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Matching Supply and Demand in the Audit Market

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by

Lin-Chih Wu

Thesis for the degree of Doctor of Philosophy

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<u>Abstract</u>

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This thesis focuses on the interface of operation research and accounting. Owing to the transparency and the uniqueness of the audit market, this thesis discusses the demand-side and supply-side problem of the audit market, where the audit market has not been discussed extensively in the operation research. In addition, this thesis further incorporates both sides to examine the simultaneous effect of the auditor choice and pricing strategy of the auditor firm.

The result of the first research in this thesis indicates the client would incur a significant switching cost when switching audit firms but the client would have different reactions (e.g. willing to negotiate or being loyal) when facing a fee discount, suggesting that the audit client would switch the audit firm for better audit quality rather than due to the lowballing effect. On the supply side, the second research approached in this thesis shows that audit firms have varied strategies for assessing their client portfolio, even among the Big Four. The specialist auditor is more likely to maintain their client-auditor relationship with the large companies when the cost increases based on the economies of scale while the auditor who owns most of the clients in the market is inclined to provide services to all sizes of the client based on economies of scope. The third research matches the demand with the supply in the audit market. The findings indicate that the client would consider differently and so the model of Bertrand competition could interpret the audit market the sample better but the predictive analysis shows the audit firms may still engage in tacit collusion with respect to a specific client, which should raise attention from the regulatory perspective.

By allowing heterogeneity among the audit clients and audit firms, this thesis can engage with the random coefficients and discuss the individual effect rather than the fixed effect, which has not yet been considered in prior accounting literature and is expected to shed light on the objectives of future accounting research.

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Chapter 1   Introduction

1.1   Motivation

Professional service, which includes law, accounting, engineering and consulting, is viewed as deploying expert knowledge in a work setting (Abbott, 2010; Freidson, 2000; Sharma, 1997; Malhotra and Morris, 2009). Unlike other professional service industries, the audit market owes its uniqueness because of the nature of the market. First, it is a mandated market where publicly listed companies are required to have an audited financial report periodically. Being that the audit work should be conducted by certified accountants, there will be no unobservable suppliers outside the market due to its entry barrier.

Second, compared to other professional services, the information in the audit market is relatively transparent. After the U.S. passed the Sarbanes-Oxley Act 2002, companies are obliged to disclose the information about the incumbent audit firm and the audit fee in the financial report. Additionally, since the information for the publicly listed companies is public information, the researcher has been able to discover more details about the supplier and the customer in each transaction, which is rarely obtained by operation and marketing research in professional service.

On the other hand, different from other professional service where the service provider would meet the client's need, the auditor is considered to be one providing service based on his perceived abilities, which include discovering material misstatement, fraud or any errors within the company and disclosing the information to the stakeholders (e.g. investor, customer and debt holder) independently (DeAngelo, 1981). Since the audited financial report is mandated, the audit firm would face different risk when providing audit service. For example, the audit firm would face the risk of litigation when the investors find that there is a material misstatement in the audited report. Gendron (2011) suggest that the auditor would face the dilemma of commercialism and professionalism when providing audit service because the auditor would have to consider the profit and risk of the engagement at the same time.

Because of the mandatory environment, the publicly listed companies are required to choose one of the audit firms to audit their financial report. Past literature has examined the determinants of the audit fee, including the complexity of the company and the financial risk. On the other hand, the audit fee is also believed to influence the client's choice where the client is more likely to choose the audit service with a lower price (e.g. Gerakos and Syverson, 2015; Guo et al., 2017) and more willingly to switch auditor for the lower price. Such context is rarely discussed in operation research

since the structure of the audit market is different from other industries where the theory of demand and supply could be applied.

Due to the unique nature of the audit market, this thesis intends to focus on the audit market in the U.S rather than discussing the professional service industry in general. Since audit market is highly monitored by the authority due to the regulation and publicly listed companies are required to have audited financial reports periodically, the audit market is different from other professional industry for its mandatory envioroment. In addition, after the U.S. pass Sarbanes-Oxley Act in 2002, the publicly listed firms are required to disclose the audit fee in their financial report, which allows the researcher to investigate the issue of audit pricing including the determinants of the audit fee and the cause of the audit firm's pricing strategy.

On the other hand, the audit firm, which is perceived as the supplier in the audit market, may face the uncertainty of loss (e.g. lawsuit) even though it provides an audit service in return for the audit fee (Crosby, 1986). Previous studies have suggested that the audit firm may resign from the engagement due to limited resources and potential audit risk (Rama and Read, 2006; Lennox and Kausar, 2017). Instead of considering only the profit, the research shows that the audit firm may choose its clients with various consideration.

Since the supply and demand problem in the audit market will be different from other professional service industry due to the regulatory environment the publicly listed companies and the audit firms face, the structure of the audit market is expected to be different from other service industry. In addition, most accounting literature discusses the demand (e.g. client's choice) and supply side (auditor resignation) of the audit market separately. Based on the law of the supply and demand, the price of the service/goods would be determined by both sides in the market. Therefore, this thesis would first introduce the client's choice for the auditors as the demand side in the audit market, and the audit firm's client portfolio for the supply-side problem and match the supply and demand of the audit market in the last research.

This thesis consists of three research to discuss the demand-side and supply-side problem of the audit market first individually and examine the simultaneous effect of both sides in the audit market. Chapter 2 illustrates the problem of auditor choice on the demand side by applying the discrete choice model to examine the factors of auditor choice and including the variable of the switch to measure the cost of the client switching the audit firm. The research further extends the discussion to examine the possible effect on the client based on the fee discount offered by the competing audit firms in the market.

Chapter 3 then discusses the strategy of the audit firm. Being that the audit firm is expected to assess the risk of the engagement for the client portfolio, this chapter aims to investigate auditor utility in selecting the client based on existing clients. In addition, with the estimated utility model, the research further discusses the optimal strategy that the audit firm would have when the cost of auditing increases.

After discussing the demand and supply sides respectively, Chapter 5 will match demand with supply in the audit market. By extending the research in Chapter 2, this chapter will consider the client's utility with the pricing strategy of the audit firm. Being the client's choice would be influenced by the audit fee and the price would also be dependent on the market share, the research will analyse simultaneous demand and supply in the audit market.

1.2   Literature Review

1.2.1   Utility Maximisation Problem

Modelling consumer's utility has been widely adopted in most operation and marketing research. Based on economic theory, the concept of utility maximisation is that the consumer would attempt to get the greatest value by considering all relative characteristics and make the trade-off between attributes (Liao, Molin and Wee, 2017). Since McFadden (1974) developed the random utility model and applied with logistic regression, the discrete choice model has been widely used by the researchers.

Under the discrete choice model, the consumer is assumed to make trade-offs between the product/service characteristics and the price and choose the product/service which provides the highest utility. Past research has applied the discrete choice into various studies, including transportation (e.g Nam, Kim Cho and Jayakrishnan, 2017), retailing (e.g. Winter and Gretibus, 2018) and tourism (e.g. Kim and Park, 2017). While most research estimates the random utility model by the maximum likelihood approach, recent operation research has adopted Bayesian approach with the random-walk algorithm to further capture the individual difference among consumers (e.g. Yang et al., 2003; Villas-Boas et al., 2005).

Besides applying the utility maximisation approach in the marketing and operation research, recent accounting literature also introduces such method to examine the audit market. For instance, Gerakos and Syverson (2015) discuss the mandatory rotation among auditors and the exit of Arthur Anderson with the client's utility model and Guo, Koch and Zhu (2017) further apply the utility model to discuss the joint audit regime, where the client has to choose two audit firms for the audited financial reports. However, besides research conducted by Gerakos and Syverson (2015;

2017) and Guo et al. (2017), it is worth noting that there is no related literature adopting the concept of utility maximisation to discuss accounting issue. Therefore, this thesis will adopt a similar concept and discuss the supply and demand side in the audit market.

1.2.2 Auditor Choice

Auditor choice has been researched with different factors and various circumstances in the existing literature. Existing literature has discussed the client's choice with respect to different auditors comprehensively (e.g. Big Four versus non-Big Four, specialist auditor versus non-specialist). When making auditor selection, the client is expected to obtain the service with high audit quality, and the past research suggests that the client would be more willing to choose Big N audit firms for their high-quality audit. While there are numerous suppliers in the audit market, the researchers suggest that large, reputable accounting firms are more concerned with protecting their reputation and therefore have more incentives to provide a high-quality audit (e.g. DeAngelo, 1981; Datar, Feltham and Hughes, 1991; Francis and Krisnan, 1999; DeFond, Erkens and Zhang, 2016).

With regard to the potential litigation, the perception of "deep pocket" has also motivated the Big Four audit firms to provide high-quality audit (Simunic and Stein, 1996). Owing to the perceived high-quality audit provided by large audit firms, especially the Big Four, studies further discuss the effect of the company choosing Big Four auditors. Khurana and Raman (2004) use the data from Anglo-American (including the U.S., Australia, Canada, and the U.K.), which have similar economics and audit market, to examine the financial reporting credibility of Big Four versus non-Big Four. The study adopts the *ex ante* cost of equity capital as the proxy for financial reporting credibility, so as the audit quality, since it could capture the long-term information asymmetry, and finds that the Big Four auditees have a lower expected cost of equity capital than non-Big Four auditees. Since the litigation risk is higher in the U.S. compared to other Anglo-American countries, the research also suggests that the high-quality audits performed by Big Four are due to litigation risk exposure rather than reputation protection.

Besides the client's choice between different auditors, existing studies also examine the factors which could influence the client's selection of the auditor (e.g. corporate governance). Publicly listed companies hire audit firms to have audited financial report is not only because of the mandated regulatory but also to reduce the information asymmetry and agency problem. Studies often adopt client characteristics as a proxy of demand for audit quality. For example, recent research by Lai, Srinidhi, Gul and Tsui (2017) has examined the relationship between the diversity

of board, audit fee and auditor choice. The study proxies the audit fee for audit effort and views the audit firm with the largest share in the city as the industry specialist. The results show that the companies with gender-diverse board tend to pay higher audit fee as they require a higher audit effort and are more likely to choose the industry-specialist auditor.

Moreover, some studies suggest that social dynamics may also impact on auditor choice. Li, Sun and Ettredge (2017) define the social norm audit office of the client as the office auditing the largest number of client's peer companies in the metropolitan area where the client's headquarters is located. The research finds that the client is more likely to choose the social norm office with the increasing proportion of its peers - meaning auditor-switching peers - audited by the norm audit office in the previous year.

1.2.3   Auditor Switch and Lowballing

The research into auditor selection further extends to the auditor switch. There are several circumstances that may trigger the auditor switch (e.g. client dismissal and auditor resignation). Some concerns are raised for the auditor switch initiated by the client, being that the company may attempt to switch to the auditor to its own benefit (e.g. opinion shopping). For example, the manager in the company may pressure the incumbent auditor into giving a clean opinion by switching the auditor because he or she is afraid of qualified opinion having a negative effect on the market price and manager's compensation (Chow and Rice 1982; DeFond, Zhang and Zhao, 2018). However, the findings of the association between audit opinion and auditor change are mixed (e.g. Johnson and Lys, 1990; Schwartz and Menon, 1985; Choi, Choi, Gul and Lee, 2015; DeFond et al., 2018).

Besides opinion shopping, existing literature discusses other reasons for auditor switch. Since the audit is aimed at reducing the information asymmetry between the management and stakeholders, the demand for higher audit quality may lead to auditor change. Prior research suggests that the client characteristics (e.g. client's size) and the auditor-client relationship would influence the client's selection (Beattie and Fearnley, 1998; Baldacchino, Caruana, Grima and Bezzina, 2017). Besides the client itself, the client may initiate the auditor switch because of the request from the capital provider and emerging needs. With the consideration of enhancing audit quality, the company is expected to switch to Big Four audit firms because the Big Four is perceived as "deep pocket" and will, therefore, perform the audit service more conservative (Simunic, 1980; Boone, Khurana and Raman, 2010).

In addition, the client may change the auditor to get a clean opinion on the financial report. Because the occurrence of auditor switch may be due to the disagreement between the client and the

auditor, the auditor switch is often considered as a signal that the company has poor performance. However, some literature documents that the client may switch the auditor to enhance the quality of the financial report and to reduce the agency cost, the findings to the client dismissal are mixed (DeAngelo, 1981; Dye, 1991; Dopuch and King, 1996; Huang, Chang and Chiou, 2016). Besides investigating the possible reason for the auditor switch, Knechel, Naiker and Pacheco (2007) examine the market reaction to the auditor switch between specialist/non-specialists and Big Four/non-Big Four. Since it is believed that the specialists in the industry would provide high-quality audit, the research finds evidence that the market would react positively to the news of the company switching the auditor from Big Four non-specialist to Big Four specialist and react negatively to the news of the company switching from Big Four specialist to non-specialist.

Even though different opinions exist on auditor switch, legislators and regulators have raised concerns about the practice of lowballing during the auditor switch. A lowballing effect is viewed as the impairment of audit quality when the price of the initial audit engagement is lower than necessary. It may lead to "a variety of independence issue" because the auditors will tend to lose his/her independence to meet the client's expectation for long-term alignment with the client in the following year, so as to incur loss in the initial engagement (SEC, 2000).

Due to the lack of data in audit effort, the empirical evidence is little of lowballing effect leading to the impairment of independence. DeAngelo (1981) develops the intertemporal audit pricing and suggests that the incumbent auditor would have a cost advantage and earn quasi-rent after the initial engagement due to the significant amount of start-up costs in audit technology and the transaction cost of an auditor switch. Contrary to the regulatory concern, the existing research claims that the lowballing effect is the response to the future quasi-rents and the auditor independence would not be impaired. Dopuch and King (1996) use the experimental market to examine whether the fee below cost would affect the attest service. The first experiment suggests that the decreasing marginal cost may induce the strategy of lowballing but does not reduce the frequency of investigation, showing that the audit quality would not be damaged. However, the second experiment considers the level of lowballing and the result shows that the service quality would be lower only when the degree of lowballing is high. However, Dye (1991) proposes another argument. Since the fee of audit service could not be observed before SOX 2002, the client would agree on quasi-rent to the auditor for the favourable financial report, which could also impair the auditor's independence. In addition, the research also indicates that if quasi-rents are observable to the investors, then the phenomenon of lowballing would not exist because the investors would

rely more on financial reports when they perceive the auditor does not earn quasi-rents and is therefore more independent.

Since the U.S. passed the Sarbanes-Oxley Act in 2002, companies are required to disclose the audit fee and the audit work carried out by auditors is expected to increase. As a consequence, the occurrence of the lowballing effect is supposed to decrease. Huang, Raghunandan and Rama (2009) suggest that that audit fee discounting in the post-SOX period would be less for several reasons. First, since the SOX Act prohibits the audit firm from providing an audit and non-audit service to the same client at the same time, the audit firm would have less incentive to lowball the audit fee to obtain the non-audit contract with the same client.

Second, the authority for selecting the auditor is changed after the enactment of SOX. In the past, management would be able to choose the auditor and negotiate the price where the management may intend to lower the cost. However, Section 301 of SOX indicates that the audit committee should be in charge of the appointment, compensation and oversight of the auditor. Since the main target of the audit committee would be to maintain the company's reputation and make sure the auditor detect any material misstatement and fraud inside the company, the issue of lowballing may not occur when the company demands a high-quality audit.

Moreover, after the exit of Arthur Andersen, the concentration of the audit market was expected to increase, especially among Big N audit firms. Therefore, the auditors may gain more bargaining power when negotiating the audit fee so as to reduce the level of lowballing. SOX 2002 demands that the audit firm have additional audit effort to the engagement and the previous literature show that the audit fee had a significant increase in 2003 and 2004 (Rama and Read, 2006). Due to extra audit work for the initial-year engagement, the practice of lowballing is less likely to occur.

After 2002, studies have examined whether the practice of lowballing decreases because of the restriction of SOX. Huang et al. (2009) compare the data from 2001 to 2006, which can be divided into the pre-SOX period and the post-SOX period from the year 2002. Their findings show that the audit fee discount is less likely to occur in the post-SOX period, especially for Big Four's clients. In addition, because the Big Four audit firms became more conservative after 2002, a significant premium is observed in 2006 for Big Four audit firms. However, some research focuses on post-SOX period has different findings. Owing to the additional mandatory audit work conducted by the auditors, the audit fee is expected to increase in the post-SOX period. The increase in the price may trigger the client to switch for a lower price. In addition, Ettredge, Scholz and Li (2007) investigated the auditor dismissal after the passage of SOX in 2002 and found a positive association with the increased audit fee and auditor dismissal, which is consistent with the previous research. In other words, paying the higher audit fee may have greater saving potential and therefore the company is

more willing to change auditor for the favourable cost. The study also shows that the companies with smaller size, greater possibility to receive the going concern report and adverse internal control reports are more likely to switch auditor since they are presumably concern more about the cost control. Therefore, in order to pay a lower price, the company tends to switch to a small-tier/lower-cost auditor and the outcome is significantly evident for the Big Four's auditees switching to non-Big Four audit firms. Recent research by Desir, Casterella and Kokina (2014) collects the sample in "extended" post-SOX period from 2007-2010 and adopts a similar method to Huang et al. (2009) to examine if the practice of lowballing resumes. The findings here show that both Big Four and non-Big Four have the audit fee discounted during the sample period and should raise the regulatory concern again.

Most of the literature on auditor choice adopts traditional logistic regression to examine the relationship between dependent variables (e.g. client size, financial risk and corporate governance etc.) and the auditor choice (e.g. Big Four versus non-Big Four and specialist versus non-specialist). A recent study by Gerakos and Syverson (2015) introduces the utility model and discuss the problem of auditor choice as a discrete choice problem. The approach of discrete choice has been widely used in the field of marketing and economic research (e.g. Berry, Levinsohn and Pakes, 1995; Yang, Chen and Allenby, 2003; Villas-Boas and Zhao, 2005). In the research of Gerakos and Syverson (2015), for instance, the concept of utility maximisation is applied when the client selects the audit firm where the attributes of the client and auditor are considered. Moreover, the study discusses the effect of the policy implications-mandatory audit firm rotation and the exit of one of the Big Four audit firms.

The results of the counterfactual analysis indicate that the market would suffer from the loss of consumer surplus if the client is required to switch audit firm after a certain period of time and that the exit of one of the Big Four audit firms would also have a significant impact on the loss of consumer surplus depending on each audit firm (Gerakos and Syverson, 2015). Guo, Koch and Zhu (2017) apply a similar method of utility maximisation and assume that the client would select the audit firm with the highest benefit to explore the joint audit policy. With different regulations in different countries, their study estimates the demand model taken from French, where the client is mandated to hire joint audit and investigate the implementation of joint audit in the UK, whose market is single audit regime. The counterfactual findings in the research show that the audit market would change significantly by introducing joint audit into single audit market where the small audit firms would have more clients and large audit firms would benefit from providing more audit service to large clients. However, the research indicates that the consumer surplus is expected

to decrease with the implementation of the joint audit. The loss would be more substantial when the workload of the audit is required to be shared equally between both auditors because the client is prohibited from giving all the audit work to its first-choice auditor (Guo et al., 2017).

1.2.4   Audit Firm Decision

Conversely speaking, the audit firm is viewed as the supplier in the audit market, where the auditor serves as the independent role to detect the material misstatements and fraud in the client company. According to the theory of production, the goal of the supplier is to maximise its profit either by raising the price or lowering the cost. However, before providing an audit service, the auditor is expected to evaluate the risk of the engagement, including the audit risk and financial risk of the client, due to the nature of the auditing.

Some previous literature suggests that the audit firm faces uncertainty when making the decision, even though the engagement has agreed upon the audit fee. Crosby, Moskowitz and Mahesh (1986) indicate that the auditor may encounter possible unpredictable situations. For example, the audit firm may face the choice of providing an alternative non-audit service to the client, which prevents the audit firm to provide the audit service. This situation is expected to be more evident after 2002 due to the restriction imposed by SOX. In addition, the auditor may face the uncertainty of client dismissal due to dissatisfaction. Moreover, the auditor will consider the legislation risk because the negligence of the audit work may cause the stakeholders, including bondholders, investors and management, to file a lawsuit against audit firm (Crosby et al., 1986; Lewis, 1980).

Hence, owing to the audit environment the auditor is facing, utility (loss) functions are proposed by previous literature to model the uncertainty of the auditor's decision. Crosby et al. (1986) adopt the utility function to examine the auditor's decision when facing risk tasks. Their research considers the individual utility function and assumes that the auditor's utility can be expressed in exponential form and power functions. The results show that auditor's utility often consists of a target point, where the utility function shows discontinuity, and the auditor tends to be risk-averse above the target point but risk-prone below the target point.

However, some research has inquired into whether the auditors would possess homogeneous utility. Lewis (1980) argues that the utilities may differ across audit firms, even among the Big N audit firms. Owing to the insurance cost and the size difference, the audit firm may have different goals to develop its reputation and therefore have varied utilities. The study conducts the experiment by examining the judgment of the professional auditor with an expected utility function and the results show that the auditors tend to have similar utility when facing the material situation while the degree of homogeneity is more evident when the auditors are from the same audit firms

(Lewis, 1980). Thus, the audit firm is expected to hire auditors with similar utility in order for the staff in the firm to achieve the same target.

Given the uncertainty of the auditor's decision, the auditor would assess the audit risk, the financial risk of the client and the relevant audit fee. Hence, studies use different factors to examine the auditor's action toward the client, including accepting new clients and resigning from their current engagement (e.g. Bockus and Gigler, 1998; Johnstone, 2000; Johnstone and Bedard, 2001; Lennox and Kausar, 2017). In addition, in order to manage the audit risk across the firm, the auditor may either increase the audit fee, select the client more conservatively or withdraw from the particular engagement to reduce the litigation risk (Pratt and Stice, 1994; Krishnan and Krishnan, 1997; Mande, Son and Song, 2017). Logically then, Johnstone and Bedard (2004) extend their research and attempt to examine the audit firm's client portfolio management. The research defines the decision into three *subportfolios*: continuing clients, discontinued clients and newly accepted clients. For example, the subsequent client portfolio includes the continuing clients and newly accepted clients, but excludes the discontinued clients, either by client dismissal or auditor resignation. The research of Johnstone and Bedard (2004) indicates that audit firms tend to be risk-averse when considering the client portfolio management, while the discontinued clients are riskier than the newly accepted and continued client. For continuing/discontinued clients, besides the fact that the client may dismiss the auditor, the audit firm may resign from the engagement owing to several possible scenarios (e.g. increasing litigation risk or auditor-client disagreement).

Besides the auditor resignation for the exisiting clients, there is a great amount of literature discussing the risk assessment before the engagement (e.g. Johnstone, 2000; Johnstone and Bedard, 2003; Gendron, 2001; Ghosh and Tang, 2015; Lennox and Kausar, 2017). Different from the supplier in other industries where the theory of supply and demand would applied and the supplier would attempt to maximise its profit, the auditor is expected to evauluate the prospective engagement differently. Gendron (2001) proposes examining the client-acceptance decision from different perspectives – in terms of mechanistic and organic, and professionalism and commercialism - which could be viewed as the pressure for the auditor to make an acceptance decision. The difference between mechanistic and organic is that the decision-maker with the mechanistic approach would strictly follow the procedure strictly, while the organic approach consists more flexibility during decision-making. On the other hand, there may be consideration of professionalism versus commercialism before accepting an audit engagement; for example, an audit engagement may deteriorate the audit firm reputation if audit risk is high (professionalism), but it has high profitability in the long term (commercialism). However, Simunic and Stein (1990) introduce the

portfolio approach and argue that the audit firm would assess the risk of the engagement in the portfolio context instead of measuring the risk of every engagement respectively. The riskiness of the prospective client should be considered in terms of the audit firm's existing client portfolio. An audit firm may adjust its combination of the clients when the firm specialises in an optimal client portfolio, which could lead to resigning from the mismatched clients or not accept the prospective client (Shu, 2000). Shu (2000) uses the index of characteristics of the client and the audit firm to measure the clientele mismatch and finds that there is a positive association between mismatch and auditor resignation. Since the reasons for mismatching include the audit firm's cost structure (Shu, 2000), it is feasible to expect that the audit firm would change its client portfolio based on the firm itself.

Besides the decision of continuing/discontinuing with existing clients and accepting new clients to mitigate the risk of the audit firm, the auditor may also consider increasing the audit fee to manage the risk. Thus, the past literature has taken a great interest in audit fees, where audit fee often becomes the proxy for the audit effort, which the researchers are not able to observe but are interested in the association with risk. Client characteristics are believed to have a great impact on the audit fee being that they would directly affect the work of the audit engagement. For example, due to the complexity of the company, the auditor may need to do extra audit work and therefore increase the audit fee. Moreover, a bigger company with more total assets and total sales, more subsidiaries or being involved in more than one industries, will be charged with higher audit fee (Simunic, 1980; Taylor and Baker, 1981; Francis and Stokes, 1986).

Since the determination of the audit fee is based on the client and the auditor, negotiation is expected between both parties. However, past research has presented mixed findings regarding the audit fee premium. Based on the theory of product differentiation, the strategy of providing differentiated audit service, which is referred to as specialisation, enables the auditor to have a competitive advantage over non-specialist auditors (Ferguson and Stokes, 2002; Casterella, Francis, Lewis and Walker 2004). The reseach examines the association between audit fee premium and auditor reputation, including brand name and specialisation and the result shows that the audit fee for Big N auditors is higher than non-Big N because of the investment in reputation and the industry specialist. A Big N auditor tends to charge higher audit fee over non-specialist Big N auditor because developing industry expertise requires additional investment. However, Ferguson and Stokes (2002) modify the market share standard of being the specialist auditor and argue that the specialist premium does not exist in the sample year, but there is limited evidence of Big N auditor charging a higher audit fee when the industry does not have specialist auditors. Casterella et al. (2004) further examine the fee premiums in U.S. audit firms in consideration of bargaining power. Their research shows that there is a positive association between the audit fee and industry specialisation

when the absolute size of the client, measured in assets, is smaller. On the other hand, a large company is more likely to have a lower audit fee because of its relative bargaining power (Casterella et al., 2004).

1.2.5   Competition in the Audit Market

With regard to the audit market, the past literature also indicates that the competition would have an impact on the pricing strategies of the audit firms. The audit market is considered to be highly concentrated since the Big N audit firms often earn most of the audit fee in the industry, but the studies have produced varied results concerning the association between the audit fee and market concentration. After the demise of Arthur Andersen, the US General Accounting Office (2003) predicted that the concentration of the audit market would increase among Big N audit firms, where the audit fee is therefore expected to increase because of their increasing market power.

After SOX 2002, a great body of accounting literature discess the difference between pre-SOX and post-SOX period, including the audit work, audit premium and the changes in the audit market. Asthana, Balsam and Kim (2009) have examined the sample from the year 2000 to 2002, which is the period during the exit of Arthur Andersen and the enactment of SOX 2002, to investigate whether the changes in the audit market would influence the audit fee. The research concludes that the Big Four audit firm will be able to charge more premium after the demise of Arthur Andersen because the existing clients, especially the large companies, are lack of choice in the audit market (Asthana et al., 2009). In response to the concern raised by regulators that the decrease in the number of the largest audit firms (e.g. from Big Six to Big Four) may affect the competitiveness of the audit market, Carson, Simnett, Soo and Wright (2012) use the sample of Australian companies from the year 1996 to 2007, representing the time from Big Six period to Big Four period, and distinguish the sample into three segments: larger global, mid-level and small local clients, to investigate the changes in the fee premium. The result shows that there is a significant increase in audit fee premium from the Big Six period to the Big Five and Big Four periods, but the outcomes vary across three segments of the client. The study suggests that the increase in the premiums for large global firms is the least consistent with the proposition that the largest companies have more bargaining power (Carson et al., 2012).

Despite there being a great amount of literature about the demand (e.g. auditor choice) and supply (e.g. audit fee), there is still a gap between applying economic theory into audit market, where the most of the existing studies adopt traditional logistic and ordinary linear regression to examine the effect. Therefore, this thesis attempts to apply structural estimation with the economic theory of

utility maximisation to investigate the demand and supply in different perspectives. The thesis is divided into three individual chapters, starting with discussing the demand and supply sides respectively, while the last one incorporates the supply and demand side to examine the simultaneous effect on both sides in the audit market.

1.3   Research Questions

This thesis intends to match demand and supply in the audit market. Despite there being a significant body of literature on both sides of the market, discrepancies are identifiable in the research regarding the simultaneous effect on the demand and supply sides. Chapter 2 and Chapter 3 will discuss demand and supply individually in the audit market, while simultaneous demand and supply will be examined in Chapter 4.

