1.669	0.044	6.561
4	0.119	0.462	0.077	0.698	0.054	1.080	0.034	2.505	0.097	0.706	0.142	0.402	0.053	1.095
5	0.054	3.081	0.042	6.743	0.022	6.409	0.021	41.363	0.033	3.457	0.060	2.471	0.030	12.575
6	0.029	4.066	0.023	8.190	0.012	8.727	0.011	46.216	0.018	4.988	0.033	3.332	0.016	14.806
7	0.066	1.057	0.047	1.755	0.028	2.413	0.023	7.588	0.046	1.523	0.076	0.904	0.033	2.904
8	0.054	5.667	0.042	11.581	0.022	12.102	0.022	66.375	0.033	6.853	0.060	4.627	0.031	21.056
9	0.037	9.812	0.029	22.756	0.015	19.918	0.015	146.898	0.022	10.233	0.041	7.738	0.021	43.288
10	0.028	3.502	0.021	6.478	0.012	7.737	0.011	32.996	0.018	4.643	0.032	2.928	0.015	11.298
11	0.022	10.869	0.017	24.511	0.009	22.331	0.009	154.487	0.013	11.756	0.025	8.642	0.013	46.192
12	0.011	57.508	0.009	136.688	0.005	115.478	0.004	900.131	0.007	57.983	0.012	45.016	0.006	262.078
13	0.013	34.823	0.010	78.674	0.005	71.489	0.005	496.657	0.008	37.578	0.015	27.673	0.007	148.355
14	0.013	38.815	0.010	88.211	0.005	79.487	0.005	559.721	0.008	41.573	0.014	30.793	0.007	166.672
15	0.006	96.323	0.005	224.900	0.002	194.964	0.002	1459.853	0.004	99.555	0.007	75.809	0.003	428.750
16	0.006	68.459	0.005	158.854	0.003	138.943	0.003	1025.880	0.004	71.352	0.007	53.979	0.004	302.229
17	0.004	86.096	0.003	197.570	0.002	175.581	0.002	1264.065	0.003	91.063	0.005	68.109	0.003	374.512
18	0.003	49.628	0.002	104.398	0.001	104.833	0.001	616.513	0.002	58.208	0.003	40.219	0.002	191.922
19	0.002	85.456	0.001	182.118	0.001	179.617	0.001	1089.399	0.001	98.812	0.002	69.016	0.001	336.417
20	0.001	446.274	0.000	1026.419	0.000	909.229	0.000	6579.712	0.000	470.623	0.001	352.803	0.000	1947.141
21	0.000	533.139	0.000	1212.485	0.000	1091.448	0.000	7698.234	0.000	570.496	0.000	422.862	0.000	2291.489

	8		9		10		11		12		13		14	
1	0.024	1.963	0.038	1.142	0.043	2.299	0.057	0.804	0.151	0.295	0.111	0.385	0.115	0.373
2	0.034	1.897	0.059	1.231	0.053	1.408	0.083	0.775	0.266	0.353	0.179	0.428	0.190	0.424
3	0.050	2.448	0.080	1.577	0.093	1.896	0.123	1.001	0.314	0.449	0.234	0.547	0.242	0.541
4	0.123	0.703	0.248	0.475	0.131	0.406	0.301	0.287	1.346	0.140	0.797	0.167	0.876	0.166
5	0.033	2.953	0.051	1.773	0.064	3.108	0.081	1.209	0.190	0.473	0.148	0.603	0.151	0.588
6	0.019	4.487	0.030	2.813	0.035	3.965	0.046	1.835	0.120	0.782	0.089	0.969	0.092	0.953
7	0.053	1.479	0.096	0.982	0.076	0.959	0.129	0.605	0.462	0.287	0.297	0.344	0.319	0.342
8	0.032	6.116	0.049	3.810	0.064	5.558	0.079	2.502	0.176	1.053	0.140	1.310	0.142	1.287