In the audit market, auditor choice will be influenced by several factors where, aside from the brand name of the audit firm, the client is thought to choose the audit firm based on its individual characteristics and the audit firm. In addition, certain studies suggest that the client will incur a switching cost when deciding to change auditors; hence, audit firms may offer a fee discount to attract the new client (DeAngelo, 1981; Chu, Simunic, Ye and Zhang, 2018). Thus, this thesis will start with the factors that might influence the auditor choice and examine the determinants of the demand side problem. Following the research of Gerakos and Syverson (2015), the first research in this thesis will use the discrete choice model with the application of utility maximisation to examine the auditor choice. In order to discuss the whether switching from incumbent auditor would incur loss to the client, the model includes the variable of the audit fee and the switch to examine whether each determinants will have impact on the client's utility. Similar as prior research, the client is expected to have negative preference toward switching the audit firm.

At the same time, the first research extends the demand-side model to discuss whether price discounting will have an impact on the auditor choice. Even though the client may have several reasons for switching auditors, including opinion shopping (e.g. DeFond, Zhang and Zhao, 2018) and demanding for higher audit service (e.g. Huang, Chang and Chiou, 2016). In addition, prior literature on lowballing are mixed, especially after SOX 2002. Therefore, with the estimated client's utility model, the first research further conducts the counterfactual analysis to discuss the client's action toward the fee discounting. The following two research questions are to be discussed and addressed in the first research in this thesis:

Research Question 1: What effect does the switch between audit firms have on the auditor choice?

Research Question 2: How does the fee discount offered by the competing audit firms affect the auditor switch?

The second line of research in this thesis shifts the focus to the supply side in the audit market, where the auditor is assumed to assess the risk of the engagement before continuing, discontinuing or accepting the client. Instead of assessing the risk of engagement respectively, the audit firm is expected to measure the risk based on the audit firm itself as well as the clients in the portfolio. Differing from the role of the supplier in other industries, the audit firm may thus attempt to not only maximise its profit but ensure the risk exposure of the client portfolio. Furthermore, the argument proposed by Gendron (2011) indicates that the audit firm will consider both professionalism and commercialism when accepting a new client. Therefore, the study will proceed by following the suggestion of certain contributions to the previous literature in seeking to determine the auditor utility for the client portfolio (Lewis, 1980; Crosby et al., 1986). In addition, after the U.S. passed Sarbanes-Oxley 2002, the audit firm is expected to increase its audit work when providing audit service (Rama and Read, 2006), which lead to the futher analysis in the second research in this thesis. Based on the estimated auditor utility, the analysis will discuss the possible influence on the change in the optimal strategy of the audit firms with the increasing cost of auditing. The research questions in Chapter 3 are then as follows:

Research Question 3: How does the audit firm's client portfolio affect the audit firm's risk assessment?

Research Question 4: How does the change in the cost of auditing affect the optimal strategy of the audit firm?

After discussing the demand and supply sides in the audit market in Chapter 2 and Chapter 3 respectively, the third research area in this thesis will study the simultaneous effect on both sides. Following the research in Chapter 2, the factors behind auditor choice could be examined, which includes the audit fee. According to the economic theory of demand and supply, the equilibrium price will be determined by the customer and the supplier simultaneously. However, such concept has not yet been considered in prior accounting literature with the structural estimation. Therefore, the third research in this thesis would attempt to fill the gap of economic theory and the audit market and examine the simulatenous effect on the demand and supply side of the audit market. In this research, the objective of the audit firm is to maximise its profit and the expected profits are dependent on the client's choices and the profit of the engagements.

In addition, the simultaneous effect in the audit market is examined under two scenarios: (1) First, the audit market is a Bertrand competition, where the audit firms are independent of the pricing strategy. Based on the economic theory, that the audit firm is assumed to maximise its profit by simply considering its profit margin and the probability of the client's choice. (2) There is tacit collusion in the audit market and the audit firm's expected profit is also based on another audit firm's profit. In such a scenario, the client would assume that the pricing strategies are negotiated across the audit firms and dependent on other suppliers in the market. By considering both sides in the audit market, the research questions in Chapter 4 is:

Research Question 5: What is the difference in auditor choice between these two conditions, Bertrand competition and tacit collusion, when simultaneous demand and supply is considered in the audit market?

1.4   Methodology

1.4.1   Philosophical Foundations

This thesis is aimed to examine the demand and supply in the audit market respectively and further extend the topic to matching supply with demand simultaneously. Before selecting the appropriate methodology and dataset used in this thesis, the philosophical foundation of this thesis is discussed to develop three research. Following previous literature, several assumptions are made in order to choose the best methodology in order to capture the nature of the audit market.

In the previous section, the research questions regarding the demand and supply in the audit market have been raised and it is believed that the questions could be examined with appropriate theory and methods. Before analysing the audit market, the philosophical foundation related to my research questions is considered to be objectivism, where the market could be analysed by the law-like generalisations (Saunders, Lewis and Thornhill, 2009). In order to illustrate the thesis more comprehensively, following assumptions could be interpreted between objectivism and subjectivism and is discussed to develop the methodology applied.

Ontology

Ontology can be defined as "the science or study being" (Blaikie, 2010). From the perspective of objectivism, the social entities are believed to exist independently and the structure does not created by the researchers, which is illustrated as the subjectivism. Realism and nominalism are the extreme forms of objectivism and subjectivism, where realism believes that there is only one true social reality while nominalism considers multiple realities because of the difference between each

person's experience and perceptions (Saunders et al., 2009). In this thesis, the audit client is assumed to choose the audit firm independently and the audit firm does would decide its client portfolio in order to maximise its utility, showing that the research is more likely to be closed to objectivism in the ontology. On the other hand, this thesis would also like to address the difference between individuals, where the client's choice and the audit firm's selection may be influenced by its own characteristics That is, with considering the reality is objective where the client and the audit firm's would be aimed to optimize its decision, the subjectivism will still be applied through the setting of the parameter. In addition, to reduce the subjectivity in this thesis where the clients from different industries may possess varied perspectives, this thesis will only collect the publicly listed companies in the U.S. manufacturing companies rather than all audit clients in the market.

Epistemology

Epistemology is defined as the study of knowledge and the assumption about what determines the acceptable and legitimate knowledge (Saunders et al., 2009). While the clients in the sample are publicly listed companies, the client's data is public information which could be considered as the legitimate knowledge. Rather than considering the reseachers' "feelings", the public information of the company could be viewed as the fact, which the researchers would considers the information is real and far less open to bias (Saunders et al., 2009). Therefore, the since this thesis attempts to analyse the structure of the model based on objectivism, the data collected in this thesis would be the public listed companies' financial information, which would not influenced by the researchers. In addition, by differentiating the epistemology by "positivist" and "interpretivist", which is similar as objectivism and subjectivism in ontology, this thesis examines the supply and demand side of the audit market with objective ontology with a positivist epistemology. Align with such assumption, the quantitative method will be applied in this thesis along with structural estimation.

Axiology

The last assumption considered here is axiology, which is defined as the study of value and ethics during the research process. The researcher's value could play an important role in the research process when making interpretation and judgment during the research process. Following previous assumptions, this thesis intends to consider the audit market as objective and therefore, the quantitative method will be applied to examine the client's choice and the audit firm's strategy. By applying the quantitative method with structural estimation, the estimation could be more unbiased without human judgment. However, the result will still be influenced by the selection of

the variables and the industry. In order to reduce the effect of different industries, this thesis will only include the publicly listed companies in the U.S manufacturing companies.

1.4.2   Data

Deriving from the philosophical foundation in the previous section, this thesis collects the financial data of the manufacturing companies in the U.S. from the year 2010 to 2015. Since 2002, the U.S. passed the Sarbanes-Oxley Act 2002 (SOX), the publicly listed companies are required to disclose the information of the audit firm and the audit fee in their financial report. Since the researchers are able to examine all the data of publicly listed companies in the U.S., it would eliminate the bias in sampling due to the lack of data. Additionally, rather than examining all publicly listed companies in the U.S., focusing on specific industry will reduce the subjectivism in ontology since the previous research shows that the audit effort and the audit fee would be affected by the industry (e.g. Bae, Choi and Lee, 2018) and therefore, the audit firms are believed to provide differentiated audit service. With the mandatory regulation of audit fee disclosure and to reduce the subjectivism in this thesis, the data collected in the thesis would be all publicly listed companies in the U.S. manufacturing industry from the year 2010 to 2015.

The financial information (e.g. total asset, inventory turnover) of the publicly listed companies are collected from Compustat, which includes the financial data for active and inactive companies around the world. The audit-related information could be extracted from Audit Analytics, which includes the date of audit-client pair, the audit fee and the auditor's opinion for each publicly listed companies in the United States. During the sampling, SIC code is used to differentiate the manufacturing companies from the market and the sample in this thesis include all publicly listed companies in the U.S. manufacturing industry. Since all the data collected for this thesis is from Compustat and Audit Analytics, the data is considered as secondary data and cross-sectional data.

1.4.3   Statistical Methodology

Following the philosophical foundations illustrated in the previous section, this thesis is considered to follow the perspective of objectivism where the audit market is believed to be depicted by law-like generalisation (Saunders et al., 2009). Moreover, rather than involving researcher's perception, the sample in this thesis includes publicly listed companies and therefore, the data is believed to be legitamte. With such setting, this thesis will use quantitative method to examine the supply and demand in the audit market while the client could select the audit firm and the audit firm could determine its optimal client portfolio and the audit fee. To carry out the estimation, the structural estimation will be carried out in all three chapters. The thesis will be considered as the cross-

sectional research where the audit client and the audit firm would make choice independently during the sample year.

The research adopts the utility theory to examine the client's and the audit firm's choice. On the demand side, following the discrete choice framework and the utility model proposed by Gerakos and Syverson (2015), the research framework assumes that the client would choose the audit firm with the highest utility. On the other hand, the second research area attempts to identify the auditor utility, assuming that the audit firm would consider its client portfolio not only by profit but also other factors (e.g. client's size and the risk of the engagement). The third research conducted in this thesis incorporates the client's utility model with the audit firm's profit maximisation to discuss the simultaneous effect of the auditor choice and audit firm's pricing strategy.

However, in order to enhance the efficiency of this research, the following assumptions are made to the demand side. First, non-Big Four audit firms are considered as one audit firm when the client chooses the auditor. Based on the market share in the sample year, the Big Four audit firms (PricewaterhouseCoopers LLP, Ernst & Young LLP, Deloitte & Touche LLP and KPMG LLP) earn more than 90 percent of the audit fee and own around 80 percent of clients, and most accounting research categorizes the non-Big Four as one audit firm (e.g. Gerakos and Syverson, 2015; Guo et al., 2017), this assumption is considered acceptable in the stream of accounting research.

Second, in order to estimate utility, the research assumes that the client will receive offers from all audit firms in the market and choose the one with the highest utility. However, since the researcher could only obtain the audit fee for the actual contract, the remaining price for other offers would be predicted following the methods proposed by Gerakos and Syverson (2015) and implemented as data before doing the estimation. Under such an assumption, the problem of the missing fee could be handled more properly. Third, the framework applied in this thesis assumes that the client signs the contract with an auditor every year, entailing that the client and the audit firm would measure the utility and assess the risk of engagement annually. In addition, the client is assumed to have a constant preference for the same attributes over time and will not deviate from this preference accordingly.

Besides adopting the structural estimation to examine both the demand and supply sides, this research adopts the Bayesian approach with the random-walk algorithm to allow heterogeneity in the audit market, where the individual in the audit market (including the audit firm and the client) would have different perspectives when making the decision. Previous accounting research has adopted ordinary least square and logistic regression to examine the client's choice and the audit

firm's client portfolio (e.g. Lai et al., 2017; Fang, Pittman, Zang and Zhao, 2017). By applying the concept of utility maximisation in the thesis, maximum likelihood estimation is most widely used to solve the discrete choice problem (e.g. Gerakos and Syverson, 2015).

However, with the traditional frequentist approach, which includes ordinary least square, logistic regression and maximum likelihood estimation, only the fixed parameters could be estimated. In order to allow the heterogeneity among individuals, where each client and audit firm would have different preferences for selection, this thesis will apply Bayesian approach rather than frequentist approach which assumes the utility models are the same among all sample. With the random-walk algorithm, the estimation will be carried out by Markov Chain Monte Carlo simulation. By setting the priors for each coefficient, the estimation will then be conducted by iterative sampling from the full condition of distribution of all estimated parameters. In addition, the benefit of adopting the random-walk algorithm is that all the individual coefficients can be estimated and saved, allowing the counterfactual analysis can be carried out based on different clients and audit firms.

1.5   Outcomes

The thesis starts with the demand side of the audit market in Chapter 2. Following the first stream of literature in Section 1.2.1, there is a great body of the accounting and auditing literature are interested in the auditor choice, while most of the studies use the logistic regression to examine the factor that impacts the selection. Following the framework used by Gerakos and Syverson (2015), the framework of this research adopts random utility function to examine the clien't choice for the audit firm on the demand side.

Moreover, besides examining the factors that may influence auditor choice, this study attempts to take the auditor switch into consideration. Therefore, in the demand model, the auditor switch is taken into account to examine if the change of auditor will have an effect on the client's selection. The model also includes the client's and the audit firm's characteristics to investigate whether the client has a preference for a specific audit firm and whether the choice will depend on the operation of the company. With assumptions that the non-Big Four audit firms are considered to provide homogenous audit service and be viewed as one audit firm, the results of the mean coefficient show that the client prefers non-Big Four audit firms when the brand name is the only consideration.

Consistent with the previous literature that the brand name of the Big Four audit firm has the positive relationship with the audit fee, the client of the Big Four tends to pay higher audit fee premium compared to other clients. Therefore, the client is less likely to choose the Big Four compared to non-Big Four audit firms. However, the company with higher sales and inventory turnover is more likely to choose Big Four audit firms over non-Big Four. Since the sample in this

research includes manufacturing companies in the U.S., the efficiency of the operation may be important for the company. Big Four audit firms are considered to provide high-quality audit insofar as the client may perceive the efficiency of the inventory inspection will be higher because of the human resources and advanced technology in the firms, which are expected to increase the propensity that the client chooses Big Four audit firms. In addition, the client would incur a switching cost when changing the audit firm, which could prevent the client from choosing the other audit firms when other factors hold.

In the random utility model, the audit fee is expected to impact on the auditor choice. Similar to the results estimated by Gerakos and Syverson (2015), the audit fee has a negative association with the client utility, showing that the client tends to choose the audit service which is less costly. However, because the framework enables heterogeneity among clients, the estimated distribution of each parameter could be obtained. By assuming the random coefficient follows a normal distribution, it is interesting to notice that the variance for the coefficient of audit fee is relatively large.

This outcome shows that even though most of the client prefer lower price, there is still a huge difference in the preference for the audit fee, which enables me to extend the research. Since the results of the estimation include all parameters for the clients in the sample, the empirical analysis could conduct the counterfactual analysis to examine the behaviour of the client receiving price discount. By adopting a similar approach to Guo et al. (2017), this analysis compares the utility of incumbent auditor and competing auditor to investigate the extent of the fee discount the client will be willing to switch auditor considering the brand name, operation and the cost of switching.

The research further defines the switching into three patterns according to the classification of the audit firms (i.e. the Big Four and non-Big Four) accounting for whether it is the incumbent and competing auditor. In addition, based on the possible behaviour, the clients are categorised into three groups: preferring higher price, willing to bargain and being loyal. Even though the mean effect of the parameter for audit fee is negative, a number of clients still perceive that paying higher audit fee could benefit the company from receiving a high-quality audit.

In order to further examine the relationship between switch behaviours and the client characteristics, a principal component analysis is applied. Principal component analysis aims to inspect the data structure according to a set of variables, which then refers to the principal component, by applying multivariate analyses. The principal component analysis shows that the client would act differently according to its characteristics, including its operation and size; that is,

because the client would have varied preferences for different audit firms, it would influence the client behaviour indirectly. For example, similar to the previous literature, the result of the principal component analysis indicates that the large companies are more willing to pay a higher audit fee to receive better audit quality. On the other hand, small clients, especially the incumbent auditees of non-Big Four audit firms, prefer to hire the auditor at a lower price, since the profit earned may be the main consideration for the client.

Following the third stream of the literature considered in the thesis, the second research in this thesis examines the auditor utility of the client portfolio. The framework follows the study of Kim, Allenby and Rossi (2002) with the additive utility function to model the auditor utility for variety. Hence, to examine the client portfolio in a more systematic way, the clients are divided into categories based on the sales of the client. The auditor is expected to conduct more comprehensive audit work to the company with higher sales volume because a large amount of inventory and transactions are expected in the operation.

Moreover, the research includes the resource constraints during the process of utility maximisation, which have not yet been considered in other accounting research. Instead of considering only the human resources, the budget constraint in this study uses the audit fee as the proxy to determine the necessary audit work, including the personnel and technology required, to examine the utility function of each audit firm. Consistent with Gendron (2011), the random utility model is adopted in the framework which allows the audit firms to adopt different strategies for assessing the risk of the client portfolio.

The posterior mean of the parameters in the utility model shows that the audit firms prefer to provide service to the companies whose sales are below average. However, the result also indicates that the variances of the parameter are large, showing that the optimal strategies for the audit firm in the market have significant differences. Therefore, instead of discussing the mean effect of the utility model, this research further examines the coefficients for top six audit firms in the market and the results are different with the mean effect, as expected. For example, owing to the size of the Big Four audit firms, the auditors would prefer to provide service to large companies with higher sales, instead of focusing on small clients.

On the other hand, the medium-sized audit firms (Grant Thornton LLP and BDO USA LLP) are more likely to accept the clients with less sales because of the limited budget. However, the results of the random coefficient show that even among the Big Four audit firms, the tendencies to accept different clients are slightly varied. Therefore, the study further implements the coefficients of each audit firm to examine whether the change in the cost of the audit work would have an impact on the client portfolio.

Chapter 1

The counterfactual analysis in the research examines the possible change to the optimal choice of the audit firm assuming that the cost of auditing in each category of client rises respectively. It is interesting to note that the optimal choices for the Big Four audit firms differ. PwC, which is viewed as the specialist in the industry, is more likely to focus on a strategy of economies of scale and retain the clients with large sales in order to maintain its reputation and market share. On the other hand, during the sample year, the number of E&Y clients adds up to the most in the manufacturing industry, which may indicate that E&Y provides a service based on the strategy of economies of scope. The counterfactual analysis also shows that E&Y would attempt to provide as many clients as possible instead of concentrating on specific groups.

To draw conclusions from the findings for the first research, the auditor choice is determined by a set of variables, including audit fee, while the probability of the client choice can be calculated by logit transformation. On the other hand, the profit of the audit firm comes from the audit fee minus the cost of the audit work, where the optimal audit fee will be influenced by the probability of client choice. Therefore, the framework in this research takes the endogeneity of audit fee into consideration to examine the auditor choice within the audit market.

In addition, two propositions are discussed considering the competition among the audit firms: (1) the Bertrand competition, where the audit firm's pricing strategy is independent and (2) the tacit collusion, where the expected profit of the audit firm also includes the probability of the client's choice for other auditors.

Here the research finds that the client's preferences are different under two propositions. When assuming that the audit market is under Bertrand competition, the client prefers to choose PwC, the leading audit firm, because the client may take specialisation seriously and perceive the reputation representing the high-quality audit. However, with the assumption that auditors are undergoing collusion, the client may not see the market share as the outcome of competition but as the ways that the audit firm attempts to increase its audit fee.

In addition, it is surprising that the companies are willing to pay higher price under both scenarios. Since the clients in the sample are publicly traded companies, the client may wish to pay a higher fee for high-quality audit to mitigate the problem of information asymmetry and agency problem. In order to determine which framework better fits the actual audit market, the information criteria, Akaike information criterion and Bayesian information criterion, are used to compare the framework under two propositions. The comparison shows that the framework under the assumption of the audit market as Bertrand game fits the sample better.

Moreover, since the individual coefficients can be estimated with the random utility model, the estimated parameters are implemented to the utility model to predict the choices from the year 2013 to 2015 and compare with the actual choices. However, the prediction shows inconsistency with the analysis of information criteria. This might due to the fact that the pricing strategy of the audit firm depending on the client, entailing that the auditor might collude with regard to a specific client rather than the whole market.

1.6　Contribution

Following the basic concept of utility maximisation, this thesis uses structural estimation to examine the effect on both the supply and demand sides in the audit market. The research is believed to have the following contributions to the existing literature for various reasons. First, the professional service industry (e.g. hotel management) has been studied in operations research. However, it is difficult for researchers to obtain the cost and the price of the personalized service and the details of the transactions. Since SOX 2002 requires that the publicly listed company in the U.S. to disclose the audit fee, the researchers will be able to obtain the details of supply and demand in the audit market. Therefore, because of the transparency of the audit market, the research is able to examine the individual choice and pricing strategy.

Second, even though there are numerous examples of accounting and auditing literature discussing the factor of auditor choice and the client dismissal on the demand side and auditor resignation on the supply side, most of the research adopts a frequentist approach for the estimation which assumes the coefficients are fixed. This research introduces the random utility to investigate the auditor choice and the client portfolio for audit firms, which allows heterogeneity among the clients and the audit firms. Consistent with previous research that different clients may have varied concerns when choosing auditor (e.g. Lai et al., 2017; Li et al., 2017), the random utility would capture the selection of each client more precisely.

On the other hand, such research is believed to be more applicable to consider the decision of auditor acceptance and resignation with parameters that vary with each audit firm, especially when the scales of the audit firm are in a significant difference. In addition, instead of adopting the frequentist approach in the estimation, the research uses the Bayesian approach with the appropriate algorithm to carry out the estimation, which is seldom applied in the accounting research. Therefore, this research is considered to shed more light on examining the individual difference in the client and supplier in the audit market.

Third, demand and supply in the audit market have been discussed extensively in the existing literature, but studies often focus on the single side of the market to determine the effect of

particular attributes. However, according to the law of demand and supply, the auditor choice and the pricing strategy of the audit firm should be interlinked. In order to fill the gap, this thesis not only examines the demand and supply sides respectively but also attempts to examine the simultaneous effect in the audit market, which is not yet be discussed thoroughly. This and future studies could thus benefit from taking both supply- and demand-side of the audit market into consideration.

1.7   Structure

This thesis consists of three individual chapters examining the effects in the audit market. Following the streams of the literature in Section 1.2, Chapter 2-4 examine the demand and supply in the audit market and discuss the research questions respectively.

Chapter 2 examines the demand side in the audit market where the client would choose the audit firm with the highest utility and the research further discusses the auditor switch based on the estimated parameters.

The research in Chapter 3 captures the client portfolio of the audit firm, where the auditor would assess the risk of each engagement based on its existing clients. In addition, the research also discusses the effect on the audit firm's optimal strategy when there is an increase in the cost of the audit engagement.

After examining both demand and supply sides in the audit market, Chapter 4 examines the simultaneous effect of supply and demand sides in the audit market. The conclusion of the thesis is to be found in Chapter 5, followed by the Markov Chain Monte Carlo estimation process and detailed derivation for each research in Appendix A to Appendix D.

Chapter 2   Auditor Switch with Audit Fee Discounting

2.1   Introduction

Lowballing effect is considered as an impairment of audit quality when the audit fee of initial engagement is lower than necessary. The occurrence of fee discount is evident when the audit client switches audit firms, but a fee discount is sufficient for the condition of the auditor switch but not necessary. The factors involved in auditor change include the audit firm's perceived audit quality and level of specialisation (e.g. Boone et al., 2010, Lai et al., 2017) and the agent-related variables of the audit client (e.g. the audit client's size and the board committee).

The companies may not only consider single aspect when switching auditors, while there is no suggestion that the fee discount will directly lead to the auditor switch. Without taking the auditor's and client's characteristics into consideration, previous studies may have failed to examine how the fee discount affect the auditor-client relationship. This study thus attempts to understand how the audit firm pricing strategy impacts upon the auditor switch.

Legislators and regulators have raised concerns about the practice of lowballing and the audit firm switch. Lowballing is believed to lead to "a variety of independence issue" because the auditor may lose their independence to meet the clients' expectation to maintain the client-auditor relationship in the following year so as to incur the loss in the initial-year engagement (SEC, 2000). After SOX 2002, the existence of fee discounting in the initial year is expected to decrease because of the restriction of the audit firm's operation (Huang et al., 2009) and the mandated audit work for the initial engagement (Huang et al., 2009; Desir et al., 2014).

Empirical studies on the association between lowballing and the evidence of the lack of auditor's independence are few because the researchers do not have the data for audit works. Despite the concerns raised by the authorities, hypotheses on the effects of lowballing are sparse. Dye (1991) indicates the effect of lowballing would impair auditor's independence while DeAngelo (1981) suggests that the issue is not significant. Thus, although there are concerns about lowballing in the initial year, the practice of fee discounting is still believed to be applicable within the audit market.

On the other hand, auditor switch is often viewed as the opinion shopping of the audit clients, in which they tend to search for the auditor who could issue clean opinion report for the company (Chow and Rice 1982). Even though there is no direct estimation of the switching cost in the past literature, DeAngelo's (1981) multi-period pricing model and Chu et al.'s study (2018) indicate that the transaction cost, including the start-up cost for the audit firm and switching costs for the audit

client, will incur during the audit firm switch. Therefore, in order to attract the new audit clients, the competing audit firms may need to offer fee discount to reimburse the switching cost that the audit clients need to take.

In addition, the studies of Gerakos and Syverson (2015) and Guo et al. (2017) indicate that the audit fee would have a negative effect on the utility, making the fee discount more preferable to the audit clients. However, studies also show that the switch may be beneficial to the companies when they are seeking better audit quality. Big N audit firms are often considered to provide higher audit quality based on their competence, independence and perceived as a "deep pocket" (Beatty, 1989; Khurana and Raman, 2004). Thus, this research intends to investigate the factors that might affect the auditor switch. This reseach will attempt to examine how the practice of fee discounting affect the audit client's choice of switching auditor with regard to the initial and competing auditors.

This research uses manufacturing companies in the U.S. as its sample. Since the company in different industries may have various concerns regarding the selection of the audit firm, the study will focus on manufacturing companies rather than taking all the publicly listed companies into consideration. The results of the utility model show that, compared to the non-Big Four audit firms, the audit clients do not prefer to hire Big Four because the clients may need to pay more for the brand name and have less bargaining power. On the other hand, the companies who have large sales and high inventory turnover are more likely to choose Big Four audit firms. In the sample, the Big Four audit firms earn more than 90% of the audit fee and own around 70% of the clients in the manufacturing industry, the client may perceive them as the specialist which could provide better audit quality.

In addition, the framework allows heterogeneity among the audit clients, where it is assumed that each client would have different preferences and consideration when choosing audit firms. Even though the sample only includes the U.S. manufacturing companies, the companies may have different consideration due to its condition (e.g. financial condition and the board committee). The findings in this research show that there is variation in the preference for Big Four and interactions with the attributes. This shows that even in the same industries, the companies still have a diverse preference when choosing the audit firms. In addition, the estimates also indicate that switching audit firm would have a negative effect on the audit client's utility and the result shows the consistency among all sample. Even though there is evidence that choosing certain auditor would have positive market reactions (Knechel et al., 2007), the outcome shows that switching is not preferable to the audit client.

Similar to the previous results, the audit fee has the negative fixed effect on the client's utility. However, by assuming heterogeneity among clients, this study finds that the audit client has a significantly different level of preference to the audit fee.

The analysis further implements the coefficients estimated for every audit client and examines the fee discount that the competing audit firms need to offer in order to induce the client to switch. Here the companies who do not switch from the previous year are used as the target of the discussion. First, research classifies the sample by the previous and the competing audit firm and calculates each client's favourable price to switch from the incumbent audit firms to the competing audit firm. The analysis first compare the actual audit fee with estimated audit fee and categorises the price difference by three different actions the client may take : (1) preferring a higher price- the new favourable price is higher than actual price, (2) willing to bargain- the audit client would switch audit firms with possible discount and (3)being loyal- the discount that the client would accept is not applicable (i.e. the favourable price is negative) and then apply the principal component analysis to examine the common characteristics that each category has. Rather than inspecting the association between the client's behaviour and financial circumstances, the principal component analysis uses multivariate analyses to inspect the client's behaviour according to a set of variables.

The findings indicate that with a larger size and sales, the company tends to choose the one that offers higher audit fee. In the past accounting research, the determinations of the audit fee are discussed extensively and research suggests that the condition of the client (e.g. client size and the complexity of the firm). In addition, audit fee is also considered as the proxy for audit quality where the client could receive higher-quality audit if the audit fee is relatively higher than other firms with similar structure (DeFond and Zhang, 2014; Fung, Gul and Krishnan., 2012; Dao, Raghunandan and Rama, 2011). Therefore, the result from the analysis shows that the clients with larger size and higher sales would be more willing to pay higher price as to obtain better audit quality. This finding also demonstrates consistency no matter whether the previous and competing audit firms are Big Four or not. On the other hand, the audit clients who have a relatively high current ratio may consider negotiating the price with competing auditors. The possible reason may be that these companies have high organisational slack and good capability of liquidity, and these advantages may increase their bargaining power with the audit firms.

Moreover, the audit client is more likely to choose the same audit firm no matter how great the discount it receives when its earnings per share is high. Since the market often sees the switching of audit firms as bad news, the company will consider not switching audit firm voluntarily in order to prevent any downside in the stock market.

It is worth noting that the company's inventory turnover has the different influence on the decision of switching. Hence, the company who hires the Big Four audit firms in the previous year is less likely to switch when its inventory turnover is relatively high. Owing to the economies of scale, Big Four is often presumed to have better knowledge and audit quality. The companies with high inventory turnover may consider it significant as the auditors may be more efficient or able to find any fraud and material misstatement. On the contrary, the company that hires the non-Big Four in the previous year is more likely to switch to Big Four for the same reason. This is because the management of the inventory is crucial to the audit clients and they are more willing to switch if the offered price from the Big Four is acceptable.

This research is believed to be one of the few studies to introduce the discrete choice problem with random utility in accounting and auditing literature. By allowing for heterogeneity among the audit clients, the research is able to estimate the individual preference rather than only the fixed effect. With the implementation of the coefficient, the analysis in this study is able to calculate the fee discount which will intrigue the audit firm switch and to analyse the behaviour that the audit clients would have. Even though the estimation for fixed effect is similar to the previous literature, this research shows that there are varied preferences among the audit clients, suggesting that the further researchers may need to take the difference into consideration.

Based on the counterfactual analysis in this research, the analysis could then explore how each audit client would react when facing fee discount offered by competing auditors, which has not been discussed in the previous research due to the estimation procedure. In addition, even though the legislators have concerns about fee discount and auditor switch, the outcomes in the research show that the audit client would like to improve its audit quality by switching audit firms. It is worth considering whether the lowballing effect only produces a negative effect and whether the ban from fee discount would prevent the companies from improving themselves.

The research is structured as follows. Section 2.2 reviews the prior literature. Section 2.3 develops the discrete choice model with random utility. Section 2.4 illustrates the estimation for the demand model and Section 2.5 shows the results of the estimation of the utility model. The research further uses component analysis to discuss the fee discounting and switch by implementing the estimated parameters in Section 2.6. Section 2.7 is the conclusion of the research. The detailed procedure of Markov Chain Monte Carlo estimation is written in Appendix A.

2.2   Related Literature

The aim of this research is to examine the auditor selection in the audit market. Besides focusing on the auditor choice, the research also conducts the counterfactual analysis to further investigate the fee discount among the audit firms. The approach applied in this research enable me to examine the actions that audit clients may take when receiving the fee discount.

This research applies the structural estimation to address the discrete choice problem where the audit client needs to choose one of the audit firms every fiscal year. The structural application of discrete choice problem has been widely used in marketing and operation research to examine the customer choice with different approaches (Berry et al., 1995; Yang et al., 2003; Villas-Boas et al., 2005).

In the discrete choice problem, the customer is inclined to choose the product with the highest utility. Recent accounting and auditing research has applied the discrete choice problem by assuming that the audit client would hire the audit firm with the highest utility. Gerakos and Syverson (2015) apply this approach to the policy implementation to examine the effect of mandatory rotation and the exit of the Big N audit firms. Guo et al. (2017) have adopted a similar method but to compare the consumer surplus between the single audit regime and joint audit regime.

However, due to large numbers of the audit firm in the market, the researchers consider that the non-Big Four auditors provide homogenous audit service and investigate the preference for each of the Big Four audit firms and the non-Big Four. In this research, the framework would apply the discrete choice problem alongside the random utility to estimate the preference for each auditor, and adopt similar approach used by Guo et al. (2017) to investigate the fee discount effect on the audit clients.

This research starts by analysing the auditor choice of the audit client. In the previous accounting research, studies place the emphasis on the policy implementation and the analysis of client attributes affecting the choice. Hence, researchers have used agency theory to explain the necessity of the audit service, where the auditor is expected to conduct independent work, and to detect and reveal the agents' failures and incorrect information (DeAngelo, 1981; Lee, Stokes, Taylor and Walter, 2003; Lin and Liu, 2009; Tsao, Lu and Keung, 2016; Fang et al., 2017).

The existing literature assumes that the client makes independent choice of the selection of the auditor and proxies the agency cost with client characteristics. Studies often divide the audit firms into two categories and examine the preference of audit clients for the Big N or non-Big N audit firms. A recent study by Lai et al. (2017) discusses how the board gender of the audit client would

affect the auditor choice and finds that the client with a gender-diverse board is more likely to choose the specialist auditor. In addition, Fischer and Huddart (2008) and Li et al. (2017) suggest that the effect of a social factor should be taken into consideration. By considering the peer choices, the study shows that the audit client is more likely to choose the social norm audit office, which has the largest number of audit clients in the metropolitan area where the client's headquarter is (Li et al., 2017). Knechel et al. (2007) then extend the existing research and find significant evidence that there would be positive market reactions to the news of company switching the audit firm from Big Four nonspecialist to Big Four specialist, showing that even within Big Four, the audit client would have different preference for certain attributes of the audit firm.

However, most of the literature examines the auditor selection only considering the specific group of auditors. In the discrete choice model used in Gerakos and Syverson (2015) and Guo et al. (2017), the researchers are able to consider all the choice in the audit market, especially the Big N audit firms in the market. Besides considering the auditor selection, the research follows the approach taken by Gerakos and Syverson (2015) and Guo et al. (2017) to implement the auditor selection model to discuss the pricing strategy that the audit firm should take in order to make the audit client switch from the incumbent audit firm to one of the competitors. In the past accounting and auditing literature, the topic of the auditor discounting the audit fee in the initial year been widely discussed and is regarded as a "lowballing" effect. For instance, DeAngelo (1981) suggests that quasi-rents will lead to a low-balling effect on the initial year audit fees, with the incumbent auditors having the benefit from the audit client switching costs and the start-up costs of providing new audit service.

The lowballing effect happens when the audit fee is lower than the cost of the total audit effort. Since the cost of the audit service is unobservable to the researchers, the previous literature uses the initial year audit fee discounting as the proxy to examine the lowballing. Ettredge and Greenberg (1990) and Huang et al. (2015) measure the audit fee discounting by calculating the audit fee difference with the previous auditor's last audit fee and the new auditor's fee bid. Lowballing has been a concern for legislators and regulators (SEC 2000). In 2000, the SEC indicates that the practice of lowballing could create "a variety of independence issue". In order to maintain the client-auditor relationship, the auditor may be inclined to meet the clients' expectation with less independence.

Previous research and evidence has shown that the audit fee discount could impair the auditor independence and the auditor may fail to find out the material misstatement in the companies' financial reports (Stanley and Dezoort, 2007). However, due to the lack of data for audit works, the

empirical evidence is few of the lowballing effect leading to a decrease in audit quality. Working under theoretical arguments, DeAngelo (1981) indicates that the decrease in audit quality would be insufficient with lowballing effect while Dye (1991) suggests that lowballing practice could impair the auditor's independence. Meanwhile, Dopuch and King (1996) use an experimental market and find that the lowballing does not reduce audit quality by the frequency of investigations.

After 2002, when the U.S. passed the Sarbanes-Oxley Act, the occurrence of lowballing was expected to decrease due to several reasons. First, Huang et al. (2009) suggest that due to changes to the audit firms' business model, the audit firm has fewer incentives to have an audit fee discount in the light of the SOX's restrictions of the audit firm providing the audit and nonaudit service to the same client. Second, because of the restrictions and mandates in SOX, significant audit works are expected to be carried out for the initial audit year and the audit firm becomes more conservative. Thus, in order to abide the SOX 2002 and increase the audit quality, auditors are less likely to lowball for the initial audit engagement (Huang et al., 2009; Desir et al., 2014). However, Desir et al. (2014) extend the research of Huang et al. (2009) and indicate that for the "extended" post-SOX from 2007-2010, audit firms started to have a fee discount for the initial-year audit engagement in the U.S.

The existing literature has presented the reasons why audit clients switch the audit firm. There are concerns about the auditor switching the regulators and legislators since the switching may represent the audit clients doing opinion shopping because the incumbent auditors cannot meet their expectation by issuing a clean audit opinion (Chow and Rice, 1982; Dye, 1991), which is often a signal to the market that the company is performing poorly. In addition, the audit fee has been considered as one of the factors affecting auditor switch and prior studies suggest that the audit client is more likely to switch auditor when the audit fee is relatively high (Ettredge et al., 2007; Woo and Koh, 2001). Geraokos and Syverson (2015) apply the discrete choice model to examine auditor choice and discover that the audit client has a negative preference for audit fee when choosing audit firms. However, Schwartz and Menon (1985) indicate that the client may switch audit firms in order to provide credible information to their stakeholders. Furthermore, studies show that clients are expected to earn positive market response if they switch to brand name auditors, such as the Big Four, which are more credible compared to other audit firms in providing better audit quality (Simunic, 1980; Dunn, Hillier and Marshall, 1999).

Big Four audit firms are often viewed as providing high audit quality based on their competence, independence and being perceived as "deep pocket" (Beatty, 1989; Khurana and Raman, 2004). However, Boone et al. (2010) compare Big Four and second-tier audit firms and find that there is little difference in actual audit quality but significant diversity in perceived audit quality. Besides

the rationale of auditor switch, studies show that the audit clients may consider the cost before switching. DeAngelo's (1981) multi-period audit pricing model incorporates the determinants of the audit fee, including the start-up cost for audit firms and the switching cost for audit clients.

However, there is little current research that focuses on estimating the switching costs for the audit clients directly. Following DeAngelo's (1981) multi-period audit pricing model, Chu et al. (2018) consider the size difference between the incumbent auditor and the largest audit firms in the market. They hypothesize that the fee premium charged by the largest audit firm in the market may be due to its market power rather than the audit quality and the results suggest that the variation of transaction cost for audit client changing audit firms is significant (Chu et al. 2018), showing that the audit firm and the client will incur cost when the client switching the auditor.

2.3   Model Development

Audit service is considered as a heterogeneous service where the audit firm would provide different levels of service according to the client. On the other hand, the client's selection of the audit firm would be based not only on the audit firm but also its characteristics. Therefore, this research proposes a utility function with allowing the interaction between the audit firm and the audit client to examine the auditor choice.

Suppose that there are I audit clients ($i \in 1, \dots I \equiv \mathcal{L}(I)$) with J possible audit firms ($j \in 1, \dots J \equiv \mathcal{L}(J)$) in the audit market at period t ($t \in 1, \dots T \equiv \mathcal{L}(T)$), where $\mathcal{L}$ is an integer from 1 to any positive integer. Each client firm i's utility from choosing audit firm j at period t as: for $i \in \mathcal{L}(I), j \in \mathcal{L}(J)$ and $t \in \mathcal{L}(T)$ would be,

$$U_{ijt} = \beta_{0i} + \left(\beta_i^n + \boldsymbol{x'}_{it}\beta_i^k\right)\boldsymbol{x}_{jt} + \beta_i^p p_{ijt} + \beta_i^w w_{ijt} + \psi_{jt} + \varepsilon_{ijt} \tag{2.1}$$

where $\boldsymbol{x}_{jt}$ is to represent the indicator variable for the audit firms, $\boldsymbol{x}_{it}$ is the client characteristics, such as sales and inventory turnover, and p_{ijt} is the audit fee that audit client need to pay to the audit firm j for the audit service. For the client's characteristics as the control variables, the model includes the company's sales and inventory turnover as the control variable. First, total sales is considered as the proxy for the firm size. Previous literature has suggested that the firm size would influence the client's choice, and coule be proxied by total assets (e.g. Habib, Muhammadi and Jiang, 2017) or total sales (e.g. Quick, Schenk, Schmidt and Towara, 2018; Aobdia, 2015). Since this thesis intend to focus on manufacturing industry, the sales of the product is expected to be the main sources of income, the model includes total sales as the proxy for the firm size. For auditing manufacturing company, the inventory inspection is expected to be the primary work since the

main operation is the manufacturing and the transaction of the product. In addition, the inventory has also be considered as one of the factors which could impact the auditor choice and auditor switch (Gerakos and Syverson, 2015; Brocard, Franke and Veoller, 2018).

In addition, the equation (2.1) includes the dummy variable w_{ijt} to capture the change of audit firm from the period $t-1$ to the period t. Following the BLP model proposed by Berry et al. (1995), the utility model also includes ψ_{jt} as demand shock with zero mean and standard deviation Σ_ψ, which could not be observed by the researchers. The error term ε_{ijt} is assumed to follows type 1 extreme value distribution.

The parameters in the model are the loadings to the utility, including the audit firms, the interaction between audit firms and client observable characteristics, audit fee and the switch cost if auditor change happens. In addition, in order better to capture the individual effect on each client's choice, the model allows the clients to have a heterogeneous preference and therefore assume that the random coefficient $\beta_i = [\beta_{0i}, \beta_i^n, \beta_i^k, \beta_i^p, \beta_i^w]$ follows normal distribution $N(\bar{\beta}, \Sigma_\beta)$.

In order to examine the preference of auditor choice, the research adopts the random utility model for the discrete choice problem. Under the assumption of utility-maximising behaviour, the decision maker will choose the alternative that gives the highest utility. That is, in the audit market, the client will select the audit firm which provides the highest utility among others. Therefore, the behaviour model of the client i would be: choose j if and only if $U_{ijt} > U_{ikt} \; \forall \, k \neq j$. Since the researchers cannot observe the client's utility directly, the characteristics of the client which are assumed to be related to the utility are included in the model. In order to derive the choice probability, the equation (2.1) can be decomposed into two parts, which is illustrated in the following equation:

$$U_{ijt} = V_{ijt} + \varepsilon_{ijt} \qquad\qquad (2.2)$$

$$\text{where } V_{ijt} = \beta_{0i} + \left(\beta_i^n + \boldsymbol{x'}_{it}\beta_i^k\right)\boldsymbol{x}_{jt} + \beta_i^p p_{ijt} + \beta_i^w w_{ijt} + \psi_{jt}$$

V_{ijt} is considered as a representative utility which can be estimated by the researchers and ε_{ijt} is the difference. The error term, ε_{ijt}, is assumed to follow type 1 extreme value distribution with density $f(\varepsilon)$. With this density, the probability of the audit client i choosing the audit firm j at period t is

$$s_{ijt} = Prob\left(U_{ijt} > U_{ikt} \;\; \forall k \neq j\right)$$

$$= Prob\left(V_{ijt} + \varepsilon_{ijt} > + \varepsilon_{ikt} \;\; \forall k \neq j\right)$$

$$= Prob\left(\varepsilon_{ikt} - \varepsilon_{ijt} < V_{ijt} - V_{ikt} \; \forall k \neq j\right)$$

$$= \int_{\varepsilon} \left(\varepsilon_{ikt} - \varepsilon_{ijt} < V_{ijt} - V_{ikt} \ \forall k \neq j \right) f(\varepsilon) d\varepsilon$$

$$= \int_{\varepsilon_{ijt}} \left(\varepsilon_{ikt} < \varepsilon_{ijt} + V_{ijt} - V_{ikt} \ \forall k \neq j \right) f(\varepsilon_{ijt}) d\varepsilon_{ijt} \tag{2.3}$$

Since the probability of $\varepsilon_{ikt} - \varepsilon_{ijt}$ below $V_{ijt} - V_{ikt}$ is cumulative distribution, the cumulative probability can be written with the density as above. In order to have logit form, the distribution of ε_{ijt} is considered to be type 1 extreme value distribution. With the assumption, the unobserved part of the utility for each alternatives have the same variance, but each of them are uncorrelated. Therefore, the density of the unobserved part of utility $f(\varepsilon_{ijt})$ and its cumulative distribution $F(\varepsilon_{ijt})$ can be derived and shown as follows:

$$f(\varepsilon_{ijt}) = e^{-\varepsilon_{ijt}} e^{-e^{-\varepsilon_{ijt}}} \tag{2.4}$$

$$F(\varepsilon_{ijt}) = e^{-e^{-\varepsilon_{ijt}}} \tag{2.5}$$

In addition, by assuming that ε_{ijt} are independent, the probability of the audit client i choosing the audit firm j can be illustrated by the multiplicative form of the cumulative probability of audit client i not choosing the audit client $1, \dots k$, where $k \neq j$, and the probability of choosing the audit client i. Therefore, based on the probability from equation (2.3) and the distribution from equation (2.4) and (2.5), the equation (2.3) could be derived as:

$$s_{ijt} = \int \left(\prod_{k \neq j} e^{-e^{-(\varepsilon_{ikt})}} \right) e^{-\varepsilon_{ijt}} e^{-e^{-\varepsilon_{ijt}}} d\varepsilon_{ijt}$$

$$= \int \left(\prod_{k \neq j} e^{-e^{-(\varepsilon_{ijt} + V_{ijt} - V_{ikt})}} \right) e^{-\varepsilon_{ijt}} e^{-e^{-\varepsilon_{ijt}}} d\varepsilon_{ijt} \tag{2.6}$$

With some algebraic manipulation of the equation (2.6), the equation could be derived into a closed form expression of the probability by the integral, which refers to the logit choice probability.

$$s_{ijt} = \frac{e^{V_{ijt}}}{\sum_k e^{V_{ikt}}} = \frac{e^{\beta_0 + \left(\beta_i^n + x'_{it} \beta_i^k \right) x'_{jt} + \beta_i^p p_{ijt} + \beta_i^w w_{ijt} + \psi_{jt}}}{\sum_k e^{\beta_0 + \left(\beta_i^n + x'_{it} \beta_i^k \right) x'_{kt} + \beta_i^p p_{ikt} + \beta_i^w w_{ikt} + \psi_{kt}}} \tag{2.7}$$

Under the condition of logit probability, s_{ijt} must be between zero and one, as illustrated for the probability of the choice of the audit client. If the deterministic part of utility for the audit client i to the audit firm j, V_{ijt}, is approaching infinity, the s_{ijt} is expected to close to one since the client would select the one with the highest utility. On the other hand, s_{ijt} will be close to 0 when V_{ijt} is

lower than other alternatives with approaching to $-\infty$ and the exponential form in the numerator is expected to become zero under the situation.

Hence, in order to perform the estimation efficiency, the following assumptions are made in this framework.

Assumption 1: Each client has to purchase the audit service and the client would sign the contract at each period.

Due to the regulatory environment, the publicly listed companies are required to hire an auditor to have an audited financial report periodically. Therefore, the research does not consider that s_{ijt} would be zero under the assumption that all clients are mandated to choose one firm and every audit firm in the market should provide the service to at least one client. In addition, the sum of the choice probabilities in the framework equals to one as:

$$\sum_j s_{ijt} = \sum_j \frac{e^{V_{ijt}}}{\sum_k e^{V_{ikt}}} = 1 \tag{2.8}$$

to represent the circumstances that every audit client choose one of the audit firms and no outside firms are considered in the framework.

In addition, since the client would sign the contract with the audit firm at each period, and the audit work is designed based on the current operation of the company, the model does not consider the future and past operation (e.g. growing or declining) would affect the client's decision.

Assumption 2: Non-Big Four audit firms are considered to be one audit firm.

Since non-Big Four audit firms only own around four percent of market share based on audit fee and less than thirty percent of the clients in the manufacturing industry, this framework assumes non-Big Four audit firms as one. When adopting logistic regression where the independent variable is the probability of choosing specific audit firm, previous literature differentiates the audit firms as Big N audit firms versus non-Big N (e.g. Quick et al., 2018; Fang et al., 2017). Moreover, Gerakos and Syverson (2015) examine the auditor choice with five options, including each of the Big Four audit firms and non-Big Four audit firms as a group. Therefore, even though the researchers could observe the client and the audit firm for each data, it would be inefficient to consider every audit firm during the estimation process. The summary statistics show that the non-Big Four audit firms only own around four percent of the market share based on the audit fee, so this assumption is believed to be non-biased to the estimation.

Assumption 3: The client is expected to receive offers from all available audit firms in the market, including the price, and the client will choose the audit firm based on all information.

After SOX 2002, every publicly listed company was required to disclose the audit fee in the annual reports. However, the researchers could not obtain the offers from other audit firms, including the price. Since the audit fee is considered one of the factors influencing the auditor choice, the research would follow Gerakos and Syverson (2015) to predict the price offered by other competitors.

With the assumptions above, the framework would only consider five audit firms in the audit market and all the prices would be observable to the researcher.

2.4   Statistical Specification

In this demand model, the audit fee for all possible choices needs to be observable. However, the audit fee of the actual choice is mandated to be disclosed on the annual reports and therefore the researcher can only observe the audit fee of the actual choice but not for the competing audit firms in the market. Hence, due to the necessity of the data for audit fee, before the estimation, this research will follow Gerakos and Syverson (2015) in predicting the unobservable audit fee before doing the further estimation.

The prediction model includes both the client characteristics and indicator variables for audit firms to estimate the price. In order to obtain a better prediction, the methods adopted for the prediction include the ordinary least squares (ols), lasso regression, ridge regression, partial least squares, recursive partitioning and randomForest for the audit fee estimation. To choose a better algorithm for predicting the audit fee, the root-mean-square error (RMSE) with the actual audit fee and predicted audit fee is used to determine the best one among all methods. The following table shows the RMSE for all methods.

Table 2.1   RMSE for All Methods of Audit Fee Prediction

Method	RMSE
Ordinary Least Squares (ols)	0.6370
Lasso Regression	0.6383
Ridge Regression	0.6457
Partial Least Squares	0.6382
Recursive Partitioning	0.6559

Method	RMSE
RandomForest	0.5469

The results of Table 2.1 indicate that the RMSE of predicting the audit fee is lowest when adopting RandomForest, the same as the method adopted by Gerakos and Syverson (2015). Therefore, the RandomForest approach is applied to estimate the unobserved audit fee before conducting the estimation on the client utility. The predicted audit fee is considered as the data in the sample, which would solve the problem of missing data in the estimation.

In the framework, the random coefficients are imputed in equation (2.1), which allows for heterogeneity among audit clients. Since this framework allows individual difference among audit clients, the research assumes that each audit client will have the same preference over time and such an assumption would be able to avoid the problem of coefficient identification during the estimation. Being that the sample consists of every individual choice and the utility would be influenced by the audit firm and client pairs, the Bayesian approach is adopted to estimate the parameter in the demand model. The estimation will hence be carried out by iterative sampling from the full conditional distribution of all estimated parameters, while the estimation process is built as a hierarchical form.

To conduct the estimation, the choice probability of audit client i choosing audit firm j at period t is specified as the equation (2.7), while the likelihood used in the Bayesian analysis could be calculated. The model is estimated by the Markov Chain Monte Carlo simulation. By adopting the logit model (Train, 2009) and assuming that there will be no outside goods and non-purchase decision in the framework, the choice probability of audit client i choosing audit firm j will be written as equation (2.7). The likelihood for the audit client i's choice can be illustrated as:

$$\text{Pr(choice)} = \prod_{j=1}^{J} \left(\frac{e^{\beta_0 + \left(\beta_i^n + x'_{it}\beta_i^k\right)x'_{kt} + \beta_i^p p_{ijt} + \beta_i^W w_{ijt} + \psi_{jt}}}{\sum_k e^{\beta_0 + \left(\beta_i^n + x'_{it}\beta_i^k\right)x'_{kt} + \beta_i^p p_{ikt} + \beta_i^W w_{ikt} + \psi_{kt}}} \right)^{I(y_{ijt}=1)} \qquad (2.9)$$

where y_{ijt} is the actual choice that the audit client i make and $I = 1$ when the audit client chooses the audit firm j, and 0 otherwise.

With this likelihood, the estimation is conducted by the Bayesian approach with the random-walk algorithm to investigate the posterior distribution for the parameters in the utility model. Compared with the frequentist, Bayesian approach with the random-walk algorithm is able to evaluate the individual-level estimates. In the estimation process, the demand shock ψ_{jt} and random coefficient β_i in the equation (2.1) are drawn consequently. The prior for each parameter is as follows:

$$\psi_{jt} \sim MVN\left(0, \Sigma_\psi\right) \tag{2.10}$$

$$\beta_i \sim N\left(\bar{\beta}, \Sigma_\beta\right) \tag{2.11}$$

In order to allow heterogeneity amongst all audit clients and derive the demand shock based on the information about the audit firm not observed by the researchers but known to the audit clients, the random utility model is modelled in the framework. To estimate the coefficient precisely, the hierarchal form is built under the assumption of the conjugate prior for $\bar{\beta}$, Σ_β and Σ_ψ to generate each parameter separately (Rossi, 2005). By sampling the estimation iteratively, the algorithm will converge to the constant value and the estimation for each random coefficient is able to be retrieved from the outcomes of the estimation.

In the estimation procedure, 80,000 iterations have been run and simulated in order to obtain reliable results. The results of the estimation could be used to analyse the information about the audit client's preference of audit firm and to examine the relative cost of auditor change if any. In the estimation, instead of capturing the mean/fixed effect of the preference of the auditor selection among the audit clients, the individual preference of each audit client in the market can be estimated because of the algorithm used in the research. The detailed process of the estimation is then written in Appendix A.

2.5   Empirical Analysis

The sample includes the publicly listed firms in U.S. manufacturing industry from the year 2011 to 2015. Considering that audit firms provide heterogeneous service to audit clients and audit firms would have different pricing strategies based on different industries the audit client in, this study has decided to focus on the manufacturing industry and classify the sample by the two-digits SIC code. The data of audit fee and related audit information, inciluding the information of incumbent audit firm, are collected from Audit Analytic. Based on the publicly listed companies, Audit Analytics includes the basic auditing information of the publicly listed companies in the U.S. Because of the mandated disclosure, the audit fee of each engagement will be collected in the Audit Analytics database. While the Audit Analytics provides limited financial information of the companies, the remaining variables that are believed to influence the auditor choice and the client's behaviour, including total assets, total size and earnings per share, are collected from Compustat, which includes the financial information of the companies around the world. After matching the company's information from Audit Analytics and Compustat, the research classifies the industry with SIC code. Since the client in each industry would have varied consideration when selecting

audit firm, this reseach would focus on manufacturing industy where the physical examiniation plays an inevitable role in the audit work.

Since there are numerous audit firms operating in the audit market, the non-Big Four audit firms are assumed to be an individual audit firm which provides the same audit service to the client. Table 2.2 shows the average market share of each audit firm (Big Four and Non-Big Four) using the audit fee and the number of clients (Francis et al., 2005; Knechel et al., 2007). The market is concentrated, while defining the market share by audit fee where Big Four audit firms earn more than 95% of the audit fee in the market. However, considering the number of clients each audit firm has, Non-Big Four audit firms have a larger market share.

From the prior research on audit fee determinants, the client size is significantly positively related to the audit fee (Huang et al., 2016). Thus, the size of the audit clients that Non-Big Four audit firms own is relatively small in the manufacturing industry. In addition, by examining the market share calculated by audit fee, PwC, who has more than 35% of the market share, is the lead auditor in the manufacturing industry in the U.S.

Since this research intends to examine the preferences of the individual audit client, the sample uses the year 2011 as the base year to collect 1284 manufacturing companies in the U.S. for five years to avoid the problem of identification during the estimation. Table 2.3 shows the descriptive statistics for all the 6420 actual choices in the study, excluding the predicted audit fee which is not observable to the researchers.

Table 2.2   Market Share of Audit Firms in the U.S. Manufacturing Industry (2011-2015)

Audit Firm	Audit Fee	Number of Clients
PricewaterhouseCoopers LLP (PwC)	37.74%	20.66%
Ernst & Young LLP (E&Y)	24.70%	24.17%
Deloitte & Touche LLP (Deloitte)	15.87%	12.49%
KPMG LLP (KPMG)	17.24%	13.02%
Non-Big Four Audit Firms	4.45%	29.66%

The summary statistics show that the clients in the sample include the company which holds $717,242,000 thousands of total assets to the company not owning total assets in the current year. The sample does not rule out the companies with a financial problem or go bankrupt because they are still publicly listed companies and need the audited reports periodically. Owing to their varied

characteristics, each company is expected to have different considerations when choosing the audit firm. Thus, the random coefficient applied in the utility model could examine the individual preference based on different companies' attributes. However, in order to examine the auditor choice, the sample used in the estimation is expended four times the actual choice than the original sample to include the choice available to the client. Therefore, the ultimate data in this research would include 38520 observations.