	8		9		10		11		12		13		14	
9	0.022	8.334	0.033	4.786	0.044	10.143	0.054	3.413	0.114	1.221	0.093	1.606	0.094	1.552
10	0.019	4.345	0.032	2.808	0.033	3.304	0.047	1.777	0.135	0.801	0.095	0.976	0.100	0.965
11	0.013	9.813	0.020	5.768	0.027	11.102	0.033	4.017	0.073	1.508	0.058	1.950	0.059	1.893
12	0.006	46.086	0.009	25.837	0.013	60.088	0.016	18.877	0.032	6.420	0.027	8.601	0.027	8.268
13	0.008	31.319	0.011	18.384	0.016	35.597	0.019	12.821	0.039	4.798	0.032	6.211	0.033	6.030
14	0.008	34.477	0.011	20.145	0.016	39.778	0.019	14.115	0.039	5.232	0.032	6.796	0.032	6.592
15	0.003	80.563	0.005	45.982	0.007	99.865	0.009	32.992	0.018	11.652	0.015	15.397	0.015	14.860
16	0.004	58.081	0.005	33.341	0.007	70.787	0.009	23.784	0.019	8.501	0.015	11.185	0.016	10.808
17	0.003	74.884	0.004	43.407	0.005	88.598	0.006	30.661	0.014	11.182	0.011	14.607	0.011	14.145
18	0.002	51.071	0.003	31.367	0.003	49.245	0.004	20.896	0.011	8.554	0.008	10.743	0.008	10.525
19	0.001	85.981	0.002	52.438	0.002	85.250	0.003	35.183	0.006	14.207	0.005	17.922	0.005	17.535
20	0.000	386.222	0.001	223.446	0.001	459.691	0.001	158.139	0.002	57.445	0.002	75.146	0.002	72.737
21	0.000	472.834	0.000	276.117	0.000	546.528	0.001	193.581	0.001	71.676	0.001	93.132	0.001	90.326

	15		16		17		18		19		20		21	
1	0.266	0.164	0.233	0.183	0.316	0.136	0.418	0.145	0.713	0.083	2.238	0.020	3.219	0.015
2	0.456	0.192	0.374	0.204	0.495	0.147	0.550	0.114	0.943	0.066	3.275	0.020	4.535	0.014
3	0.556	0.245	0.492	0.260	0.669	0.188	0.907	0.149	1.548	0.087	4.790	0.026	6.925	0.018
4	2.222	0.076	1.666	0.079	2.113	0.057	1.619	0.038	2.810	0.022	12.386	0.007	15.851	0.005
5	0.342	0.261	0.311	0.287	0.427	0.211	0.614	0.207	1.047	0.119	3.136	0.030	4.592	0.022
6	0.212	0.428	0.187	0.461	0.253	0.335	0.340	0.290	0.580	0.168	1.807	0.047	2.606	0.033
7	0.780	0.156	0.622	0.163	0.811	0.117	0.814	0.084	1.401	0.049	5.178	0.016	7.016	0.011
8	0.318	0.577	0.295	0.623	0.408	0.454	0.610	0.400	1.039	0.231	3.048	0.064	4.500	0.045
9	0.208	0.680	0.196	0.765	0.273	0.568	0.419	0.630	0.712	0.360	2.059	0.085	3.059	0.063
10	0.235	0.437	0.200	0.464	0.268	0.335	0.331	0.263	0.566	0.153	1.847	0.046	2.617	0.032
11	0.131	0.836	0.122	0.928	0.169	0.685	0.252	0.714	0.429	0.409	1.259	0.101	1.859	0.074
12	0.059	3.595	0.057	4.099	0.079	3.063	0.124	3.613	0.211	2.063	0.603	0.468	0.900	0.354
13	0.072	2.660	0.068	2.957	0.095	2.184	0.147	2.284	0.250	1.309	0.719	0.321	1.070	0.237
14	0.071	2.904	0.068	3.236	0.094	2.393	0.146	2.533	0.249	1.452	0.716	0.353	1.065	0.261
15	0.032	6.499	0.031	7.335	0.043	5.456	0.067	6.147	0.114	3.515	0.327	0.821	0.488	0.615
16	0.034	4.736	0.032	5.328	0.045	3.957	0.070	4.392	0.119	2.512	0.343	0.593	0.510	0.442
17	0.025	6.217	0.023	6.957	0.033	5.154	0.050	5.575	0.085	3.192	0.246	0.766	0.365	0.569
18	0.019	4.704	0.017	5.112	0.024	3.735	0.033	3.436	0.056	1.980	0.171	0.530	0.249	0.381
19	0.011	7.822	0.010	8.529	0.014	6.242	0.019	5.861	0.033	3.375	0.100	0.891	0.146	0.642
20	0.003	31.949	0.003	35.790	0.004	26.530	0.007	28.842	0.011	16.513	0.033	3.949	0.048	2.935
21	0.002	39.788	0.002	44.349	0.003	32.798	0.004	34.778	0.008	19.929	0.022	4.846	0.033	3.582