Table 2.3   Descriptive Statistics for the Audit Clients in U.S Manufacturing Industry (2011-2015)

Variable	Mean	Standard Deviation	Minimum	Maximum
Audit Fee(US Dollar)	2,872,466	5,836,842	10,000	87,100,000
Total Assets(thousands)	7,238,711	30,904,912	0	717,242,000
Sales (thousands)	5,554,497	23,012,997	-5,087	475,793,482
Inventory Turnover	7.10	41.68	-5.24	2064
Current Ratio	3.61	3.89	0	82.56
Restatement	0.09517	0.29	0	1
COGS to Sales	218.31	3,667.52	-0.51	157,838.89
EPS	1.29	2.74	-18.14	94.94

Table 2.4 presents the posterior mean of the estimation from the utility model. The mean of the coefficients shows that the audit client prefers non-Big Four when only considering the brand name. In view of the great reputation possessed by Big Four audit firms, they may charge a higher audit fee than the others and their clients may have less bargaining power when negotiating. However, this study focuses on the manufacturing industry, where the utility model includes the variables that are believed to be the concern of the manufacturing company. Thus, the model includes the total sales and inventory turnover of the audit client to examine whether the client's characteristics will have an impact on the utility.

For manufacturing companies, the role of efficiency is vital in their operations. Since it may take a lot of time for auditors to do the physical examination including the inventory examination, the audit client may tend to choose the one with a specialisation or a higher level of efficiency to ensure that the inspection will not affect the usual business operations. The results of the interaction term show the additional effect of the preference of the Big Four when the audit clients consider their own situation.

The coefficients of the interaction between Big Four and sales are all positive with PwC 1.607, E&Y 0.703, Deloitte 0.016 and KPMG 0.757. This demonstrates that the audit client with higher sales tends to choose the Big Four. Larger companies are more likely to have higher sales volume and are the leader of the industry. They are more likely to hire an audit firm which has a reputation in order to improve their credibility to stakeholders, including the suppliers and retailers.

On the other hand, the coefficients between the Big Four and inventory turnover are varied. The audit client is inclined to have a significantly positive preference to PwC with 0.540 when its inventory turnover is higher but have a negative effect on its utility when the audit firms are Deloitte and KPMG. From the descriptive statistics of market share, PwC comes out as the leading audit firm in the manufacturing industry and the audit client may consider it as the specialist in this area. Owing to the economies of scale, the specialist may invest in more advanced technology in the industry and will conduct the audit work more efficiently. The audit clients who have a higher inventory turnover may consider specialisation important because the specialised auditors are more likely to discover fraud or inventory theft during the examination with their knowledge.

For the variable w_{ijt}, which equal to one if the auditor is not the incumbent auditor, the result of the estimation shows that the audit clients have a negative preference for changing auditors, with the posterior mean of -7.469 and variance of 3.137. Consistent with the previous research that the audit firm and the client will incur transaction cost when switching auditor (e.g. DeAngelo, 1981; Chu et al., 2018), the client may prefer not to change audit firm. In addition, the research has the similar result of Gerakos and Syverson (2015) where the mean estimation of the preference to audit fee is negatively associated with the audit clients' selection, demonstrating that the most of the audit clients are still reluctant to pay a higher price.

The difference between this research and the existing literature about auditor selection is that this research allows for customer's heterogeneity in the utility model. Instead of considering the fixed coefficient, this estimation allows the audit client to have different preferences for each attribute. Table 2.5 shows the covariance matrix Σ_β to capture the heterogeneity among the audit clients. The diagonal elements in the matrix are the variance of each random coefficient.

The results here show that there are significantly diverse preferences among the audit clients. It is not surprising to see that client have different priority when choosing amongst the Big Four and non-Big Four audit firms. The previous literature shows that the company with certain characteristic may prefer the Big Four since they have a relatively great reputation than the others (e.g. Pittman and Fortin, 2004). As for considering the event of switching the auditor, the variance of the coefficient is only 3.13, which is relatively small compared to the mean effect -7.49, showing that most of the audit clients are reluctant to change the auditors.

The results here are consistent with the transaction cost proposed by DeAngelo's (1981) multi-period pricing model and the study of Chu et al. (2018). However, the result of the preference for price indicates that the audit clients in the industry have very diverse opinions regarding the audit fee when selecting the audit firm. As mentioned before, previous literature and the result of the fixed effect show that the clients tend to choose the one with lower price. Nevertheless, by allowing the heterogeneity among the audit clients, the research shows that even though the mean effect is 0.929, the variance of the preference among all clients is 17.810, indicating that not all the client prefer low price when choosing the audit firm.

Some clients may view a high audit fee as the signal of a better audit quality and will therefore be willing to pay higher price to have a high-quality audit. Thus, the assumption that the audit service is not homogenous in the framework is applicable because it is possible that the client would be willing to pay higher audit fee to obtain a better audit service and receive better audit quality.

In this framework, the discrete choice model with the random utility is applied to capture the preference of the audit client for selecting audit firms. From the results, not only might the mean effect of each variable be examined but the evidence of diversified preference among the audit clients could also be evaluated. The Bayesian approach adopted in the estimation procedure enables the estimation to obtain the coefficients of each audit client.

The outcome of the estimation shows that it is important to consider the individual preference in the audit market. Moreover, the counterfactual analysis will be able to examine the possible behaviour of each audit client when receiving a discounted offer.

Table 2.4 Posterior Mean of the Demand Estimation $\bar{\beta}$

Variable	Posterior Mean $\bar{\beta}$ (Standard Deviation)
$Intercept$	-0.49512209 (0.24433264)
PwC	-0.47915826 (0.24056484)
$E\&Y$	-0.48951513 (0.13138817)
$Deloitte$	-0.69563519 (0.11435612)
$KPMG$	-0.52597701 (0.17904018)
$PwC \times SALES\ (STD)$	1.60731945 (0.14951081)
$E\&Y \times SALES\ (STD)$	0.70276423 (0.16259089)
$Deloitte \times SALES\ (STD)$	0.01564519 (0.10588727)
$KPMG \times SALES\ (STD)$	0.75700108 (0.15714352)
$PwC \times INV\ TURN\ (STD)$	0.54013552 (0.13737098)
$E\&Y \times INV\ TURN\ (STD)$	0.18507765 (0.24940006)
$Deloitte \times INV\ TURN\ (STD)$	-2.06500149 (0.22562639)
$KPMG \times INV\ TURN\ (STD)$	-0.29523274 (0.11615065)
$Switching$	-7.46859532 (0.09679124)
$Audit\ Fee\_Log$	-0.92942584 (0.18020757)

Table 2.5 Posterior Mean of Covariance Matrix Σ_β

Variable	Intercept	PwC	E&Y	Deloitte	KPMG	PwC × SALES (STD)	E&Y × SALES (STD)	Deloitte × SALES (STD)	KPMG × SALES (STD)	PwC × INVTURN (STD)	E&Y × INVTURN (STD)	Deloitte × INVTURN (STD)	KPMG × INVTURN (STD)	Switch	Audit Fee _Log
Intercept	4.7365 (0.6869)														
PwC	0.6320 (0.4696)	7.1872 (0.8801)													
E&Y	1.0506 (0.6325)	3.3085 (0.6195)	3.4023 (0.3109)												
Deloitte	1.2828 (0.3706)	4.2665 (0.8455)	2.4422 (0.4536)	4.5513 (0.7806)											
KPMG	-0.1643 (0.5474)	1.8601 (0.4442)	0.5735 (0.4341)	1.3476 (0.3502)	2.1923 (0.3601)										
PwC × SALES (STD)	0.9685 (0.6096)	-1.0064 (0.5691)	-0.4034 (0.4649)	0.0682 (0.4132)	-0.1129 (0.2112)	2.3769 (0.4499)									
E&Y × SALES (STD)	-0.8919 (0.6618)	-2.5998 (0.3610)	-1.8135 (0.3005)	-1.5260 (0.2789)	-0.3668 (0.3991)	0.9245 (0.4643)	2.6192 (0.7059)								
Deloitte × SALES (STD)	0.3955 (0.2884)	-0.0675 (0.7984)	-0.2103 (0.3338)	0.3057 (0.2330)	0.4552 (0.3545)	0.1259 (0.2486)	0.1636 (0.2859)	1.9729 (0.3029)							
KPMG × SALES (STD)	0.3088 (0.4453)	-1.9699 (0.4937)	-0.9633 (0.6385)	-1.4881 (0.6860)	-0.4935 (0.4540)	0.8482 (0.6504)	0.7047 (0.5045)	-0.4241 (0.3668)	3.0394 (0.9540)						
PwC × INVTURN (STD)	0.4980 (0.3643)	-0.6573 (0.3139)	0.2748 (0.4575)	-0.2875 (0.5478)	-0.7065 (0.5073)	0.1759 (0.2493)	-0.2972 (0.3798)	-0.7938 (0.2090)	0.9922 (0.3551)	2.5495 (0.5382)					
E&Y × INVTURN (STD)	0.7574 (0.3012)	1.0048 (0.4796)	0.5175 (0.2426)	0.9772 (0.3986)	0.4314 (0.3611)	-0.2001 (0.4560)	-0.5085 (0.2228)	0.4916 (0.3708)	-0.1025 (0.2440)	-0.2425 (0.2691)	1.7002 (0.3922)				

Variable	Intercept	PwC	E&Y	Deloitte	KPMG	PwC × SALES (STD)	E&Y × SALES (STD)	Deloitte × SALES (STD)	KPMG × SALES (STD)	PwC × INVTURN (STD)	E&Y × INVTURN (STD)	Deloitte × INVTURN (STD)	KPMG × INVTURN (STD)	Switch	Audit Fee _Log
Deloitte × INVTURN (STD)	2.5124 (0.8118)	1.1294 (0.6068)	1.4606 (0.4543)	1.8598 (0.5475)	-0.0676 (0.3500)	1.0871 (0.4956)	-0.6376 (0.3761)	-0.5935 (0.1586)	-0.0357 (0.4003)	1.2518 (0.3496)	0.3307 (0.4049)	3.8904 (1.1827)			
KPMG × INVTURN (STD)	-0.0432 (0.5044)	0.4233 (0.3881)	-0.1341 (0.4645)	0.2717 (0.5831)	0.4203 (0.2821)	-0.4267 (0.6674)	-0.1504 (0.5399)	0.7871 (0.3026)	-0.6841 (0.7861)	-0.5630 (0.2434)	0.3433 (0.2844)	-0.6527 (0.4430)	1.7006 (0.6510)		
Switching	-2.4349 (0.4857)	-0.7002 (1.3338)	-0.4340 (0.4005)	-1.3700 (0.4273)	-0.3095 (0.3948)	-1.2875 (0.3390)	-0.0442 (0.3070)	-0.4892 (0.2521)	-0.0759 (0.4852)	-0.0370 (0.3835)	-0.5692 (0.3139)	-1.8140 (0.6235)	0.1736 (0.2650)	3.1372 (0.4177)	
Audit Fee_Log	-1.9323 (0.8365)	-9.4464 (0.6325)	-6.3748 (0.4979)	-6.1668 (0.8433)	-2.1202 (0.7939)	1.7561 (1.1643)	4.6267 (0.6177)	0.9768 (0.8218)	2.6132 (1.2151)	0.0054 (0.8697)	-1.7437 (0.3816)	-2.9548 (1.0872)	0.3139 (0.8724)	1.1050 (0.6509)	17.8097 (1.4824)

2.6   Counterfactual Analysis

By applying utility model into auditor choice, this research is able to examine the preference of each client. With the result of the estimation from the previous section, this section intends to discuss the effect of fee discounting further, including how the client responds to the offer from the competing audit firms and whether the client would switch from the incumbent audit firm to the new one.

Following the similar concept of considering consumer surplus applied by Guo et al. (2017), the counterfactual analysis in this section calculates the utility difference of the actual choice and other available audit firms in the market. With this approach, the determination of how much an audit fee cut is necessary for each audit firm to have an audit client switch their audit firm. The utility for client i at period t could be compared with the following equation:

$$u_{ikt}(\beta_i, x_{it}, x_{kt}, p_{ikt}, w_{ikt}, \psi_{kt}) = \max_{p_{int}} u_{int}(\beta_i, x_{it}, x_{nt}, \boldsymbol{p_{int}}, w_{int}, \psi_{nt}) \qquad (2.12)$$

where k is the actual choice that audit client i makes in period t and n is the competing audit firm which would be willing to lower its fee for initial audit engagement to attract the new audit client. In the framework, the audit client is believed to have the highest utility for the actual choice of the audit firm. p_{int} is measured to be the new offered audit fee necessary for audit firm n to make the audit client i willing to change from the audit firm k to the audit firm n. For example, supposing that the audit client i has chosen audit firm k at period t, and by making the audit client has indifferent utility to consider the other audit firm n, the audit firm n will need to lower its price from the original price to p_{int}. Since the estimated parameters can be observed at the individual level, the counterfactual analysis of this research can examine every audit client's choice and discuss the possible reactions that each audit client might have.

The analysis in this section will only focus on the audit clients who hire the same audit firms from the previous year and investigate the level of the fee discount the competing audit firms should take in order to intrigue the audit client to change. By measuring all the available options for the audit client, the analysis is able to calculate the minimum fee discount for each audit firm in the audit market. Hence, in order to obtain the fee discount needed for each audit firm to the audit client, an approach similar to that applied by Gerakos and Syverson (2015) and Guo et al. (2017) is adopted to derive the utility for each audit client.

In the discrete choice framework, the consumer tends to choose the one with the highest utility; therefore, the estimated parameters could be implemented to the utility model, including the actual choice and other available audit firms. For the audit client i, a vector of the error term is drawn from type 1 extreme value distribution for each option available in the audit market, while the utilities for audit client i to every audit firms, including the incumbent and competing auditors, could be calculated respectively. With the random coefficient estimated in the previous estimation, the client's utility may be compared and the audit client can be said to have different behaviour when facing the fee discount offered by other auditors in the market.

However, it is possible that the same audit client may have different responses to different auditors because the utility model includes the factors of the audit firm and other interaction terms, even though the switching cost is the same for the client. From the results of the estimation, the client tends to choose the non-Big Four when it only considers the brand name, but the sales and inventory of each client will also affect the utility at a different level. Being that the audit client will only choose the audit firm who has the highest utility, the other audit firms will need to adjust their fees in order to make the utility indifferent or higher than the actual choice. With this assumption, p_{int} can be solved and the minimum fee discount for the audit firm n who has lower utility with respect to each audit client can be measured. Hence, in order to compare the price that the competing audit firms offered to the audit client, the percentage of estimated audit fee to the original audit fee can be calculated to examine the necessary percentage of fee discount.

To gain a better understanding of the effect of fee discounting to auditor switch, the sample is further categorised by the switching pattern and the percentage of fee discount needed. First, even though the framework assumes that Big Four audit firms provide heterogeneous service, they are categorised as a group when considering the switch pattern. Figure 2.1 depicts the switch pattern used in the following discussion, including the switching between Big Four auditors, such as switching from PwC to KPMG, switching from one of the Big Four to non-Big Four and switching from Big Four to non-Big Four audit firm. Being that all non-Big Four audit firms are viewed as an individual audit firm in the utility model, the discussion does not consider the circumstance that the audit client switch from the non-Big Four auditor to another non-Big Four auditor.

	Last Year/Incumbent		Competing
Switch 1	Big Four	→	Big Four
Switch 2	Big Four	→	Non-Big Four
Switch 3	Non-Big Four	→	Big Four
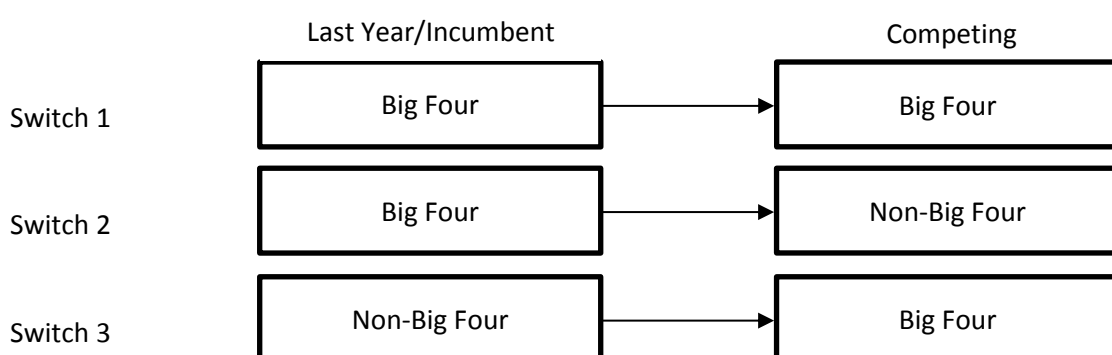
Figure 2.1   Switch Pattern

Second, by examining the necessary fee discount that competing audit firms need to offer, the results are categorised by the expected reaction that each audit client may have. The three classifications used to compare in the discussion are then the following: preferring higher price; willing to bargain; and being loyal. In the group "preferring higher price", the audit clients are inclined to choose the audit firm which offers the highest price, which is consistent with the estimation where the coefficient for the audit fee is positive.

The second group consists of the audit clients who have the willingness to bargain with the audit firms for a favourable audit fee. Assuming that there are no boundary or limitation for the competing audit firms to offer the price, the audit clients in this group are more likely to switch the audit firms if the audit fee is preferable to the audit client. In the analysis, it is worth noticing that there are some audit clients who are not willing to switch auditors unless the audit fee is nearly zero or even negative, which would be not applicable in any situation. The audit client behaves in such way as to be seen to perceive loyalty to its initial audit firm and not willing to switch auditors when receiving the discount offer.

In this section, the observation covers the audit clients who do not switch auditors from the previous year. The total sample consists of 6222 actual choice and 24888 counterfactual analysis for fee discount from the Big Four and non-Big Four audit firms. Table 2.6 shows the number of the sample included in each category.

Table 2.6 Outcomes for each Switch Pattern (Numbers of client and percentage)

	Big Four to Big Four (Switch 1)	Big Four to Non-Big Four (Switch 2)	Non-Big Four to Big Four (Switch 3)
Preferring Higher Price	3256 (24.76%)	1022 (23.32%)	1110 (15.09%)
Willing to Bargain	8819 (67.06%)	3047 (69.54%)	5457 (74.18%)
Being Loyal	1075 (8.17%)	313 (7.14%)	789 (10.73%)
Total	13150 (100%)	4382 (100%)	7356 (100%)

The results from Table 2.6 show that when the audit clients have the power to bargain with the audit firms, around 70% of the audit clients are willing to negotiate the price with competing auditors and switch to the new audit firms. It is consistent with the argument of the previous literature that considering the switching cost, the audit clients are more likely to make an auditor change if the fee discount is favourable. From the category of Switch 1 and Switch 2, where the initial audit firm belongs to the Big Four, a greater number of clients are more likely to accept higher price, which may be because they believe that the audit firms who charge for higher audit fee would provide better audit quality.

In contrast, the audit clients who hire non-Big Four auditors in the previous year are more likely not to switch the audit firm easily or willing to switch if the price offered is acceptable. As discussed in the previous section, most audit clients owned by the non-Big Four audit firms are small. For the smaller firms, they may prefer a lower price and may not consider the audit quality or the reputation as the main consideration when choosing the audit firms. In addition, the smaller
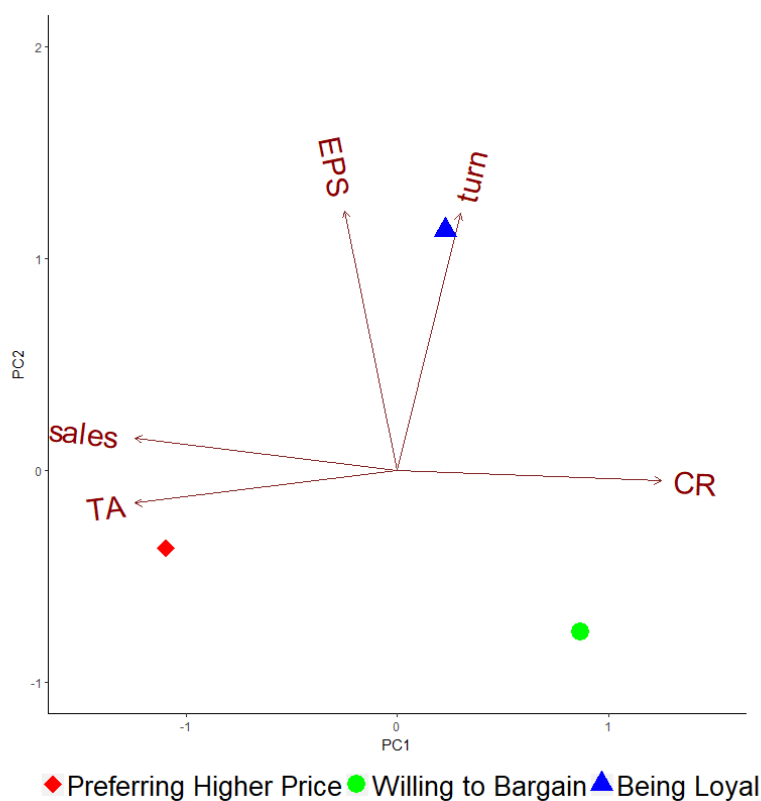
Figure 2.2   Results of Principal Component Analysis with All samples

company may have higher loyalty to its auditor. It is possible that the auditor and the client have built a long-term relationship and the switching cost will be much higher if the audit client wants to switch the auditor.

To further examine if the audit clients in the certain group share the similar characteristics, the principal component analysis would be applied in the following analysis. The principal component

analysis would enable me to inspect the relationship between the client's behaviour and the characteristics of each client. The concept of the method is to apply multivariate analyses to inspect the structure of the data by a set of variable, which is referred to as the principal component. With this approach, the association between loadings of each principal component could be examined, which is formed by weighted variables selected in the analysis, and the clients in each group.

The analysis will hence use total assets (TA), earnings per share (EPS), current ratio (CR), inventory turnover (turn) and total sales (sales) to study if there is any evidence in the audit clients' switching behaviour. The first investigation includes all the data in three switch patterns. Figure 2.2 displays the results for the principal component analysis while Table 2.7 shows the principal combination in the analysis. Instead of focusing on the value of loadings in each principal component, the highlight of the principal combination is to inspect the direction of each variable and to determine which variable stands out in the principal component. Table 2.8 indicates the mean of each variable in the three groups. Notice that all the variables in the analysis have been standardised with zero mean and a standard deviation set to one to compare each attribute in a more direct way. Thus, the results should be interpreted in relative scales instead of the initial value of the financial information.

Table 2.7   The Loadings of the Principal Component Analysis with All Samples (percentage)

Variable	PC1	PC2	PC3
Total Assets	0.5668058	-0.08964124	-0.7841359
Earnings Per Share	0.1134077	0.70443903	0.1649658
Current Ratio	-0.5708105	-0.02870271	-0.4671000
Inventory Turnover	-0.1360949	0.69805008	-0.3121227
Total Sales	0.5670304	0.08736328	0.2057401

Table 2.8   The Group Mean of each Variable in each Group with All Samples

	Total Assets	Earnings Per Share	Current Ratio	Inventory Turnover	Total Sales
Preferring Higher Price	0.31511	0.04219	-0.14573	-0.03731	0.26051
Willing to Bargain	-0.09669	-0.03315	0.04808	-0.02204	-0.08891

	Total Assets	Earnings Per Share	Current Ratio	Inventory Turnover	Total Sales
Being Loyal	-0.01052	0.15940	-0.02192	0.28745	0.06245

It is clear in Figure 2.2 that three groups can be clearly classified by the principal component analysis. Although it is relatively difficult to interpret the loadings of the principal component in Table 2.7, the result still sheds light on the dominant attributes that each category has. In component one, the loadings on current ratio and inventory turnover are in the opposite directions to the other variables. The group "preferring higher price" is separated from the other two group with relatively low current ratio, inventory turnover and high total sales and total assets. The high loadings on inventory turnover and earnings per share in component two indicate that the group "being loyal" is expected to be significant for these two variables.

Concluded from the results of the first analysis, the audit clients who have bigger size or higher total sales are more likely to choose the audit firms with higher price. The results show that the group "preferring higher price" includes the large firms with the standardized mean of 0.31 of total assets and total sales of 0.26. This is consistent with the previous argument that the larger companies may consider that the higher audit fee represents higher audit quality. The big companies may then consider that paying a higher audit fee is a positive signal to their stakeholders that they take audit quality seriously and the auditor may take more caution when seeking fraud and misconduct in the business.

In the second group of the audit clients who are willing to bargain with the competing auditors, the result shows that they tend to have a significantly higher current ratio compared to the others. The companies which have higher current ratio are expected to have more capacity to pay back the short-term liability and have higher organizational slack. A good financial performance may help the audit client to have higher bargaining power with the auditors and it may not be willing to pay a higher price and decrease its available resource and jeopardise its financial condition in the company.

On the other hand, the clients who are loyal to their audit firm have an inventory turnover above average and high earnings per share with a standardised mean of 0.159 in the industry. Coherent with the argument in the previous section, the companies with high inventory turnover may consider that the efficiency of the auditors is the priority when selecting the audit firm. Since the incumbent auditor would be more familiar with the audit client, it is reasonable to presume that the efficiency of the audit firms will increase after the second engagement and thus make the audit client unwilling to change the audit firm.

In addition, the companies who have higher earnings per share may consider the relationship with the incumbent auditor is important. Owing to their high earnings per share, their goal is to present a good performance in order to attract investors. However, the switch between the auditors gives the market the wrong signal that the auditor has been changed owing to resignation or dismissal. Such reasons may prevent the audit client from switching the audit firms and staying with the incumbent audit firm.

Besides examining the overall sample, the following analysis further categorises the sample into three switch pattern, as shown in Figure 2.1, to investigate whether, as the incumbent or competing audit firms, the Big Four and non-Big Four would have an effect on the audit client's reaction to the fee discount.

Switch 1: Big Four to Big Four

Figure 2.3 and Table 2.9 present the results of the principal component analysis, while Table 2.10 shows the mean of each variable in each group when the audit client is switching from one of the Big Four audit firm to another Big Four audit firm. The analysis shows a similar result with the overall sample. The loading on the current ratio in component one is in an opposite direction to the others, which is able to differentiate the group "willing to bargain" from the other two groups.

The figure shows that the group "willing to bargain" has the distinct characteristics of the current ratio compared to the others as well. With the arrow of each variable, the group "willing to bargain" have high loadings on component one, which is high in current ratio but low in total assets and sales. In component two, the inventory turnover and earnings per share have high loadings in it, which amplifies the characteristics possessed by the group "being loyal". On the other hand, the group "preferring higher price" has a weaker association with component one and component two, making it stand out in the left corner of the figure.

The result shows that the group "preferring higher price" has slightly higher total assets, higher total sales and lower current ratio. Consistent with the argument before, the bigger companies focus on whether the audit firms could provide better audit quality and that paying a higher audit fee could present a better image and show to the public that they are trustworthy. Even though their short-term liquidity is relatively low, it would not prevent them from paying the high price since they may have a thorough financial plan.

Compared to the overall sample where the average size of this group is 0.315, the average size of the companies in the group "preferring higher price" are slightly bigger with the standardised mean

of 0.568. Going by the descriptive statistics of the market share, the bigger companies tend to choose Big Four as their auditor to have good audit quality and gain reputation. Therefore, it is plausible that the clients in this group are bigger.

With regard to the group "willing to bargain", the companies have a relatively high current ratio and their sizes are relatively small compared to the other two groups. Being that they have a better capability of liquidity and more organizational slack, they may consider maintaining its financial condition and searching for the lower price in the market-place. In addition, since they are relatively small, they may care less about the public response and may not therefore consider switching will send out the bad signal to their stakeholders.

For the group "being loyal", the group mean shows that the companies are only slightly smaller than the group "preferring higher price". However, what differentiates this group is that they have higher EPS and inventory turnover than others, similar to the effect with the overall sample. It shows that this type of audit client cares more about how the effect of switching will bring (and normally the bad one) and the efficiency the incumbent auditor could have compared to the new ones.

However, compared to the overall sample, this group in Switch 1 tends to have higher sales and total assets. This indicates that besides considering the size of the audit clients, if the audit clients are large but also have high inventory turnover and earnings per share, then they might still believe that switching will jeopardise their reputation or the new engagement will cause inconvenience when the auditors perform their examination of the physical inventory.

Figure 2.3   Results of Principal Component Analysis with Switch 1

Table 2.9   The Loadings of the Principal Component Analysis with Switch 1 (percentage)

Variable	PC1	PC2	PC3
Total Assets	0.5357353	-0.2497564	0.4281513
Earnings Per Share	0.2286238	0.6585264	-0.3745660
Current Ratio	-0.5661360	0.0969384	0.6294476
Inventory Turnover	0.1491354	0.6936494	0.4642554
Total Sales	0.5638861	-0.1158371	0.2542624

Table 2.10   The Group Mean of each Variable in each Group with Switch 1

	Total Assets	Earnings Per Share	Current Ratio	Inventory Turnover	Total Sales
Preferring Higher Price	0.56830	0.12491	-0.22238	-0.03392	0.35879
Willing to Bargain	0.27580	0.08257	-0.03578	-0.02112	-0.01432
Being Loyal	0.40473	0.39557	-0.15373	0.46235	0.21276

Switch 2: Big Four to Non-Big Four

The second sample for the Switch 2 includes the audit client who hires the Big Four in the previous year, while the competing auditor in the current year is non-Big Four. The audit clients from Switch 2 are the same as the audit clients in Switch 1 because the incumbent auditors of the clients are Big Four audit firms, but the analysis differentiates two samples based on the competing audit firms. Figure 2.4 and Table 2.11 illustrate the principal component analysis of this sample, while Table 2.12 shows the average of each characteristic in each group.

The outcomes show similar results as for Switch 1. It indicates that even though the audit clients have different preferences for the auditor, their reaction is just the same regarding the fee discount offered by different auditors. The loadings on the current ratio in component one have the opposite direction with other variables, showing that the current ratio can be viewed as the main consideration for switching audit firms. Thus, component two includes high loadings on earnings per share and inventory turnover, which differentiates the group "being loyal" from the group "preferring higher price".

The results from the group mean show similar outcomes as the previous switch pattern. In this analysis, the group "being loyal" has a higher weight on component two, representing that most of the audit clients in this group have higher EPS and inventory turnover. However, the average of total assets and total sales of this group are close to the group "preferring higher price". Considering the size of the company, the result is slightly different since the means of total assets and total sales of both groups are higher than average, showing that the big companies would have inconsistent reactions when the competing audit firm is non-Big Four. This suggests that even though big companies with large sales may consider the audit quality as one of their critical concerns and would be willing to pay higher audit fee, when their earnings per share and inventory turnover are much higher than the companies in the same industries, they tend to maintain their current

advantages and keep their allegiance to their initial auditors. Different from the other big companies requesting for higher audit quality, the companies in the group focus on the efficiency of the physical examination of inventory and therefore would prefer the same audit firm to provide the audit service.

On the other hand, if they care more about the stock performance, they would prefer not to switch auditor to avoid speculation in the stock market. The attributes of the group "willing to bargain" is nearly the same as the sample in Switch 1, indicating that the audit clients who see the audit fee as the main concern have better financial performance. They choose the audit firms by the audit fee instead of whether the audit firm belongs to the Big Four or not.
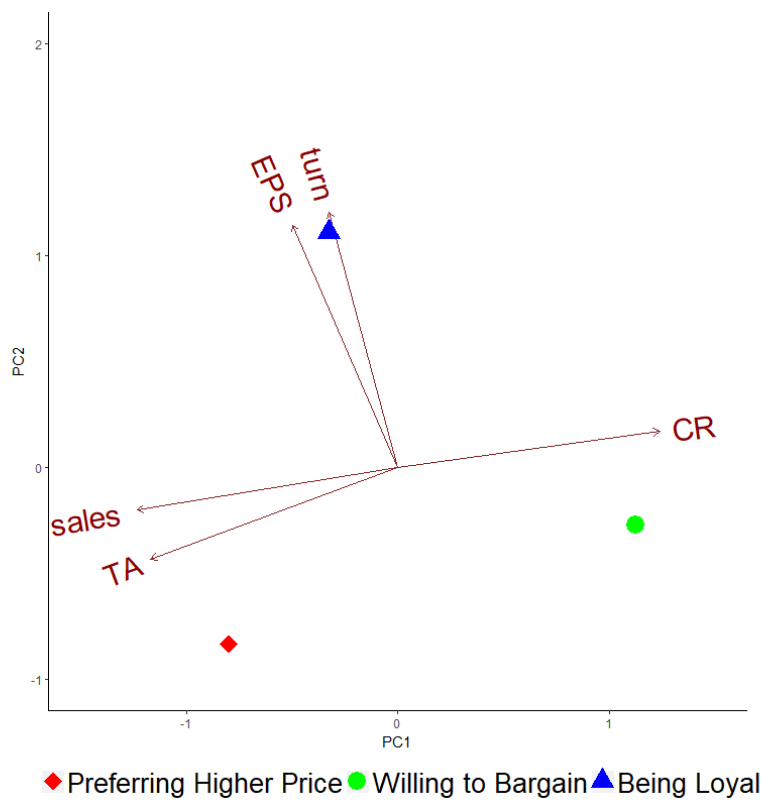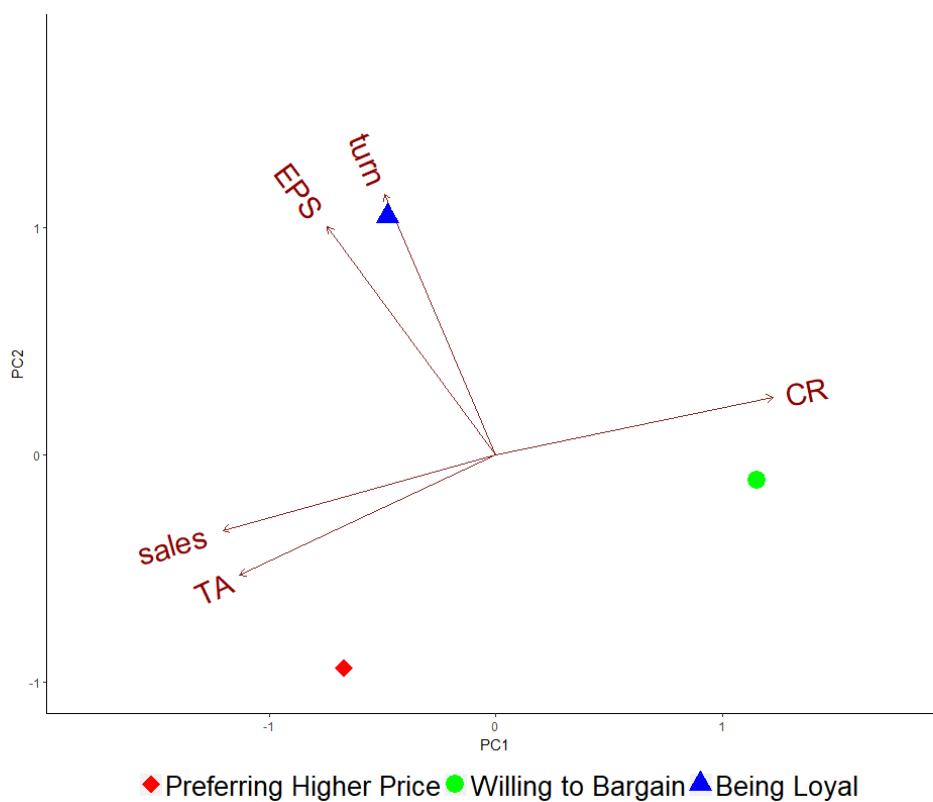

Figure 2.4   Results of Principal Component Analysis with Switch 2

Table 2.11   The Loadings of the Principal Component Analysis with Switch 2 (percentage)

Variable	PC1	PC2	PC3
Total Assets	0.5045780	-0.3186736	-0.0525726
Earnings Per Share	0.3320086	0.6015516	0.6914807
Current Ratio	-0.5460661	0.1515166	0.2810805

Variable	PC1	PC2	PC3
Inventory Turnover	0.2193751	0.6883636	-0.6413512
Total Sales	0.5374548	-0.1994520	0.1695667

Table 2.12   The Group Mean of each Variable in each Group with Switch 2

	Total Assets	Earnings Per Share	Current Ratio	Inventory Turnover	Total Sales
Preferring Higher Price	0.61834	0.15247	-0.23500	-0.03211	0.46513
Willing to Bargain	0.26419	0.07596	-0.03521	-0.01794	-0.04570
Being Loyal	0.43768	0.42543	-0.17454	0.49357	0.28037

Switch 3: Non-Big Four to Big Four

The third sample includes the audit clients that the non-Big Four audit firms own in the previous year because the framework in this research assumes that all non-Big Four audit firms provide homogenous audit service, while the auditor switch between the non-Big Four audit firms would not be discussed.

Figure 2.5 and Table 2.13 illustrate the outcomes of the principal component analysis. Compared to the previous figures, the results are different. In component one, the loadings on the total assets and total sales take opposite directions with the other variables, while Figure 2.5 also shows that the group "preferring high price" can be differentiated from the other two groups. As the second component consisting of high loadings on total assets and earnings per share, the figure shows that the group "being loyal" is of a bigger size with a better performance than the group "willing to bargain".

Table 2.14 shows the mean of each variable in this sample. Even though this switch pattern includes more audit clients because of their small size, it is difficult to find distinct characteristics that each group has. Following the result of the principal component analysis, the companies in the group "preferring higher price" have more total assets while their market shares are relatively large compared to the others under this switch pattern. However, the mean of both variables is under 0, indicating that the assets and sales they have are still under average. Since the companies have larger sales, it may represent that the companies are expanding or growing and they would consider

paying more audit fee to help the companies to obtain better audit quality, while the auditor from the Big Four may be able to detect fraud or increase the efficiency of the operation.

Similar to the previous result, the group "willing to bargain" in this sample has the mean current ratio of 0.23, which is above average and higher than other groups in this sample. However, different from the other two samples, the small audit client who has a relatively high inventory turnover would be willing to negotiate the price with the Big Four auditors rather than retaining the same auditor. This shows that besides having apprehension with financial performance and maintaining the operational slack, the small companies with a better inventory turnover rate would like to see if the Big Four audit firms can provide a better service when considering the audit fee. Moreover, since Big Four audit firms usually have a standard procedure to perform the physical examination, the audit clients may consider it of benefit if they can increase the efficiency of the inventory check with the reasonable price.

The characteristics of the group "being loyal" are not as distinct as others. As discussed before, the smaller audit clients would prefer to stay loyal with the non-Big Four auditors because they have built a long-term relationship and the switching cost will be higher if they want to change to the Big-Four. Since they have relatively high earnings per share, they might be afraid that the auditor from Big Four would find deficiencies in the operation of the companies and therefore affect its performance if they decide to switch to the Big Four audit firms.

This section is aimed at discussing whether the fee discount would trigger the incentives for certain clients to switch auditors. From the counterfactual analysis, the data is categorised into three switch patterns and the analysis shows that the audit client would have different reactions with different audit firms. For the audit clients who hire Big-Four audit firms in the initial year, the bigger companies with higher sales are more likely to choose the one who provides a higher audit fee, whether the competing audit firms are from Big Four or not. The companies may take the audit quality and reputation as priority and believe that they can receive better audit quality by paying higher audit fee.

However, the smaller companies, especially the non-Big Four's clients, may not consider that paying higher price to Big Four to obtain better audit service is their main consideration when choosing the audit firm. In addition, the audit clients who have higher earnings per share are inclined to hire the same audit firms because they care more about their performance and may try to prevent bad news of dismissal or resignation in the stock market. Companies who hire the Big Four in the

previous year tend to sign a contract with the same audit firm again when they have a higher inventory turnover.

They may see the efficiency of the auditors performing year-end physical examination is the main consideration when choosing the audit firm and believe that Big Four could also provide a higher audit quality. The results of the group "willing to bargain" shows that the companies believe that they have the bargaining power to the competing audit firms and are therefore willing to switch the auditors if the price is desirable. However, besides the common attributes that the audit clients who have relatively high current ratio are more likely to bargain with the competing audit firms, the small companies who have high inventory turnover may also want to hire Big Four to increase the audit quality.

Even though there are certain attributes which might influence an auditor switch, different clients would have different reactions when facing a fee discount. By adopting the random utility model in the framework, this study has been able to focus research on every individual client rather the market as a whole.

Table 2.13   The Loadings of the Principal Component Analysis with Switch 3 (percentage)

	PC1	PC2	PC3
Total Assets	0.3994374	0.6867184	0.4506996
Earnings Per Share	-0.3906531	0.7198473	-0.5018898
Current Ratio	-0.4784470	0.0767237	0.7290395
Inventory Turnover	-0.4791675	-0.0354061	-0.0484821
Total Sales	0.4788809	0.0556555	-0.1054863

Table 2.14   The Group Mean of each Variable in each Group with Switch 3

	Total Assets	Earnings Per Share	Current Ratio	Inventory Turnover	Total Sales
Preferring Higher Price	-0.70674	-0.30200	0.161256	-0.05204	-0.21618
Willing to Bargain	-0.90017	-0.28110	0.230111	-0.02579	-0.23358
Being Loyal	-0.75409	-0.26791	0.218198	-0.03261	-0.22880
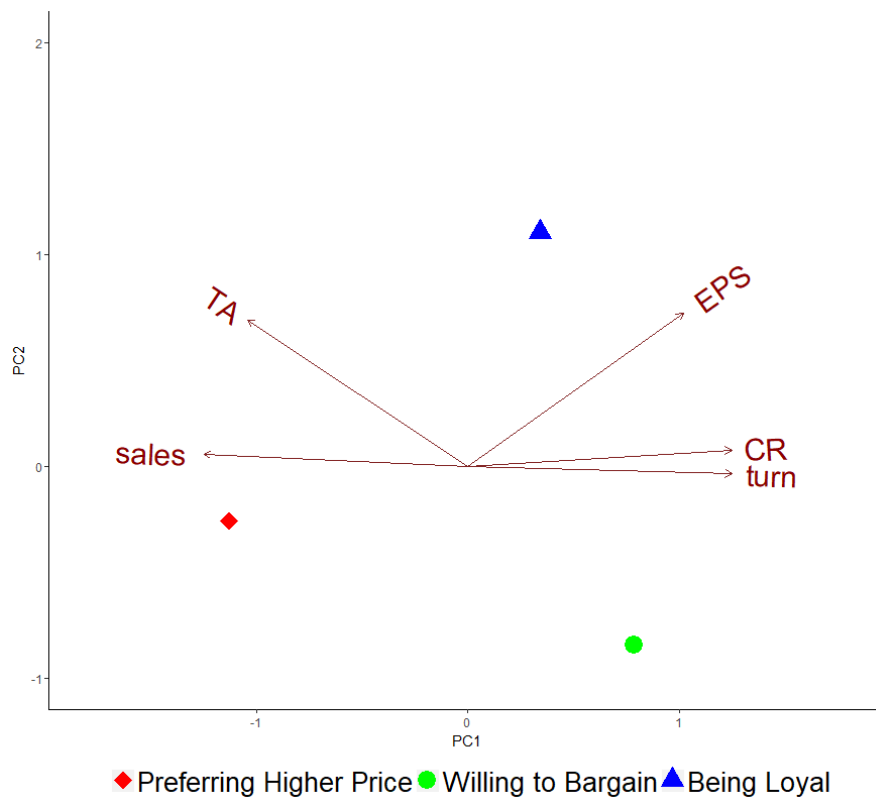
Figure 2.5   Results of Principal Component Analysis with Switch 3

2.7   Summary

This research has aimed to investigate the auditor choice in the U.S. manufacturing industry and to discuss how the audit fee discount could influence the auditor switch. The research applies the discrete choice model with the random utility to examine the auditor choice in the audit market. By allowing for heterogeneous preference among audit clients, the individual coefficients could be estimated instead of only the mean effect in the prior research.

The results show that the clients do not prefer to switch audit firms since this may incur switching cost. However, it is surprising to find that even though the mean effect of price is negatively

associated with the utility, which is similar to previous research, the variance of individual parameter shows that the audit clients have varied preferences for the price when choosing the audit firm. Therefore, the counterfactual analysis in this research further discusses the client behaviour of the auditor switch with the fee discount.

By imputing the coefficient that each client has and comparing the utility, the necessary fee discount that each competing audit firm need to offer to the audit client could be measured. In addition, principal component analysis has been applied to examine the reactions of the audit clients. The reactions of the audit client are categorised into three groups: preferring higher price, willing to bargain and being loyal.

By classifying the switch pattern into three samples, each group is found to possess different characteristics. The companies with large size and sales above average tend to look for high audit quality by paying a higher audit fee. Those who value operational performance with earnings per share will continue to hire the same auditor to prevent the wrong signal in the stock market. In each switch pattern, the clients who have relatively high current ratio would like to negotiate the price with the competing audit firms. These companies often have organisational slack and in seeing themselves as having good financial management, they could ask for the lower price to maintain the financial performance. However, there are different results for the audit clients from the Big Four and non-Big Four when considering the impact of inventory turnover. Companies who hire Big Four before are more likely to hire the same auditor since they believe the familiarity could enhance the efficiency of performing inventory examination. On the other hand, the companies who hire non-Big Four as the incumbent auditor would try to switch to Big Four if the offered price is acceptable because they believe one of the Big Four could provide high-quality audit and therefore to enhance the operation efficiency or detect any deficiency.

Regulators and legislators have raised concerns that lowballing could impair the auditor independence and may decrease the audit quality. However, past literature shows that an audit firm with the brand name, such as Big Four, could provide better audit quality compared to others. The results of this research show that besides considering the negative effect of switching, the audit client is willing to improve their performance by hiring different audit firm for better audit quality with a limited budget. Therefore, it is worth considering whether the fee discounting would only impose a negative effect on the audit market, or whether the reasonable fee discount offered by audit firms will encourage the audit client to switch the audit firm in order to enhance its performance. Hence, this study is believed to shed some lights on the issue of fee discounting and auditor switch by incorporating utility model into the audit market.

Chapter 3   Client Portfolio of the Audit Firm

3.1   Introduction

In the audit market, the audit firm is viewed as the supplier of the audit service while also serving as an independent role to detect material misstatements and fraud in the company. Compared to the suppliers in other industries, the audit firm is not only concerned about its profit but also its reputation (e.g. risk and professionalism) when accepting an audit engagement. The uncertainties of an audit engagement, including regulatory requirement, client dismissal and litigation risk, have been studied extensively in the existing literature. In addition, the auditor may initiate resignation because of the increasing audit risk of the client or limited resources (e.g. Rama and Read, 2006). However, instead of discussing factors influencing the client-auditor relationship, this research has aimed to examine the auditor utility and the client portfolio, which has been explored little in the field of auditing research.

Unlike other suppliers whose business aim is to maximise profits, the audit firm might need to assess the engagement between commercialism and professionalism (Gendorn, 2001). Traditionally, the objective of the supplier is to maximise its profit, either by selling more products or services to the customer or increase the price due to the limited quantiy provided. With similar concept, the audit firm is expected to provide service in return of the audit fee. However, because of the regulatory environment of the audit market, the audit firm is expected to reduce the agency problem between the audit client and the stakeholoders, where the profit may not be the only consideration since the audit firm would have to bear the risk of being sued by the stakeholders because of the negligence or the client's bankruptcy. Therefore, the audit firm may evaluate the uncertainty before bidding the prospective client. The past literature suggests that the expected utility (loss) function can be adopted properly considering the uncertain outcomes (Lewis, 1980; Crosby et al., 1986). Since the audit firm need to consider the trade-off between profit and the potential risk when providing audit service, the concept of profit maximisation may not be able to capture such trade-offs. Therefore, rather than focusing on the audit fee itself, this research applies the utility framework to examine the client-acceptance decisions of the audit firm.

Before accepting the audit engagement, the audit firm is expected to evaluate the risk of the engagement, including the audit risk and financial risk of the client. Most literature indicates that the audit firm is risk-averse because it would prefer to maintain its reputation and protect itself from litigation. However, there is a diversity of opinion amongst researchers about the client acceptance decision of the audit firm. First, the Big Four audit firms are viewed as the "deep pocket"

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so they may avoid accepting the client who is riskier (DeAngelo, 1981; Raghunandan and Rama, 1999). On the contrary, there is an argument that because of the large pool of clients, the Big Four is able to spread the risk through diversification and accept the client who has higher litigation risk. In such a case, the audit firm may assess the risk of the prospective client with the existing client portfolio (Simunic and Stein, 1990), indicating that the decision of client acceptance is made in accordance to other clients in the portfolio of the audit firm. Following a similar concept, this research adopts the utility function to examine the preference of the auditor for different clients.

The goal of the structural estimation in the framework is to estimate the parameters in the utility function of the audit firm. Hypotheses have been raised that different auditors may favour different types of client in a different level. Lewis (1980) conducts an experiment with auditors in different audit firms and suggests that the auditors in the same audit firm are more likely to pursue the same target. The audit firm is then expected to hire the auditors who possess similar traits and targets. Therefore, instead of considering the utility of each auditor, this research focuses on the audit firm that provides services to publicly listed companies. By allowing random coefficients in the utility model, the research findings will be able to determine the preference of each audit firm.

Since this research is aimed at investigating the optimal strategy of the audit firm, the sample includes all the audit firms which provide service to publicly listed companies in the U.S. manufacturing industry from the years 2011-2015. In addition, being that the study has aimed to measure the preference of the individual audit firm with the random coefficient, the research chooses to focus on six individual audit firms, including Big Four audit firms (PricewaterhouseCoopers LLP, Ernst & Young LLP, Deloitte LLP and KPMG LLP), Grant Thornton LLP and BDO USA LLP, due to the large numbers of the audit firm conducting audit services in the audit market. Hence, in following the structural estimation framework proposed by Kim et al. (2002), the research allows heterogeneity among the audit firms in the market. The estimation procedure is conducted with the Bayesian approach where, the Metropolis-Hasting algorithm allows the estimation process to estimate the random coefficient in the utility model and the problem of normal distribution without closed form could be solved by GHK simulator.

The result of the estimation shows the mean of the parameters in the utility function first. Compared to the smallest clients, the audit firms in the audit market are more likely to choose the clients who are slightly larger, but not the companies whose sales are above average. However, the covariance for the random coefficient in the utility models is significant, showing that the preferences of the audit firms are diverse. It strengthens the justification of allowing heterogeneity among audit firms since the outcome suggests that the impact on each audit firms may be varied.

Therefore, besides analysing the parameters in the utility model, the research further discusses the change of optimal strategy to each audit firm when the cost of auditing rises. The analysis uses the individual coefficient so, by applying nonlinear programming under limited budget constraints, the differences can be obtained by the percentage of the change in each category of the client. From the results of the individual coefficient in the utility model, Big Four and the other two medium audit firms chosen in this research have diverse preferences with mean effect.

Moreover, it is surprising that even the Big Four audit firms, which own most of the market share in the industry, have different optimal choices when providing services to different clients. By assuming the rise of cost, the empirical analysis in this research finds that PwC, which earns most audit fee in the manufacturing industry, is more likely to maintain the auditor-client relationship with companies with higher sales in order to be considered as the specialist in providing the audit service among manufacturing companies.

On the other hand, Ernst & Young owns most of the clients in the manufacturing industry. Rather than focusing on the large company as PwC, the strategy of Ernst & Young is to achieve economies of scope, where it provides services to all the clients more equally. With such a strategy, the analysis finds that when the cost of auditing rises, E&Y tends to consider all sizes of clients and seeks to maximise its utility by providing as many clients as possible under a limited budget and the rising cost.

Moreover, the medium audit firms show different tendencies for the optimal choice of the client portfolio. Since the medium audit firms do not have as much budget as the Big Four, they would not consider providing the audit service to companies with large sales and the complex environment because the engagement may deter the audit firm to provide services to other clients due to limited resources. The estimation of the individual coefficient and empirical analysis of rising costs show that compared to Big Four, these audit firms are more likely to provide services to the companies with sales under average.

The audit firm may intend to audit as many as clients, especially to small companies, to build a long-term auditor-client relationship. Even though the two medium audit firms chosen in this research have similar amounts of clients in the manufacturing industry, the market share based on audit fee is varied. Grant Thornton earns more audit fees compared to BDO USA, showing that instead of focusing on companies with less sales, GT does consider auditing large companies. Being that the marginal utility for GT providing to different categories of clients is relatively close, the optimal choice for client portfolio is not as evident as other audit firms which tends to decline the specific engagement.

With regard to BDO USA, which is believed to be similar as other small audit firms in the market, the audit firm prefers to provide service to small clients and aims to maximise its utility by having more clients. The empirical analysis also suggests that BDO is more willing to decline engagement with large clients and increase the number of small clients audited under limited budget and rising costs.

Since there is little literature concerning the client portfolio of the audit firm, the analysis of the engagement strategy of the auditor is believed to be one of the main contributions of this research. Besides considering acceptance and resignation from a certain client, the research estimates the preference of the audit firms by assuming that the audit firm will maximise its utility while considering the risk, including client business risk and audit risk. Moreover, in order to capture the optimal strategy of the audit firms better, the framework incorporates the satiation parameter, which represents the diminishing marginal utility and considers budget constraints in the utility function.

The framework in this research is believed to be the first to discuss the audit firm strategy of engagement in such a comprehensive way. Instead of categorising the audit firms as Big Four and non-Big Four, the utility function adopted in the framework allows heterogeneity among audit firms, which is much alike the actual audit environment where audit firm may consider its ability to provide the audit service based on its specialty and budget. By adopting the Bayesian approach and allowing random coefficient in the structural estimation of the client portfolio, this study is believed to shed more light on applying the advanced approach to discuss the supply side in the audit market.

The research in this chapter is structured as follows. Section 3.2 reviews the existing literature on the auditor utility and client portfolio of the audit firm. The utility model and the procedure of structural estimation are developed in Section 3.3, while Section 3.4 shows the procedure and assumption for the estimation, including the methods and the assumed priors in the estimation process. The sample of the research and the results of the parameter are presented in Section 3.5. With the estimated coefficient, Section 3.6 discusses the possible change of optimal choice for audit firm with rising costs. The detailed procedure of the Bayesian approach adopted in the estimation is then illustrated in Appendix B.

3.2   Related Literature

This research is aimed to adopt the concept of utility maximisation to discuss the optimal selection for the audit firm. The research estimates the parameters in the utility function first and further discusses how the audit firm will react if the cost of auditing rises.

In the conventional marketing research, the supplier decides the number of quantities to produce and sell to maximise its profit, which is referred to as the theory of production. On the other hand, utility maximisation is often used to examine the consumer purchasing behaviour. In the audit market, even though the audit firm is perceived as the supplier who provides audit service and agrees in return of the audit fee, the literature suggests that the audit firm faces uncertainty in the auditor's choice (Crosby et al., 1986).

During the auditing engagement, the auditor is expected to decide to which client the service should be provided and whether to end the engagement. After the U.S. passed Sarbanes-Oxley (SOX) in 2002, the audit firm is expected to be more conservative regarding the decision of retention and acceptance. The acceptance of the new client in the audit market means that the audit firm would offer to bid to provide audit service to the potential client (e.g. Huss and Jacobs, 1991).Gendron (2001) indicates that the client-acceptance decision consists of two aspects: professionalism and commercialism. The audit firm may face the dilemma while the potential client is considered to be profitable (commercialism), but the audit firm may deteriorate its reputation if the audit risk is high (professionalism). Besides considering the acceptance, Johnstone and Bedard (2004) examine the audit firm portfolio of clients and discuss the act of continuing or resigning for the existing client and accepting a new client.

Consistent with Gendron's (2001) research, researchers have suggested that the auditor would encounter different types of risk during an audit engagement, including litigation risk, audit risk and client's financial risk besides the audit fee (Huss and Jacobs, 1991; Johnstone and Bedard, 2004). While litigation risk is considered to be the major determinants of the auditor resignation, the study of Catanach, Irving, Williams and Walker (2011) shows that the business risk, which is defined as the probability of the company's continuance, will also influence audit firm's behaviour. Moreover, Ghosh and Tang conduct a comprehensive analysis on the *ex ante* risk factors and find that the audit firm would consider all risk factors and the litigation risk is considered as the most important determinants for auditor resignation. However, most research examine the client portfolio with respect to risk in linear

Since the auditor's decision would not be same as the suppliers in other industries where profit maximisation is the ultimate goal, this research propose to adopt additive utility function to

examine the audit firm's behaviour. Previous accounting literature has adopted loss (utility) function to examine the auditor's behaviour since there are several determinants that may affect the audit firm's decision. For instance, expected utility framework has been applied to investigate the auditor's professional judgement (Kinney, 1975; Lewis, 1980). However, concern has been raised because the utilities among auditors may differ. Since the auditor may pursuit different level of profit and reputation, a difference between audit firms is anticipated. Lewis (1980) conducts the experiment with auditors representing the Big 8[1] to examine their professional judgment and suggests that the auditors tend to have homogenous utilities when facing the material situation and the relationship is even more evident for the auditors in the same audit firm. Hence, in order to eliminate the individual difference in the audit firms, the audit firm would attempt to recruit the partner and staff who are able to impose the same utility function.

In addition, research has suggested that the selection process includes assessing the financial and audit risk of the potential client (Huss and Jacobs, 1991; Gendron, 2001). However, some studies argue that the audit firm would consider the risk of the prospective client along with the portfolio of the existing clients. Simunic and Stein (1990) suggest that the audit firm would measure the risk of an audit engagement with the client portfolio context instead of measuring in isolation.

As a consequence of the enactment of SOX 2002, the audit firms encounter the heavy burden of audit work with limited resources in order to fulfil the regulatory requirement (Rama and Read 2006; Nagy and Cenker, 2008). Rama and Read (2006) have discussed the possible reasons for the selection of the auditor. Due to the legislative requirement, the risk and the increasing cost of auditing after SOX period. The audit firm will attempt to reduce the likelihood of undesired regulation (Rama and Read, 2006).

On the other hand, owing to the exit of Enron and Anderson, the large audit firm, especially Big Four, have stronger incentive to protect its reputation. As encountering the rise of auditing cost with limited resource, the audit firm may consider dropping the client which is marginally profitable or relatively small. Rama and Read (2006) have compared the resignation of audit firms between 2001-2003, before and after SOX period, to find that the Big Four audit firms are more likely to resign from small clients in 2003. In regard to auditor resignation, most research focuses on factors influencing the auditor to resign from engagement. For example, Cenker and Nagy (2008) find the

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[1] Big 8 audit firms was made up of (1) Arthur Anderson, (2) Arthur Young & Co., (3) Coopers & Lybrand, (4) Ernst & Whinney, (5) Deloitte, Haskins & Sells, (6) KPMG, (7) Touche Ross, and (8) Price Waterhouse.

negative relation between auditor resignation and auditor industry specialisation when the audit firm is considered to be specialised on both local and national level.

3.3   Model Development

In this section, the utility model is introduced to examine the effect of the client portfolio, which could accommodate the assumption that the optimal choice for auditors could be to select more than one variety of clients. The framework follows the additive utility proposed by Kim et al. (2002) to examine the audit firm's strategy for supply. The framework here assumes that each auditor represents the overall audit firm. The utility model for each audit firm i ($i = 1, ... I \equiv \mathcal{L}(I)$) over the client j ($j = 1, ..., J \equiv \mathcal{L}(J)$) categories at time period t ($t = 1, ... T \equiv \mathcal{L}(T)$), is defined as: for $i \in \mathcal{L}(I), j \in \mathcal{L}(J), t \in \mathcal{L}(T)$,

$$U_{it} = \sum_j \varphi_{ij}(x_{ijt} + \gamma_j)^{\alpha_j} \tag{3.1}$$

$$\text{subject to} \sum_{j=1}^{J} p_{ijt}x_{ijt} \leq E_{it}$$

where x_j is the number of clients that audit firm i take, and φ_j, γ_j and α_j are the parameters in the utility function. As shown in the equation (3.1), the utility of each audit firm is a nonlinear and additive utility function, where the utility will be the sum from supplying each variety of audit client. Under such a framework, the restriction of restraining $\varphi_j > 0$ and $0 < \alpha_j \leq 1$ is imposed during the estimation. The reason for the restriction is that it is presumed the audit firm will benefit from offering service to the audit client, including monetary incentive and gaining reputation, and the satiation with more than one client can be captured by the diminishing marginal returns with a limited budget held by each audit firm.

In order to accommodate the circumstance that small audit firms may only consider offering the audit service to a specific category of clients, the utility function introduces γ_j to control translated utility function. If, there will be an interior solution and the audit firm is assumed to provide a service to at least one client in each category. On the other hand, if $\gamma > 0$, the optimal solution could be a corner solution, where the audit firm could choose not to offer service to a specific group of the client.

In addition, equation (3.1) can be adopted with different supply strategy. For example, the audit firm with the high budget would consider offering services to a wide range of clients, but a firm with a limited budget may consider providing the audit service to a specific category of clients to maximise its utility. On the other hand, φ_{ij} captures the preference of audit firm i to provide audit service to the variety of audit client j and α_j represents the rate of diminishing utility for the audit client j. If α_j is close to one, it is expected that the audit firm would provide numerous services to a specific group of clients instead of numerous varieties when the parameters of preference for the audit firm i to all varieties of the audit client, φ_{ij}, are merely the same.

For most of the marketing and economic research, the utility model is used to examine consumer purchasing behaviour, while researchers are able to define the product characteristics and price. However, this framework intends to measure the audit firm's utility as the combination of monetary incentive and other virtual motivation such as reputation. Even though the financial information and client's attributes can be observed through the public information, the model aims to examine whether the audit firm will adopt a different supply strategy considering the preference for each category of clients instead of a specific one. Therefore, following the approach used by Kim et al. (2002), the utility model will only be based on the number of clients to which the audit firm will consider providing services.

In order to estimate the parameter in the framework further, the marginal utility with the assumption of the error term is defined as:

$$\ln(u_{ij}) = \ln(\bar{u}_{ij}) + \varepsilon_{ij}, \text{where } \bar{u}_{ij} = \frac{\partial U_{it}}{\partial x_{jt}} \tag{3.2}$$

$$\varepsilon_{ij} \sim N(0,1) \tag{3.3}$$

where u_{ij} is the marginal utility for the audit firm i for providing audit service to the audit client category j and $\bar{u}_{ij}$ is the derivatives of the utility function in the equation (3.1) with respect to x_j. The reason for taking logarithm is to ensure that the marginal utility would be positive where the audit firm would be willing to provide more audit service with a limited budget. The error term ε_{ij} is assumed to follow a log-normal distribution with the identity covariance matrix. However, it would be valid to assume that the audit clients are related, especially in the same industries, but for simplicity's sake, the identity matrix will be applied in the estimation rather the full covariance matrix.

In the model, ε_{ij} in the equation (3.2) is viewed as the factor that the audit firm would know but cannot be observed by the researchers. In order to understand the supply strategy of each audit

firm, the audit firm's optimal strategy of providing service is defined as the auditor would attempt to maximise its utility. With the information of the audit cost p_{jt}, the audit firm's budget E_{it} and the assumption of the error term, the framework is able to be derived from the definition and the optimal choice x_{ijt}^* could be determined. However, as mentioned by Kim et al. (2002), there are technical concerns in the framework to obtain the distribution of the optimal solution (3.1).

Being that the additive utility function in the equation (3.1) is nonlinear and the distribution of the optimal solution x_{ijt}^* could not be observed, so the change-of-variable technique will be adopted during the estimation. (2) Thus, the distribution of the optimal solution may be mixed discrete-continuous since the corner solution where $x_{ijt}^* = 0$ is permitted in the framework.

In the setting, the audit firm would attempt to maximise its utility with a limited budget. Since the audit work involves human and technical resources, the total cost of audit work should be equal to or below the budget limit. Therefore, following the technique of solving the optimal solution, the Lagrangian with Kuhn-Tucker first-order condition is applied and could be written as

$$U_{it} - \lambda\left(P_{ijt}' X_{ijt} - E_{it}\right) \tag{3.4}$$

where P_{ijt} is a vector consisting of the service cost per client for each category, X_{ijt} represents the optimal choices for the audit firm where $X_{ijt} = [x_{i1t}^*, \dots x_{ijt}^*]$, and E_{it} is the budget the audit firm has for each period t. Second, the Kuhn-Tucker first-order condition could be derived by taking derivatives of the equation (3.4) with respect to X_{ijt} as follows:

$$\bar{u}_{ij} e^{\varepsilon_{ij}} - \lambda P_{ijt} \leq 0 \quad if\ X_{ijt}^* \geq 0 \tag{3.5}$$

and to illustrate more clearly, the equation (3.5) can be written as

$$\bar{u}_{ij} e^{\varepsilon_{ij}} - \lambda P_{ijt} = 0 \quad if\ X_{ijt}^* > 0 \tag{3.6}$$

$$\bar{u}_{ij} e^{\varepsilon_{ij}} - \lambda P_{ijt} < 0 \quad if\ X_{ijt}^* = 0 \tag{3.7}$$

Furthermore, the above equation (3.6) and (3.7) are divided by the fee P_{ijt} and takes the logarithm, and the equations can be rewritten as

$$V_{ij}\left(X_{ijt}^* \big| P_{ijt}\right) + \varepsilon_{ij} = \ln \lambda \quad if\ X_{ijt}^* > 0 \tag{3.8}$$

$$V_{ij}\left(X_{ijt}^* \big| P_{ijt}\right) + \varepsilon_{ij} < \ln \lambda \quad if\ X_{ijt}^* = 0 \tag{3.9}$$

where $V_{ij}\left(X_{ijt}^* \big| P_{ijt}\right) = \ln\left(\varphi_{ij}\alpha_j\left(X_{ijt}^* + \gamma_j\right)^{\alpha_j - 1}\right) - \ln(P_{ijt}) \quad j = 1, \dots k\ categories.$

Being that the budget constraint is introduced in the framework which limits the total number of clients that each audit firm can take, the problem of singularity may arise for the distribution of the optimal solution X_{ijt}^*. In order to solve the equation, Kim et al. (2002) manage to differentiate the first-order conditions with respect to a specific group of product and assume that this particular goods must be purchased. Therefore, the same technique has been applied in the framework by assuming that the audit firm would provide service to at least one group of the client and this assumption would not lose the generality of the research. Therefore, by subtracting the equation (3.3) and (3.4) from category one, which is $j = 1$, the equations can be written as:

$$\mu_{ij} = \pi_{ij}(X_{ijt}^*, P_{ijt}) \quad if X_{ijt}^* > 0 \tag{3.10}$$

$$\mu_{ij} < \pi_{ij}(X_{ijt}^*, P_{ijt}) \quad if X_{ijt}^* = 0 \tag{3.11}$$

where $\mu_{ij} = \varepsilon_{ij} - \varepsilon_{i1}$ and $\pi_{ij}(X_{ijt}^*, P_{ijt}) = V_{i1}(X_{i1t}^*|P_{i1t}) - V_{ij}(X_{ijt}^*|P_{ijt})$ with $j = 2, \dots k$ categories. In addition, assuming that ε follows a multivariate normal distribution with the identity covariance matrix Ω, and Ω is a $(k-1) \times (k-1)$ matrix with diagonal element $(i, i) = 2$ and off-diagonal element $(i, j) = 1$, the distribution of μ_{ij} in the equation (3.10) and (3.11) can be illustrated as:

$$\mu_{ij} \sim N(0, \Omega) \tag{3.12}$$

Hence, in order to calculate the probability of the audit firm's optimal solution X_{ijt}^*, the equation (3.10) and (3.11) will be derived respectively. From equation (3.10), when $X_{ijt}^* > 0, j = 2, \dots k \; categories$, the optimal choice for audit firm i is an interior solution, in which the audit firm provides services to all categories. In this case, the optimal solution in equation (3.10) is a nonlinear function and the distribution of the optimal solution X_{ijt}^* can be derived from μ_{ij} given by the multivariate normal distribution of ε in which $\mu_{ij} \sim N(0, \Omega)$. By applying the change-of-variable theorem, the Jacobian term for deriving distribution of X_{ijt}^* from μ_{ij} is as follows.

$$J_{ij} = \frac{\partial \pi_{ij+1}(X_{ij+1t}^*, P_{ij+1t})}{\partial X_{ij+1t}^*}, \quad i, j = 1, \dots k - 1 \tag{3.13}$$

Therefore, the distribution of optimal choice for audit firm i to provide audit service to all categories, in which the solution is interior for all categories is:

$$P_i(X_{ijt}^* > 0, j = 2, \dots k) = \phi(\pi_{i2}, \dots \pi_{ik}|0, \Omega)|J| \tag{3.14}$$

where the Jacobian term, $|J|$, is illustrated in the equation (3.13) and ϕ is the function for the normal density.

On the other hand, if the audit firm only chooses to provide services to one specific category, the optimal solution should be a corner solution, which can be defined as the equation (3.11) in which $X_{ijt}^* = 0, j = 2, \dots k$. For the clients whom the audit firm decides not to serve, the probabilities that the solutions of these categories are zero can be calculated by integrating the normal distribution of μ_{ij} with the appropriate region. Thus, the probabilities of a corner solution in which only one category is chosen is

$$P_i\left(X_{ijt}^* = 0, j = 2, \dots k\right) = \int_{-\infty}^{\pi_{ik}} \dots \int_{-\infty}^{\pi_{i2}} \phi(\mu_{i2}, \dots \mu_{ik}|0, \Omega)\, d\mu_{i2} \dots d\mu_{ik} . \qquad (3.15)$$

Given the circumstances that the audit firm may choose several groups of clients, but not all categories to provide the audit service, the distribution of optimal solution will have mixed a discrete-continuous distribution with the combination of scenarios corresponding to the equation (3.14) and (3.15) above. Therefore, the probability density function will have both a density component representing the categories of clients that the auditor chooses not to serve and the mass function corresponding the categories that auditor provides audit service to. The probability that n of k categories of audit clients are provided with audit services by audit firm i can be defined as

$$P_i(X_{irt}^* > 0 \ and \ X_{ist}^* = 0; r = 2, \dots n \ and \ s = n + 1, \dots k)$$

$$= \int_{-\infty}^{\pi_{ik}} \dots \int_{-\infty}^{\pi_{i(n+1)}} \phi\left(\pi_{i2}, \dots \pi_{in}, \mu_{i(n+1)}, \dots \mu_{ik}|0, \Omega\right) |J| d\mu_{i(n+1)} \dots d\mu_{ik} \qquad (3.16)$$

3.4   Statistical Specification

In this study, heterogeneity is allowed and examined in an auditor's utility model, in which the auditors could have different preferences for different types of clients when they consider providing services. The random utility model with coefficients dependent on the audit firm φ_{ij} are illustrated in the equation (3.1). From the previous section on the model development, in order to handle the problem of mixed discrete-continuous distribution, marginal utility for auditor i to the audit client j is derived and depicted in the equation (3.2). The marginal utility could be written as

$$\bar{u}_{ij} = \frac{\partial U_{it}}{\partial x_{jt}} = \varphi_{ij}\alpha_j(x_{ijt} + \gamma_j)^{\alpha_j - 1}. \qquad (3.17)$$

Thus, to estimate the parameter in a more direct way without encountering the problem of identification, the new coefficient β_{ij} and δ_j are introduced here and assumed to be $\beta_{ij} = \ln(\varphi_{ij}\alpha_j)$, which is unrestricted, and $\delta_j = \alpha_j - 1$, with the uniform distribution of $(-1,0)$ because

the satiation of each category of audit clients is assumed to be $0 < \alpha_j \leq 1$. In addition, the distribution of the random-effect to allow heterogeneity among auditors is assumed to be normal:

$$\beta_{ij} \sim N\left(\bar{\beta}_j, V_{\beta_j}\right) \tag{3.18}$$

where $\bar{\beta}_j$ is a vector specifying all the mean effect of the preference to all categories of clients and V_{β_j} is the covariance matrix for the random coefficient. To conduct the estimation, the Markov Chain Monte Carlo method with the Bayesian approach will be carried out to estimate the parameters and the estimated value would be derived from the hierarchical form for the prior distribution. To estimate the random coefficient for individual preference and the satiation for each category, the Metropolis algorithm with random walk approach would be applied.

The advantage of this approach is that instead of estimating the mean effect $\bar{\beta}_j$, the algorithm is able to examine and store the individual coefficient β_{ij} and to obtain the converged estimation by iterative sampling. The detailed procedure of the estimation are illustrated in the Appendix B.

However, during the estimation process, the distribution of mixed discrete-continuous form, as derived in the equation (3.16), could not be evaluated directly. To solve the problem, this research will follow the method applied by Kim et al. (2002) to transform the joint distribution into a continuous distribution in order to evaluate the likelihood. First, with the assumption made in the previous section that the audit firm chooses n of k categories of clients to provide services and the μ_{ij} in the equation (3.16), $\mu_i = (\mu_{i1}, \ldots, \mu_{ik})'$, could be decomposed into $\mu_i^a = (\mu_{i1}, \ldots, \mu_{in})'$ and $\mu_i^b = (\mu_{i(n+1)}, \ldots, \mu_{ik})'$. The multivariate normal distribution of μ_i^a and $\mu_i^b \mid \mu_i^a$ is shown as follows:

$$\begin{bmatrix} \mu_i^a \\ \mu_i^b \end{bmatrix} \sim MVN\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \Omega^{aa} & \Omega^{ab} \\ \Omega^{ba} & \Omega^{bb} \end{bmatrix}\right). \tag{3.19}$$

With the multivariate normal distribution illustrated in equation (3.19), the distribution of μ_i^a and $\mu_i^b \mid \mu_i^a$ can be defined respectively:

$$\mu_i^a \sim MVN(0, \Omega^{aa}) \tag{3.20}$$

$$\mu_i^b \mid \mu_i^a \sim MVN(\lambda_i, \Sigma_i) \tag{3.21}$$

where $\lambda_i = \Omega^{ba}\Omega^{aa-1}\mu_i^a$ and $\Sigma_i = \Omega^{bb} - \Omega^{ba}\Omega^{aa-1}\Omega^{ab}$.

Based on the equation (3.10), when there are interior solutions, $\mu_i^a = \pi_i^a = (\pi_{i1}, \ldots, \pi_{in})'$, and thus the probability of audit firm choice from the equation (3.16) will become:

$$P_i(X_{irt}^* > 0 \ and \ X_{ist}^* = 0; r = 2, \ldots n \ and \ s = n + 1, \ldots k)$$

$$= \phi(\pi_{i2}, \ldots, \pi_{in}) \int_{-\infty}^{\pi_{ik}} \ldots \int_{-\infty}^{\pi_{i(n+1)}} \phi_{\mu_i^b \mid \mu_i^a}(\mu_{i(n+1)}, \ldots \mu_{ik} \mid \lambda_i, \ \Sigma_i) |J| d\mu_{i(n+1)} \ldots d\mu_{ik} \qquad (3.22)$$

Being that the integral of the probability does not have a closed form with the assumption of μ_{ij} being distributed as a normal distribution, the estimation must be conducted through simulation. In the evaluation, in the Bayesian approach, the GHK simulator (Keane, 1994; Hajivassiliou et al., 1996) will be carried out to solve the problem of the integral form of multivariate normal distribution. The GHK method thus aims to construct importance sampling to draw the estimation from integral with univariate truncated normal distribution (Rossi, 2005).

3.5   Empirical Analysis

The sample in this research uses cross-sectional data of the publicly listed companies in the U.S. manufacturing industry from the year 2011-2015. From the annual reports of the companies, the public can find the audit firm that provides the audit service to the company. Unlike the prior research which only considers the difference between Big Four audit firms and non-Big Four audit firms, this research examines each auditor's utility individually.

In addition, instead of including all clients in the industry, the research intends to focus on manufacturing industry because the audit firm is believed to have various strategies to provide service to different industries and it would be better to focus on a specific industry to examine the auditors' action toward the audit client. The two-digits SIC code is used to classify the sample, while the auditor-client data can be extracted from the Audit Analytics database.

Table 3.1 shows the average market share of the audit firm. Following the existing literature, three indicators are used to measure the average market share that the audit firms hold, including audit fees, the numbers of clients and client sales. Besides considering the Big Four audit firms (PwC, E&Y, Deloitte and KPMG), the analysis also includes two medium audit firms, which is Grant Thornton and BDO, that have more than 50 audit clients and possess more clients than other small audit firms in the audit market. The number of clients is used as a benchmark because this research attempts to examine the number of clients to whom the audit firm would consider providing services.

The result of the average market share shows that the Big Four audit firms own the majority of the market share based on audit fee and clients' sales. However, more than 20% of the clients are received service from non-Big Four, if the criterion of market share is based on the number of clients. Following the prior research, companies with bigger size and higher sales tend to have a higher

audit fee. Therefore, it is presumed that the clients whom non-Big Four audit firms serve are smaller and have less sales in the industry.

Table 3.1   Average Market Share of each Audit Firm in the U.S. Manufacturing Industry (2011-2015)

Audit Firm	Audit Fee	Number of Clients	Sales
PricewaterhouseCoopers LLP (PwC)	37.74%	20.65%	43.57%
Ernst & Young LLP (E&Y)	24.70%	24.17%	21.37%
Deloitte & Touche LLP (Deloitte)	15.87%	12.49%	14.46%
KPMG LLP (KPMG)	17.24%	13.02%	19.23%
Grant Thornton LLP (GT)	1.71%	5.13%	0.61%
BDO USA LLP (BDO)	0.91%	4.63%	0.21%
Non-Big Four Audit Firms (167 firms)	1.83%	19.91%	0.55%

The aim of this research is to examine the auditor's utility based on different varieties of clients. The sample is further divided into five groups by the clients' total sales. For example, Client 1 includes the companies whose sales is the least 20% in the sample; Client 2 includes the companies whose sales ranked 60% to 80% in the manufacturing industry; the companies in Client 3 ranked 40% to 60% with their sales and the companies in Client 4 ranked 20% to 40% with their sales. The last group, Client 5 includes the companies which earn the most, ranked at top 20% in the sample. With such classification, the result is able to evaluate the preference of each audit firm for different categories of clients, which includes the group with less sales to the companies who have the higher market share in the industry.

Table 3.2 shows the percentage of the number of clients in five categories to the total number of clients that each audit firm provides service to. From the table, Big Four audit firms tend to provide service to the client who has higher sales. The percentage of the clients from Client 5 and Client 4 is around 25% each, which is consistent with the summary in Table 3.1. As the leading audit firm in the manufacturing industry, PwC has more clients with high market share classified in Client 5. However, the result shows that Ernst & Young may have a strategy distinct from others.

The last column of Table 3.2 shows the average number of clients that the audit firm have each year. Not only does E&Y have the most clients, instead of focusing on big clients, the percentage

for each category are closer to each other than other Big-Four audit firms. E&Y may attempt to reach as many clients as possible and earn a reputation from all scale of clients in the industry for economies of scope, instead of concentrating on specific groups for economies of scale.

On the other hand, compared to the Big-Four audit firms, the fifth and sixth audit firms tend to have completely different concerns about offering the audit service. In Table 3.1, small audit firms are more likely to have contracts with smaller clients, while these two audit firms also consider the second and the third quantile of the client pool as their main target client.

Table 3.2   Client Portfolio of each Audit Firm (2011-2015)

Audit Firm	Client 1	Client 2	Client 3	Client 4	Client 5	Average Number of Clients
PricewaterhouseCoopers LLP (PwC)	8.63%	10.06%	18.19%	28.62%	34.50%	267(100%)
Ernst & Young LLP (E&Y)	16.30%	16.35%	21.11%	24.01%	22.23%	312(100%)
Deloitte & Touche LLP (Deloitte)	7.34%	10.64%	23.66%	30.89%	27.47%	162(100%)
KPMG LLP (KPMG)	8.06%	17.44%	20.06%	24.60%	29.84%	166(100%)
Grant Thornton LLP (GT)	17.98%	35.44%	37.47%	6.84%	2.27%	66(100%)
BDO USA LLP (BDO)	33.63%	32.73%	26.73%	6.91%	0	56(100%)

The estimated coefficients are presented in Table 3.3 and Table 3.4. First, Table 3.3 shows the fixed coefficient of $\bar{\beta}_j = \ln(\varphi_{ij}\alpha_j)$ and $\delta_j = \alpha_j - 1$ in equation (3.17). The first two columns of Table 3.3 show the initial estimation of two parameters, where $\bar{\beta}_j$ represents the marginal utility of each client compared to the Client 1. The results of the audit firms show the highest marginal utility for Client 2 and the marginal utility for Client 1 is higher than the other groups of clients. After obtaining the estimated value of $\bar{\beta}_j$ and δ_j, the parameters in the model (3.1) can be calculated, which are shown in the last two columns of Table 3.3.

The result of $\overline{\varphi_j}$ shows that most of the audit firms prefer the smaller client, while the value decreases along with the clients' sales. Being that there are numerous audit firms in the market and their budget is not enough for them to provide service to the clients with higher sales, they may prefer to maximise its client pool and to audit as many as clients as possible. On the other hand, α_j

shows the curvature of each category of client. As the audit firms tend to provide service to more than two clients, or even more, the value of α_j indicates that the utility will not increase substantially when the auditor decides to provide one more client. The result shows that Client 5 has the greatest satiation among all clients, which is obvious that compared to other clients, the clients with higher sales are expected to have a higher audit fee and the leading position in the market may help bring auditors a significant reputation in the industry.

Table 3.3   Posterior Mean of Random Coefficients $\bar{\beta}_j$ and δ_j

	$\bar{\beta}_J$	δ_j	$\bar{\varphi}_J$	α_j
Client 1	0	-0.9915481	118.316838	0.0084519
		(0.0071815)		
Client 2	0.2960607	-0.9875834	108.286749	0.0124166
	(0.1522093)	(0.0113591)		
Client 3	-0.6377539	-0.9785758	24.6672995	0.0214242
	(0.320092)	(0.0225866)		
Client 4	-1.2725419	-0.9724274	10.1593182	0.0275726
	(0.4395336)	(0.0257539)		
Client 5	-3.2431324	-0.9133897	0.4507711	0.0866103
	(0.7619090)	(0.0670837)		

Table 3.4   Posterior Mean of Covariance Matrix V_{β_j}

	Client 2	Client 3	Client 4	Client 5
Client 2	2.244574			
	(0.575955)			
Client 3	2.667562	5.980243		
	(0.729455)	(1.428565)		

	Client 2	Client 3	Client 4	Client 5
Client 4	2.307076	5.211199	6.295101	
	(0.842298)	(1.400836)	(1.949434)	
Client 5	3.910411	8.984991	9.718945	17.941814
	(1.350551)	(2.354909)	(2.441017)	(4.918431)

However, according to Table 3.4, the covariance matrix of the random coefficients shows that there is substantial heterogeneity between the audit firms. As previously discussed, numerous audit firms provide a service to the clients in the industry and it is plausible that the audit firms of different scales will have varied preferences. Besides Grant Thornton and BDO USA, many audit firms only audit one or less than five publicly listed companies in the industry. On the contrary, Big Four audit firms provide more than one hundred clients each year and because of their resources, are more capable of auditing bigger companies since it may bring more benefit due to the economies of scale. As a consequence, it is not surprising to find that the variance of the random coefficients is large and this result can also suggest the future researchers should consider the audit firm individually rather than only examine the mean effect in the audit market.

3.6   Counterfactual Analysis

In the previous section, the results showed that there is significant heterogeneity between audit firms. Therefore, it may not be applicable to consider that the audit firms are the same and examine the audit firms' strategy of providing service. The advantage of applying the Bayesian approach with the random-walk algorithm to investigate individual data allows the analysis to examine the strategies of each audit firm further by evaluating their utility models. Despite there being 173 audit firms providing audit service in the sample, only the Big Four audit firms and the other medium audit firms (GT and BDO) will be discussed in this research.

The counterfactual analysis will examine how the change of the cost of audit work impacts upon the audit firm's choice. After the U.S. passed SOX in 2002, audit work was expected to increase and therefore, with the limited budget, audit firms may consider dropping the clients which are relatively unimportant or trivia to its operation and try to maintain the auditor-client relationship to the clients that they value most.

To run a counterfactual analysis to the sample, it is assumed that the cost of audit work will raise from P_{ijt} to $\boldsymbol{P}^*_{\boldsymbol{ijt}}$, and the total budget of each audit firm will remain the same. With the individual coefficient estimated in the previous section, the following equations can be solved by

nonlinear programming while the optimal number of clients that each audit firm is willing to audit could be estimated:

$$\max_{X^*_{ijt}} U_{ijt}\left(\varphi_{ijt}, X^*_{ijt}, \alpha_j, \boldsymbol{P^*_{ijt}}\right) \tag{3.23}$$

$$\text{subject to} \sum_{j=1}^{J} \boldsymbol{P^{*\prime}_{ijt}} X^*_{ijt} \leq E_{it}$$

Being the structure in this research could observe and estimate the actual choice and the optimal choice after the cost of audit work changing respectively, the difference between the audit firm's choices would be compared. First, the discussion starts with increasing the cost of audit work from 5 percent to 50 percent gradually, while the analysis focuses on increasing only one category of client. With such attempts, the analysis can distinguish whether the audit firm will maintain the relationship with the certain group of clients or switch to others when the cost rises.

Thus, by assuming that all costs of auditing in the industry rise, the optimal solution is expected to be different considering the satiation and the parameters in the utility model. In order to measure the change more precisely, the percentage of changes with each category of clients will be analysed instead of the change of client number. The adjustments of the audit firm's optimal choice are presented in Figures 3.1-3.6, including the Big Four audit firms and the two medium audit firms (Grant Thornton and BDO USA).

Table 3.5 shows the individual coefficient φ_{ij} in the utility model for the Big Four and medium audit firms (Grant Thornton and BDO USA) and Table 3.6 shows the parameters for marginal utility. The results of the random coefficients enable the research to examine the actions that may be taken by each audit firm rather than the market-based reactions. From the estimated outcomes, the individual coefficients are significantly different from the results of the mean effect in Table 3.3. Being that the sample in the research includes all small audit firms who have audited publicly listed companies in the manufacturing industry, the outcome is biased with large numbers of small audit firms.

With the Bayesian approach, this research could benefit from the advantages of the algorithm and retrieve individual parameters during the estimation. Hence, contrary to the mean coefficient, Big Four audit firms have the least value for Client 1 and tend to prefer Clients 3- Client 5, which are the companies with the highest sales. Hence, even though bigger companies may have higher litigation risk due to large numbers of stakeholders and complex structure of the corporate, the Big

Four prefer to provide service to larger companies in order to earn more profit and reputation in the industry.

The table shows that PwC and KPMG are more likely to choose Client 5, which has the highest value in the parameters. On the other hand, Ernst & Young and Deloitte favour Client 4 the most while Ernst & Young even favour Client 3 more than Client 5 in the utility model. The estimation is consistent with Table 3.2 where PwC and KPMG provide audit service to more clients in Client 5 more and the percentages of Client 4 in E&Y and Deloitte are higher than other categories.

Furthermore, Grant Thornton and BDO USA also show different preferences to the fixed effect. Since GT and BDO are considered to be medium audit firms which provide service to over 50 audit clients, the results are expected to be diverse with Big Four and other small audit firms. Even though the parameters between the two audit firms are slightly different, the coefficients toward Client 5 are lowest compared to Client 1. The reason may be that the audit firms do not have enough budget while the optimal strategy will be to provide an audit service to as many medium-sized clients as possible in the industry.

Table 3.5   Individual Coefficients for the Audit Firms φ_{ij}

	PwC	E&Y	Deloitte	KPMG	GT	BDO
Client 1	118.3168	118.3168	118.3168	118.3168	118.3168	118.3168
Client 2	197.9246	149.6195	140.9109	266.8796	315.1848	133.0350
Client 3	368.7595	257.2056	318.6446	333.3280	370.7772	99.9347
Client 4	657.1455	262.4978	483.0320	566.1715	126.7081	41.6198
Client 5	843.7994	190.5022	437.2571	686.6672	46.6877	2.0797

Table 3.6   Parameters for Marginal Utility β_{ij}

	PwC	E&Y	Deloitte	KPMG	GT	BDO
Client 1	0	0	0	0	0	0
Client 2	0.8991	0.6194	0.5594	1.1981	1.3644	0.5019
Client 3	2.0669	1.7077	1.9208	1.9659	2.0723	0.7613
Client 4	2.8970	1.9793	2.5891	2.7480	1.2510	0.1376
Client 5	4.2916	2.8033	3.6342	4.0855	1.3971	-1.7141

Figures 3.1-3.6 show the percentage of changes that the audit firm will make to each category of clients considering the rise in cost. First, Figure 3.1 shows how the changes in the cost will affect PwC's optimal choice. For example, the first graph shows that when the cost of auditing Client 1 rises from 5 percent to 50 percent, the percentage of clients that PwC is willing to drop or take compared to the original scenario. From the descriptive statistics, PwC is considered as the specialist auditor in the manufacturing industry with the largest market share based on the audit fee. In addition, PwC owns most of the clients from the category of Client 5, showing that PwC focuses on providing services to leading companies in the industry.

With the cost of Client 1 and Client 2 increasing, the outcomes show that PwC will attempt to maintain the relationship with Client 4 and Client 5 and so reduce the number of clients served in the other groups, especially for Client 1 and Client 3. It is reasonable to presume that PwC would choose to lose smaller clients since the audit firm aims to provide services for economies of scale, and it will therefore not be willing to drop the big companies if necessary.

However, besides economies of scale and providing audit service to larger clients, PwC may consider lowering the number of clients in Client 3 because it may try to make sure it has a certain level of reputation in each category. PwC would rather drop clients from Client 3, which it owns slightly more than the group Client 1 and Client 2, in order to keep serving the clients from Client 1 and Client 2 when the cost increases. Since the cost of audit work is relatively low in Client 1 and Client 2, changes to the optimal choice may not be significant.

From Figure 3.1, the optimal choices for the changes in the cost in Client 3 to Client 5 are different from the previous two scenarios. Even though PwC wants to maintain the client-auditor relationship with the companies in Client 5, it will not risk losing too many clients in other categories. Being that the audit firm is assumed to be risk averse because of the litigation risk, it may still consider providing services to as many clients as possible to ensure that the risk is minimised. Therefore, with regard to the changes in the cost of the other three categories, PwC may decide to reduce the clients in Client 5 and keep providing service to the other groups.

However, it is surprising that the optimal choice of PwC shows that no matter how the cost changes, PwC will continue to provide service to the clients in Client 4. Since the cost of auditing between Client 4 and Client 5 may be huge, in order to maintain the advantage of economies of scale in auditing big companies, Client 4 may be a better choice for PwC to remain competitive in the industry. The last chart in Figure 3.1 shows that when all costs of auditing manufacturing companies increase with the same budget, PwC may still consider giving up the clients in Client 5 first since it

may attempt to reach its objective of being specialists in the industry by providing more clients in other categories, especially Client 1 and Client 2, which have a relatively low cost of auditing, in order to earn as much audit fee as possible.

Furthermore, by comparing the PwC preference for each category of clients in Table 3.5 with Figure 3.1, the preference of PwC for Client 4 and Client 5 are higher than the other categories of client. However, even though PwC will obtain more utility when providing service to Client 5 than Client 4, the optimal choice for PwC is to give up the companies in Client 5 under the circumstances that the cost of Client 3 to Client 5 rises. The possible argument is that the cost of auditing Client 5 is much higher than Client 4 and therefore it would not be feasible to maintain all customers in Client 5 to maximize its utility.

Figure 3.2 shows the optimal choice calculated by the individual coefficients of Ernst &Young. The outcomes are expected to be slightly different from PwC. According to the summary statistics listed in Table 3.2, Ernst & Young owns most of the clients in the manufacturing industry and is more focused on economies of scope, where the numbers of clients in each group are very similar. With regard to the cost increasing in Client 1 to Client 3, it is obvious that E&Y tends to remain the clients from Client 2 to Client 5 as many as possible and decrease the number of clients in Client 1. This is consistent with the parameters estimated in the utility model, where the parameter of Client 1 is the lowest for E&Y.

Similar to PwC, E&Y will drop the bigger clients when the cost of Client 4 and Client 5 goes up. Since the budget allocation will be affected significantly due to the high cost of auditing companies in Client 4 and Client 5, E&Y will consider giving up the client-auditor relationship with bigger companies to keep their contract with the others. However, it is worth noticing that E&Y prefers to remain contracted to the clients in Client 3 and Client 4, while the individual coefficients in the utility model are also coherent with the analysis. The results from the estimation show that E&Y prefers Client 3 and Client 4 the most, which is different from the PwC.

In addition, the graphs show that for E&Y, the change of optimal choice often includes the increase of certain group of clients along with the reduction in other groups. It is consistent with the fact that E&Y is considered as the leader in the industry with owning the largest number of clients in the industry. To maintain the advantage, instead of focusing on bigger companies, E&Y may attempt to provide service to as many clients as possible under the budget constraint.

Figure 3.3 and Figure 3.4 delineate the changes to the optimal choice of Deloitte and KPMG respectively. Compared to PwC and Ernst& Young, Deloitte and KPMG are not considered as the leader in the industry, but each still owns more than ten percent of the market share. With the

consideration of market share based on audit fee and the number of clients that the audit firms own, these two audit firms are very similar. Even though the preferences for the client are slightly different between these two audit firms, both audit firms tend to maintain the auditor-client relationship with Client 4 and Client 5 when the cost of auditing small companies rises. Being that the budgets of Big Four are higher than other audit firms, the audit firms will attempt to keep providing audit service to big companies, especially influential companies, not only to maintain their reputation as Big Four but also to be regarded as specialists in the industry to attract more clients in the future period.

Hence, in order to remain competitive in the industry, the optimal choices under different situations of cost rising are much similar, where both audit firms attempt to remain contracted to bigger companies; namely, Client 4 and Client 5. When the cost of auditing the Client 5 gets higher, it is reasonable that the audit firms will give up the auditor-client relationship since the cost of auditing larger companies is too high to be covered by the limited budget. However, it is worth noticing that when the cost of auditing all companies in the manufacturing industry rises, the changes in the optimal choices are slightly different between the two audit firms. Similar to the situation when the cost of auditing Client 5 rises, it is rational for audit firms to decrease the number of clients audited in Client 5, but Deloitte and KPMG have differing strategies to other clients in the industry. The analysis shows that when all the costs increase, the changes in optimal choice fluctuate simultaneously to the percentage of cost increasing.

The last graph in Figure 3.3 shows that when the cost increased to 50%, Deloitte will decrease the number of clients in Client 1 and Client 5 and maintain or even increase the number of clients in other categories. The result is consistent with what was discussed previously; namely, that the audit firm will have no other choices but to give up the auditor-client relationship with large companies since it would cost too much to provide service. Moreover, since the impact from Client 1 may not be significant, Deloitte would prefer auditing more clients in other categories, which is coherent with the estimation that Deloitte has a higher preference for Client 2 to Client 4 compared to Client 1. On the other hand, KPMG shows the higher value of the parameter for Client 5 in the utility model, suggesting that KPMG may consider keeping as many large companies as possible to maximise its utility. Therefore, compared to Deloitte, the figures shows that the KPMG has the lower percentage of dropping the clients in Client 5 and is more willing to give up the relationship with other categories.

As mentioned earlier, the results estimated by the Bayesian approach enable this research to examine the individual coefficients for every audit firm. In order to compare the Big Four with

non-Big Four audit firms, the analysis further discusses how the medium-sized audit firms chosen (Grant Thornton and BDO USA) will change their strategies of providing audit service when the cost of auditing increases.

Since the target for the medium audit firm may not be becoming the specialist or leader in the market, the optimal choices for them are expected to be different from the Big Four audit firms. Hence, Figure 3.5 shows the changes in optimal choices for Grant Thornton. According to the sample, Grant Thornton only audits one client from Client 5 every year, so it would not be feasible to discuss the changes of Client 5 in this case. The estimated coefficient shows that Grant Thornton prefers Client 2 and Client 3 more, followed by Client 1 and Client 4. However, from Table 3.6, the marginal utilities for Grant Thornton for all clients are similar, compared to Big Four which have higher marginal utility for the bigger companies. Therefore, the analysis for Grant Thornton is varied under different situations considering the audit firm has a limited budget and the costs of auditing are different.

Different from the Big Four, the optimal choice for Grant Thornton is not always to resign from Client 1 when the cost of auditing rises. Being that the parameters in the utility model and the marginal utility for GT for the clients are relatively similar, the audit firm may not regard dropping the small companies as the ultimate solution but will consider how to allocate the limited budget to maximise its utility. In addition, from the descriptive statistics, being that most of GT's clients are categorised in Client 2 and Client 3 and the marginal utility is diminishing when the number of client increase, Grant Thornton is more likely to decline the engagement from Client 2 and Client 3 under the situation that cost increases, as shown in the last graph in Figure 3.5.

The changes in the optimal choice for BDO USA are shown in Figure 3.6. As the original sample shows that BDO does not provide audit service to the companies listed in Client 5, the analysis for BDO USA does not recognise the change for Client 5 as well. From the estimated coefficients showed in Table 3.5, BDO prefers the small clients than the companies with large sales, which may result from its limited budget and that the audit firm is inclined to provide services to as many clients as possible. According to the summary statistics listed in Table 3.2, most of the clients of BDO are classified from Client 1 to Client 3 so therefore, the change of optimal choice for BDO is expected to be distinct to the previous audit firms.

Moreover, the counterfactual result is consistent with the estimated parameter where BDO prefers Client 1 and Client 2 more than Client 3 and Client 4 with budget constraints. Since BDO only has around two clients in Client 4 every year, the average percentage of changes will not be obvious in the analysis, where the decline may be due to a declination of a client in a single year. The outcomes of the counterfactual analysis shown in Figure 3.6 clearly delineate that BDO would be willing to

give up the companies which have bigger size in order to maintain the relationship with small companies, even though the cost of auditing particular category of clients increases. Similar to what was speculated upon in the previous section, the medium or small audit firm would prefer to audit small clients and not to decline the clients, and even the cost increases, because the audit firm may attempt to build a long-term relationship with small companies in order to compete with other medium and small audit firms in the market.

Figure 3.1   Percentage of PwC's Client Change with Change in Cost

Figure 3.2   Percentage of E&Y's Client Change with Changes in Cost

Figure 3.3   Percentage of Deloitte's Client Change with Change in Cost
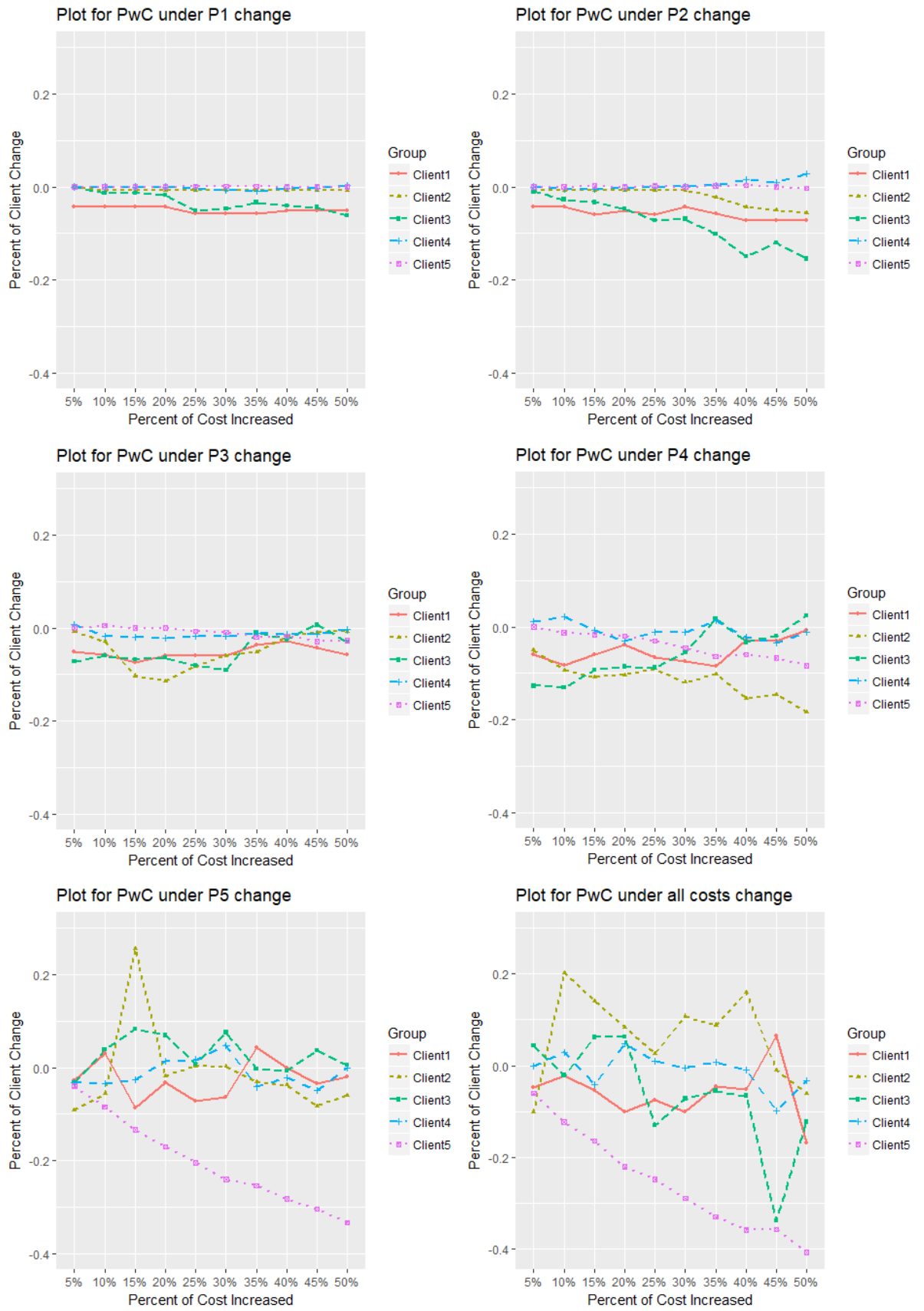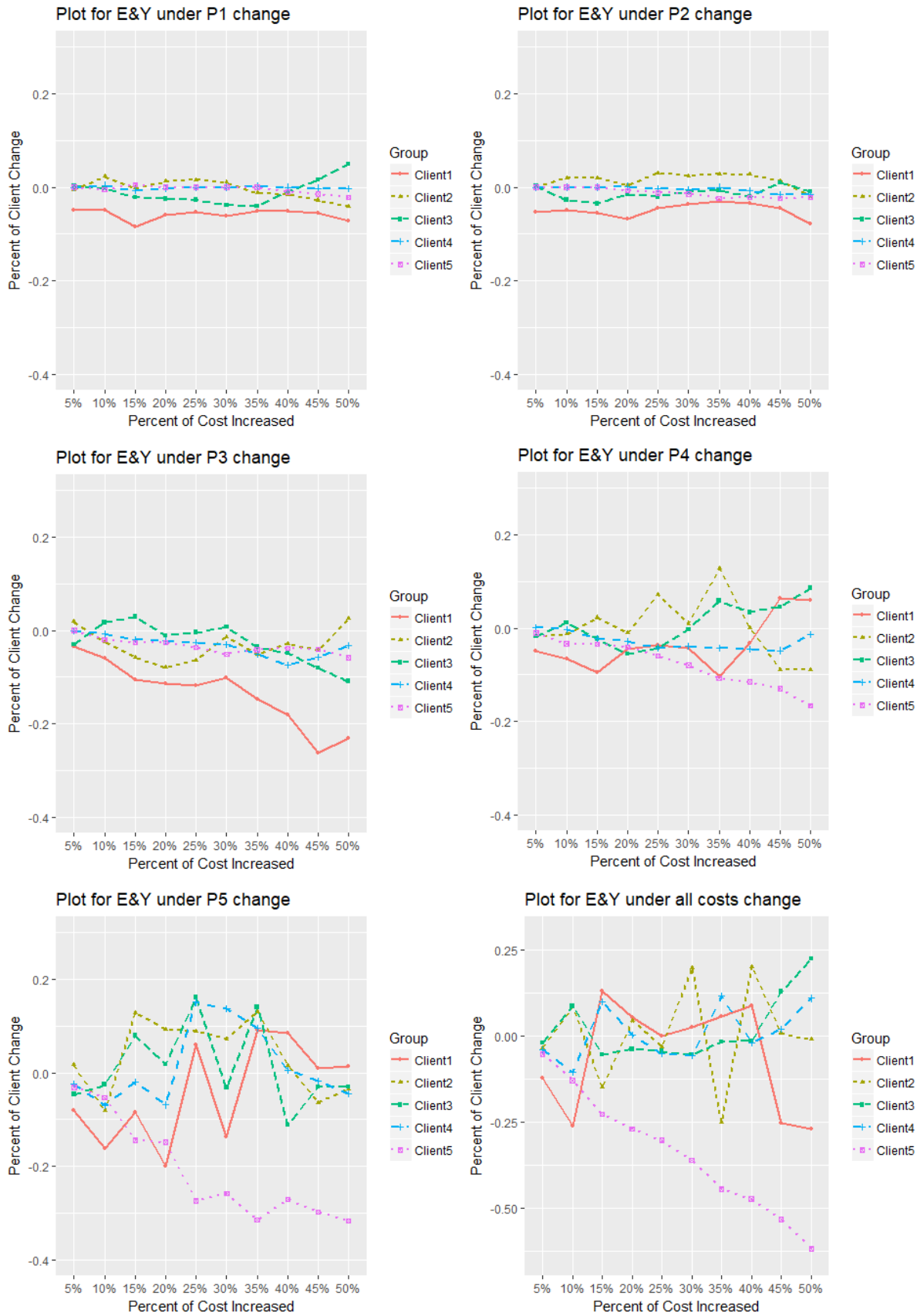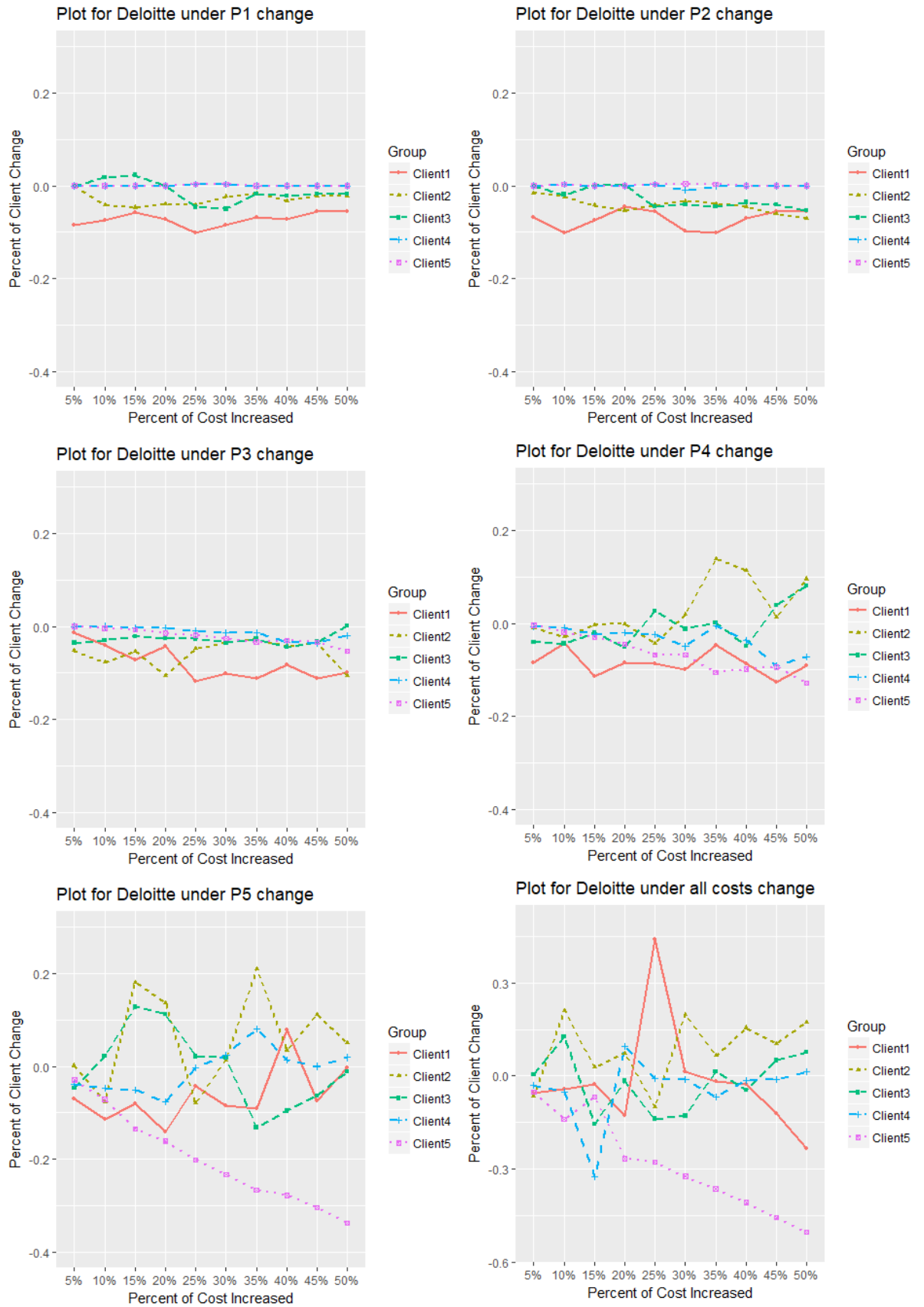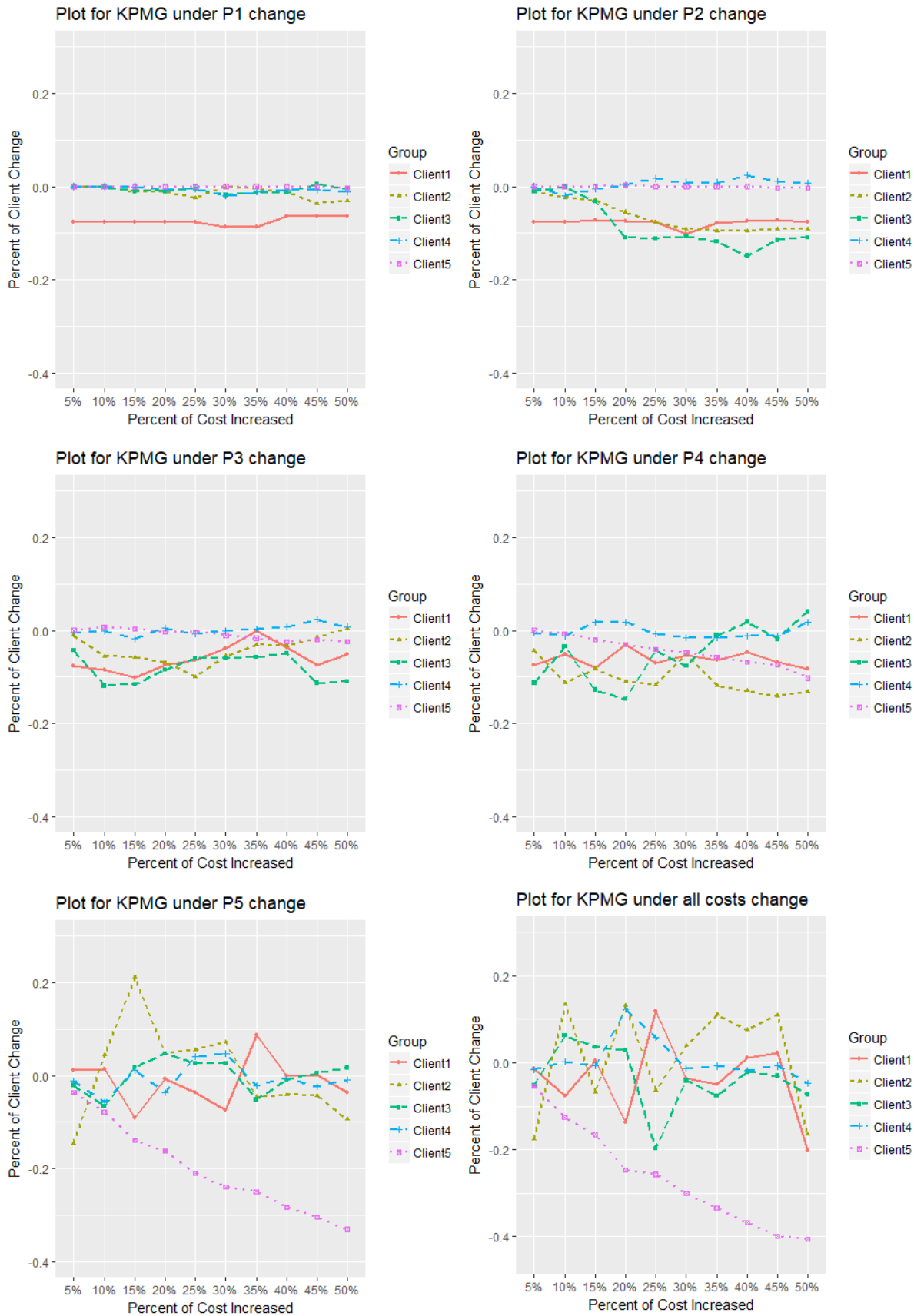
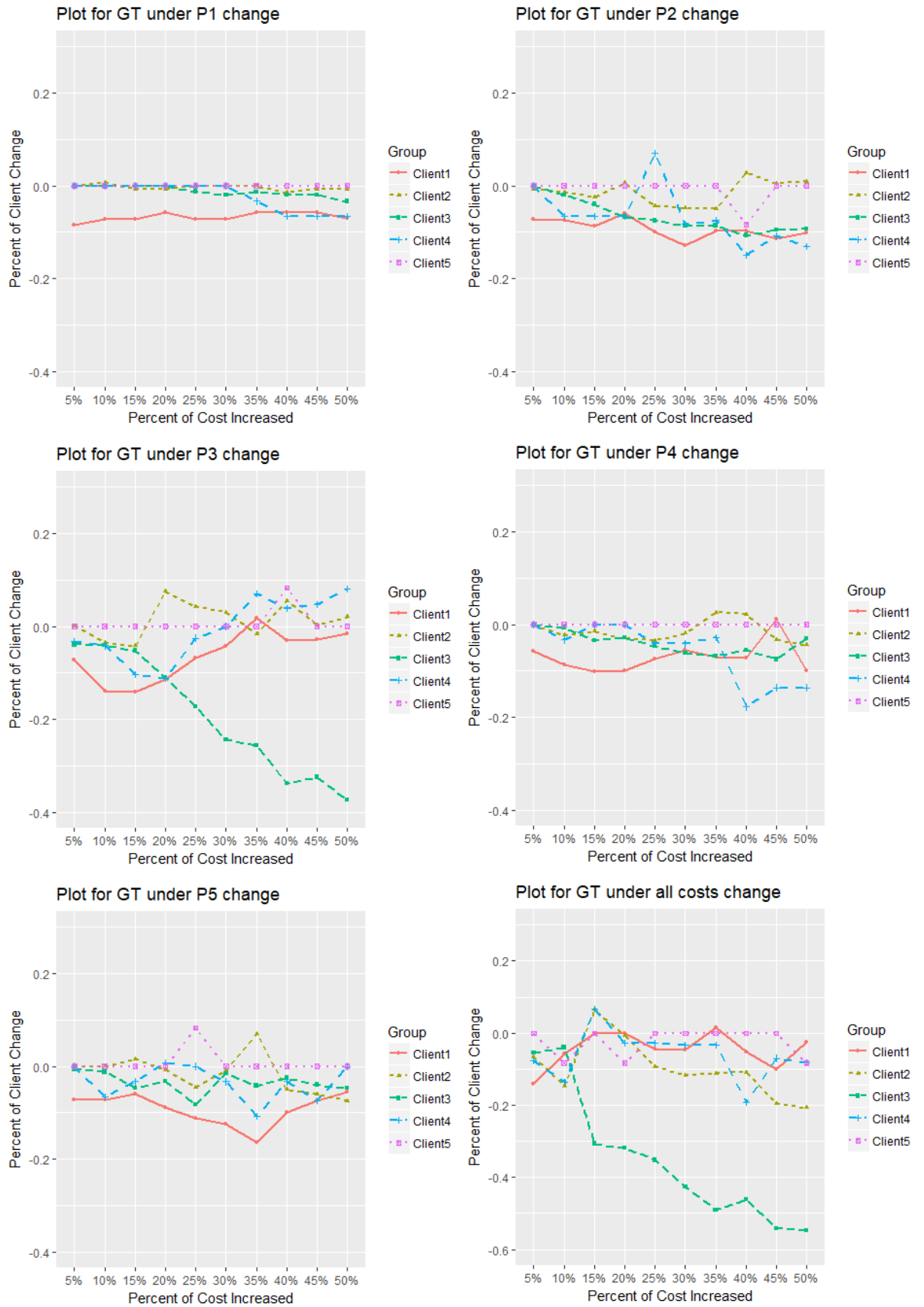Figure 3.4   Percentage of KPMG's Client Change with Change in Cost

Figure 3.5   Percentage of GT's Client Change with Change in Cost
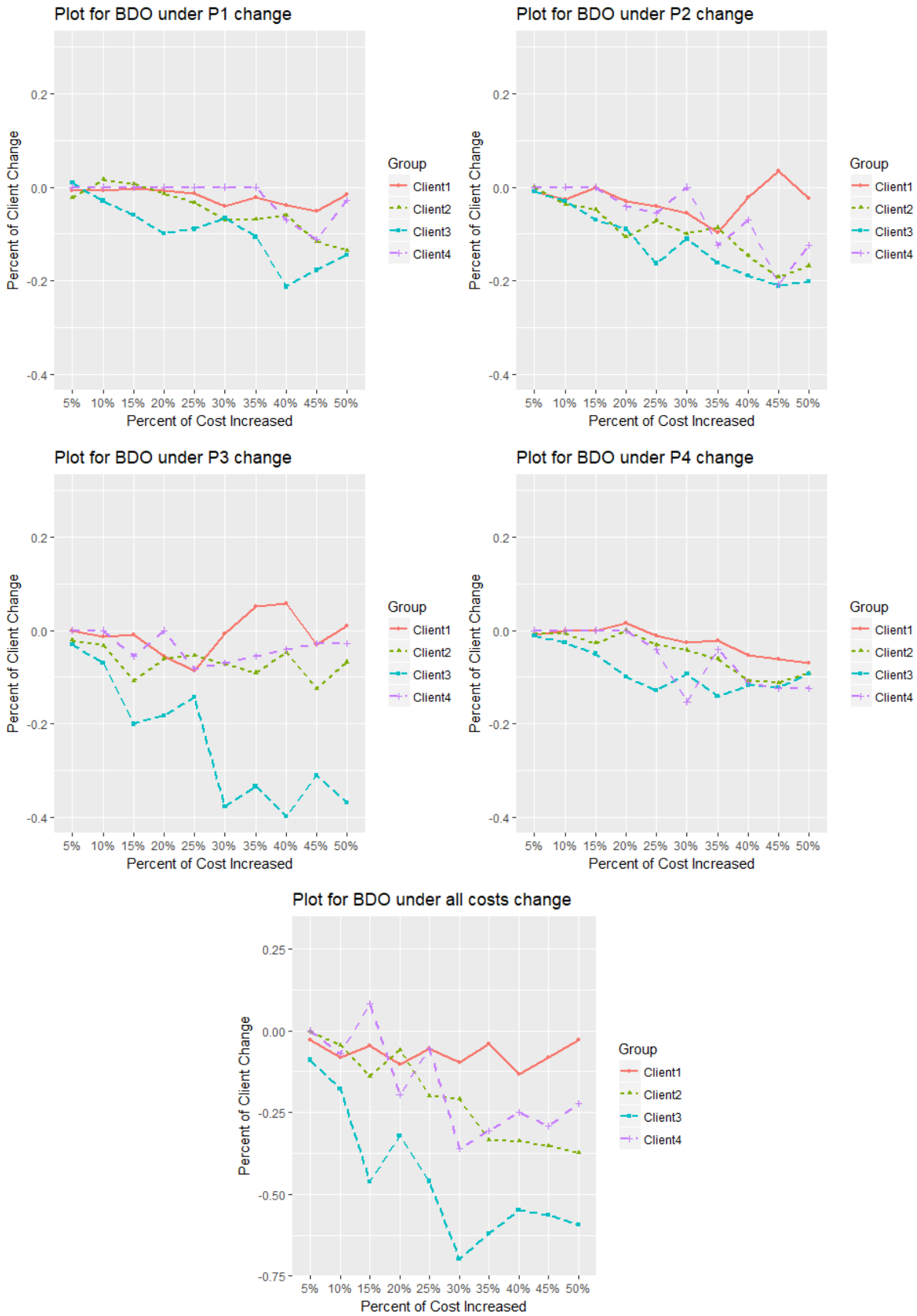
Figure 3.6   Percentage of BDO's Client Change with Change in Cost

3.7   Summary

This research is aimed to examine the client portfolio of the audit firm. Rather than focusing on the factor of a single event, such as the resignation or acceptance of an auditor, the research considers the optimal strategy of an audit firm providing an audit service to the manufacturing industry. By dividing the clients by sales, the estimation is conducted to investigate the preference for different clients. The structural estimation is carried out using the Bayesian approach with the random-walk algorithm and the problem that the probability of normal distribution does not have any closed form can also be solved by GHK simulator.

The mean effect of the result shows that the audit firms prefer small clients whose sales are under average. However, as there are numerous audit firms auditing publicly listed companies in the manufacturing industry, especially small audit firms, the outcomes may be biased. To overcome the problem of such bias, the random utility model is used to measure the auditor's utility, where it allows the heterogeneity among the audit firms. The results show that the variances of the coefficient are large, showing that the results of the mean effect are not significant.

In view of the advantage of estimating the random utility model with the Bayesian approach, the research further examines the individual coefficients for the individual audit firms, especially Big Four and two medium-level audit firms. Based on the market share, each of the Big Four audit firms owns more than 10 percent of the market share and two medium-sized audit firm, Grant Thornton and BDO, owns more clients than other audit firms in the industry. The estimation of the individual coefficients shows that Big Four audit firms are more likely to provide services to the client with higher sales, which is different from the posterior mean in the estimation. Since Big Four audit firms have more resources, including human resource and advanced technologies, they are more capable to audit the clients with more sales. In addition, the companies which have higher sales will dominate the industry and providing audit service to such companies could bring reputation to the audit firm, which is consistent with previous literature that the audit firm would consider commercialism when choosing the client (Gendron, 2001). However, even though the Big Four audit firms have more tendency to provide service to clients with high sales, there is a slight difference among them, justifying the assumption that the audit firms provide heterogeneous service to the client. PwC, which is viewed as the specialist in manufacturing industries with highest market share based on the audit fee, tends to provide more clients with the largest sales. On the contrary, Ernst & Young, who owns most of the clients in the industry prefer clients with average sales more because its strategy may be to achieve economies of scope by providing to as many clients as possible.

With such outcomes of respective preference, the empirical analysis in this chapter further uses the individual parameter to discuss the possible effect on the client portfolio when the cost of auditing changes. By assuming the percentage of the rising cost from five percent to fifty percent, the analysis will be able to determine the change of the optimal choice for each audit firm. The analysis shows that based on the different strategies of each audit firm, even among the Big Four, the outcomes are different. The strategy of PwC is more focused on economies of scale, where it prefers to provide audit service to clients with larger sales and become specialized in the industry. When the audit cost rises, PwC tends to maintain the relationship with clients having high sales and resign or give up the clients which are relatively small.

On the other hand, based on the data, E&Y is more inclined to provide services to all sizes of clients to achieve the goal of economies of scope. With the assumption of rising cost, E&Y is more focused on balancing the number of clients in each category so as to keep the advantage of retaining as many clients as possible. On the contrary, because the medium and small audit firms do not have as large a budget and resources as the Big Four, the analysis shows that they will attempt to maintain auditor-client relationships with small clients as to build a long-term relationship.

The existing literature has examined the decision of the auditor extensively but only a few consider taking the client portfolio into consideration. This research shows that the auditor considers the engagement with the client portfolio and by assuming the budget constraints, the optimal choice for auditor can be illustrated in the utility function. Rather than examining the data directly or by linear association, the model in this reseach assumes that the audit firm would have resource constraints that would prevent the auditor from bidding clients above its capability. In addition, by adopting the theory of utility maximisation, the model assumes that the audit firm would have decreasing marginal utility within the portfolio context, which could not be observed by the researchers. The limitation of this research is that due to the variety of clients, the auditor may need to consider more causes in more detail to decide the client portfolio. Further research should hence focus more on client differentiation to better understand the strategies of the audit firm.

However, this study is believed to shed some light on the proof that it is better to consider the audit firm individually rather than Big Four and non-Big Four since the preferences of each audit firm are varied. Researchers in the future should thus take heterogeneity into consideration when discussing the decision of the auditor, such as resignation and acceptance.

Chapter 4   Simultaneous Effect of Supply and Demand in the Audit Market

4.1   Introduction

The audit market is often considered to be a unique market where the setting of demand and supply is different from other service industries. Auditor in this market is expected to be a monitoring role, while the client requests audited financial reports from the auditor. The existing literature in accounting and auditing has discussed the demand (e.g. the auditor choice) and supply (e.g. the audit fee) extensively but separately. However, it is essential to examine the effect of the two parties based on the economic theory of supply and demand. This research has hence aimed to fill the gap and therefore to discuss the simultaneous effect of demand and supply in the audit market.

Professional service is viewed as deploying expert knowledge in a work setting, which includes law, accounting, engineering and consulting (Malhotra and Morris, 2009). Compared to other professional services, the audit market is unique for several reasons. First, the auditor is considered as the independent role monitoring and detecting material misstatement or fraud in the companies, whereas the traditional service provider behaves in the interest of the client. Second, the audit service for publicly listed companies is mandated, where the companies are required to have audited financial reports periodically. In addition, owing to the entry barrier, the client could only purchase the audit service from audit firms, allowing the researchers to examine transactions in the market-place. In view of such uniqueness, this research focuses on examining the audit market based on economic theory.

With regard to the demand side of the audit market, auditor choice has been discussed thoroughly. The audit is expected to reduce the agency problem and information asymmetry by detecting the failure and incorrect information of the company (DeAngelo, 1981). The literature has examined the factors which influence the auditor selection, including policy implication (e.g. Gerakos and Syverson, 2015) and quality consideration (e.g. Pittman and Fortin, 2004).

However, most of the research distinguishes the audit firms by the Big Four and non-Big-Four or specialist and non-specialist when investigating the effect of auditor selection. Instead of selecting among different categories of the audit firm, Gerakos and Syverson (2015) adopt the framework of discrete choice to examine the auditor choice more directly. In such a setting, the audit firms are

considered to provide heterogeneous audit services which allows the client to have varied preferences for different audit firms.

On the other hand, the problem of audit fee has been greatly investigated. Existing literature puts emphasis on the factors that may impact the pricing of audit service. For example, the bigger company with a complex structure is more likely to have higher audit fee due to the complexity of the audit work (Simunic, 1980; Taylor and Baker, 1981). Besides the client characteristics, research shows that the attribute of the audit firm could have an impact on the audit pricing. From the aspect of fee premium, the specialist in the industry is believed to charge a higher audit fee because of its market power in negotiating (Ferguson, Francis and Stokes, 2003). However, according to the economic theory, the expected profit of the supplier should consider the probability of obtaining the client and the profit of engagement, which the existing accounting and auditing literature does not account for. Therefore, this research intends to fill the discrepancy between the economic theory and the audit fee pricing.

This research adopts structural estimation to examine the effect of demand and supply sides in the audit market. On the demand side, the client is expected to choose the audit firm based on utility maximisation and discrete choice model is applied in the framework. Following the previous research proposed by Gerakos and Syverson (2015), the client utility consists of the audit firm, the interaction between the audit firm and the characteristics of the client, and the audit fee. Moreover, besides allowing the client to have different preference to different auditors, the random utility is introduced to the demand side. Instead of examining the mean effect, the random utility recognises the heterogeneity among the clients, where each client would have different consideration for the auditor and the audit fee.

Such an approach has not been carried out yet in accounting research and it is realistic to consider that the company would have varied concerns when requesting the audit service. On the other hand, the supplier in the audit market, the audit firm, is expected to set the audit fee which may maximise its profit, where the expected profit is based on the probability of client choice and the profit earned. Since the audit fee would influence the client utility and pricing strategy is based on the client utility, the simultaneous effect between demand and supply sides is developed.

In addition, this research proposes two arguments on the supply side: (1) based on the basic economic theory, the Bertrand competition assumes that the audit firm would attempt to maximise its expected profit by only focusing on its expected market share and profit margin. (2) The second proposition assumes that the suppliers in the audit market participate in tacit collusion, where the

audit firm will consider to maximise its profit through undergoing actions with other audit firms to avoid audit fee cut or even raise the fee premium. The research would conduct two sets of estimation and examine if the tacit collusion would have an impact on the auditor choice of the client.

The data in this thesis includes the publicly listed companies in the U.S. manufacturing industry from the year 2010-2012. Since the company in different industries may have varied consideration when choosing the audit firm, this research focuses on a single industry to carry out the estimation. To accommodate the data into the framework and increase the efficiency of the estimation procedure, the following assumption has been made: (1) Due to the high concentration of Big Four and the large number of audit firms providing audit services, non-Big Four audit firms are considered as one unit providing the same level of service with an undifferentiated pricing strategy. (2) There will be no switching cost for the client to change the auditor; the research assumes that the client would take all available audit firms into consideration and make an independent contract with the audit firm each year. (3) The client would be able to obtain complete information from all the available audit firms, including the audit fee, and choose the one with the highest utility.

Even though the information of audit fee becomes transparent in the U.S. after SOX 2002, the researchers could only observe the price for actual choice instead of all available offers. Hence, to carry out the estimation more successfully, this research follows the method suggested by Gerakos and Syverson (2015) to predict the audit fee beforehand for the unobservable audit fee.

In the research, the framework is carried out with Markov Chain Monte Carlo (MCMC) estimation and Bayesian approach with the random-walk algorithm is adopted for the estimation. Owing to the complexity of this framework, the MCMC estimation could be broken down into several steps with appropriate algorithms, including different algorithms under the Bayesian approach. By iterative sampling, the posterior mean and the likelihood converge after the burn-in iterations. The advantage of such approach allows the researcher to examine the parameters individually and the prior for the parameters and hyperparameters can be assumed beforehand. The samplings would be carried out several times with different priors to make sure that the results of the estimation are similar under different attempts. The research is expected to shed more light on introducing the Bayesian approach with a random coefficient in the accounting literature, which mainly focuses on the frequentist approach and the results of the mean effect.

The results of the estimation justify the assumption made in the framework that the client would have a different preference to the audit firms, even among Big Four audit firms. The posterior means in the utility model show that the client prefers PwC, which is considered as the specialist auditor based on the market share of audit fee, when the audit market behaves as Bertrand

competition. The client may consider the specialisation to be important and the recognition from the industry indicates that the audit firm with good audit quality. However, when the audit firms are assumed to be undergoing tacit collusion, the client may not see the specialists in the same way.

Here the client may consider the market share is the outcome of the tacit collusion, which may not indicate the level of audit quality and the audit firm may also increase the audit fee with its reputation. On the other hand, the client is less likely to choose Deloitte compared to Non-Big Four audit firms. Since Deloitte owns the least market share amongst the Big Four, the client may not view the significant difference between Deloitte and other medium audit firms. Therefore, the client may consider choosing the Non-Big Four to have more power and build a long-term relationship with the auditor.

However, it is surprising to find out that the client would consider paying a higher audit fee when choosing the auditor under both assumptions of Bertrand competition and tacit collusion. The client may be willing to pay a higher price because it is believed that the higher audit fee represents better audit quality. Therefore, being publicly listed companies, the client may consider paying higher fee as a signal to reduce information asymmetry to its stakeholders. Even though the client may be aware that the audit firms undergo tacit collusion when offering the audit service and therefore increasing the price intentionally, the client may be more willing to pay higher price since it is mandated to have audited financial reports while paying higher fee premium could enhance the audit quality.

With two different assumptions, the information criteria, Akaike information criterion (AIC) and Bayesian information criterion (BIC) are used to determine which framework fits the sample better with higher likelihood. The outcomes of the comparison show that the model with Bertrand competition could interpret the sample better. Furthermore, because of the advantage of the Bayesian approach, the individual coefficients may be obtained and the future individual choice is able to be predicted. Hence, in order to examine which framework would predict the choice more accurately, this research further compares the actual choice from the year 2013 to 2015 with the predicted choices based on two sets of parameters respectively. However, the accuracy of the prediction is higher upon assuming the auditors engage in tacit collusion, which is inconsistent with the information criteria. Due to the fact that the audit firms may not engage in collusion for every client in the industry and some clients may not be concerned whether the audit market is Bertrand competition or not, which the prediction should consider examining accordingly.

This research is believed to have several contributions to the accounting and auditing literature. First, even though there is plenty of literature discussing the demand- and supply-side of the audit market, there is little research incorporating both sides of the market. By examining the simultaneous effect on both supply and demand for the audit service, this research is believed to fill the discrepancy. In addition, most of the accounting and auditing literature adopts the traditional frequentist approach and consider the mean effect of the audit choice. By allowing heterogeneity among the clients and applying the Bayesian approach in the estimation, the study will be able to determine the individual coefficients which are able to shed more light for the future research in considering the difference between the clients.

The research is structured as follows. Section 4.2 includes a survey of the existing literature researching on demand- and supply-side in the audit market. The models required are developed in Section 4.3 and statistical specification including the estimation process is illustrated in Section 4.4. Section 4.5 shows the preliminary descriptive statistics and the posterior estimation in the model and the comparison is explained in Section 4.6. Section 4.7 is the conclusion of the research in this chapter. The Markov Chain Monte Carlo estimation and the detailed calculation for the model are depicted in the Appendix C and Appendix D.

4.2   Related Literature

The objective of this research is to examine the simultaneous effect of the audit client and the audit firm from auditor selection to pricing strategies. This research adopts the framework of structural estimation for the discrete choice problem which is widely used in marketing and operation literature (Berry et al. 1995; Yang et al. 2003; Villas-Boas et al. 2005). In past accounting and auditing research, the structural estimation has been used in policy implementation. Gerakos and Syverson (2015) examine the effect of consumer surplus for mandatory rotation and the exit of one of the Big 4 audit firms. Meanwhile, Guo, Loch and Zhu (2017) investigate the audit market structure and consumer surplus of implementing joint audit.

However, there has been little research on the structural application in accounting field considering the impact of consumer choice to audit firm pricing strategies. Therefore, this research attempts to follow the application of the demand side from the previous research but extends the structural estimation to decisions on the supply side, which is the pricing strategy of the audit firm.

First, on the demand side, the study focuses on the auditor choice of the audit client. Most of the related literature on auditor selection have put emphasis on the policy implementation or cost and quality consideration. By applying the agency theory, the audit is expected to be an independent work to detect and reveal the failure of the work of the agent and incorrect information to reduce

agency cost as well as the information asymmetry (DeAngelo, 1981; Lee, Stokes, Taylor and Walter, 2003; Lin and Liu, 2009; Tsao et al., 2016; Fang et al., 2017). Hence, the auditor is expected to serve in a monitoring role who is independent of the company. The existing research has studied the factor contributed to auditor selection thoroughly and extensively. The empirical studies of auditor choice show that the audit client will choose the audit firm based on different expectations and varying circumstances. Pittman and Fortin (2004) examine the auditor choice for newly public firms and find that the audit client tends to choose Big Six audit firms for enhancing the credibility of the financial report so as to have lower debt rate.

The brand and the attribute of the audit firm are also some of the criteria for the client to consider when purchasing the audit service. For example, Li et al. (2017) reveal that the audit client tends to choose the social norm audit firm, whose headquarter is located at metropolitan area and has the largest number of clients in such an area. Tóth (2014) also argues that the signal of audit quality will affect the auditor choice when the accounting scandals and auditor's accuracy are major concerns of the audit client. Instead of adopting logistic regression to examine the choice with an indicator variable, recent literature has employed the discrete choice model for the selection of the audit firm. By considering the fact that the client may only choose one of the audit firms to provide an audit service, Gerakos and Syverson (2015) and Guo et al. (2017) uses the framework of discrete choice to investigate the how the characteristics of the client itself, the auditor and the audit fee would influence the auditor choice. In addition, this chapter also considers the audit competition and pricing strategy for the supply side in the audit market. In fact, the competition in the audit market has been studied extensively in the past literature, especially on the audit fee and previous studies have indeed adopted different independent variables to examine the factors that may affect the audit fee.

With regard to client characteristics, bigger firms with more total assets, more subsidiaries and participating in more industries are more likely to have higher audit fee because of the complexity of the corporate (Simunic, 1980; Taylor and Baker, 1981; Francis and Stokes, 1986; Pham, Duong, Quang and Thuy, 2017). On the other hand, audit firms could also negotiate the price with the client based on their reputation and specialisation in a certain industry (Ferguson, Francis and Stokes, 2003). Research shows that a specialisation will have a significant effect on the audit pricing. Here, Casterlla, Francis, Lewis and Walker (2004) find evidence that higher audit fee will be charged by the Big Six specialists when then clients are smaller.

Besides that fact that the client characteristic would have an influence on the audit fee, literature has also argued that the competition in the audit market would impact the pricing strategies of the

audit firms. However, the results of examining the relationship between the audit fee and the audit market concentration are mixed. The positive relation between concentration and audit fee shows that when the audit market is concentrated, the suppliers, which are the audit firms, have more market power to the client and therefore are not afraid of losing clients by charging a higher fee (GAO, 2003; Chi, 2006; Jacob, Desia and Agarwalla, 2018). By examining the post-Enron period, Asthana et al. (2009) find that the audit fee increases after the demise of Arthur Anderson because the clients are lack of choice, especially for the larger companies which tend to ask for audit services from Big Four audit firms. Carson et al. (2012) use the data from 1996 to 2007 in Australia to investigate the Big N audit fee premium. The outcome shows that there is a significant increase in Big N audit fee premium when the number of audit firms decreases from Big Eight to Big Five and Big Four, while the mid-level and small local clients experience a more significant increase in premium compared to global companies. This suggests that even though the Big N audit firms have increased market power over time due to the decrease of competitors in the audit market, clients which are relatively large still have more bargaining power than the small clients.

4.3 Model Development

4.3.1 Demand-Side Problem

The research is aimed at examining both the supply and demand side in the audit market. In the traditional marketing research, the customer is expected to choose the product which provides the highest utility. Similarly, in the audit market, the client selects the audit service from the audit firm in order to maximise its utility. In addition, because the publicly listed company is required to obtain an audited financial report periodically, the client in the audit market would be mandated to choose one of the audit firms in the market.

When choosing the audit firms, in the framework, each audit client only selects one audit firm for the service in each period. During the selection process, the client will assign a utility to each audit firm depending on the auditor and the client itself. The client will choose one of the audit firms which gives the client the highest utility. Suppose that there are I audit clients ($i \in 1, \dots I \equiv \mathcal{L}(I)$) with J possible audit firms ($j \in 1, \dots J \equiv \mathcal{L}(J)$) in the audit market at the period ($t \in 1, \dots T \equiv \mathcal{L}(T)$, where $\mathcal{L}$ is an integer from 1 to any positive integer. The utility model for each client firm i's from choosing audit firm j at period t can be depicted as:

$$\text{for } i \in \mathcal{L}(I), j \in \mathcal{L}(J) \text{ and } t \in \mathcal{L}(T),$$

$$U_{ijt} = \beta_{0i} + \left(\beta_i^n + x'_{it}\beta_i^k\right)x_{jt} + \beta_i^p p_{ijt} + \psi_{jt} + \varepsilon_{ijt} \tag{4.1}$$

where x_{it} is a k × 1 vector of service clients' observable characteristics x_{jt} is the indicator variable for each audit firm in the market and p_{ijt} is the audit fee that audit firm j offers to client i. Extending from the demand-side model in Chpater 2, the client's characteristics include the company's sales and inventory turnover. Following the prior accounting literature, total assets or total sales could be treated as the proxy for client's size, which is expected to influence the client's selection (e.g. Aobdia, 2015; Habib et al., 2017; Quick et al., 2018;). As this reseach focuses on the manufacturing industry, total sales of the companies is used to proxy the client's size, which is expected to have impact on the client's choice. Moreover, with the numerous transaction within the manufacturing industry, the management of the inventory is also considered as the main determinants for the client selecting the audit firm. Therefore, the model also includes the inventory turnover in client's utility model (Gerakos and Syverson, 2015; Brocard, Franke and Veoller, 2018). Then, ψ_{jt} is a scalar representing demand shock, which could not be observed by the modeller, and it is assumed to follow a normal distribution with zero mean and standard deviation Σ_ψ . The error term ε_{ijt} is assumed to be distributed as the type 1 extreme value. The parameters in the model are the utility loadings on the variables, including audit firms, the client itself and the audit fee in each contract.

In addition, besides considering the mean effect among all clients, the utility model adopted in this framework allows heterogeneity among companies. Following the BLP approach introduced by Berry, Levinsohn and Pakes (1995), the choice of the audit client can be estimated by the random utility logit model with random shock. The random utility model allows for heterogeneity among clients (Berry et al., 1995; McFadden, 1973), whereas the client could have different preference to the product attribute. By allowing such an assumption, the research considers that the audit service provided by different audit firms are differentiated and based on the client characteristics, the audit firm would provide a different level of audit works. Therefore, in the equation (4.1), the random coefficients differ with audit clients as $\beta_i = [\beta_{0i}, \beta_i^n, \beta_i^k, \beta_i^p]$, including intercept, loadings to each audit firms, and audit fee. The coefficient is considered to follow normal distribution $N(\bar{\beta}, \Sigma_\beta)$, which will be illustrated in detail in the next section.

Apart from the traditional marketing research dealing with the discrete choice problem, the audit market is unique because of the regulatory environment. Hence, in order to apply the discrete choice problem for an audit client, the following assumptions are made to the demand-side model in the equation (4.1):

Assumption 1: Each client has to choose one of the audit firms.

In the conventional marketing research, the framework allows the customer to purchase outside goods, or even make a non-purchase decision. However, because the sample used in this research are publicly listed companies in the U.S, every client is required to have audited financial reports periodically and does not have the choice of not hiring any auditor due to the mandatory regulation. Therefore, it is appropriate to assume that non-purchase decision is excluded in the framework because of the uniqueness of the audit market.

Assumption 2: Non-Big Four audit firms are considered as one audit firm.

Even though the audit market is a regulated market, there are still numerous audit firms which provide audit service to publicly-listed firms. However, based on the market share calculated by audit fee and numbers of the client, Big Four audit firms earn more than 90 percent of the audit fee and owns around 70 percent of the clients. In the prior accounting and auditing research on the client's selection, researchers adopts logistic regression to examine the association between client's characteristics and the choice of Big Four audit firm (e.g. Quick et al., 2018; Fang et al., 2017). Therefore, the research only differentiates the audit firms between Big Four and non-Big Four and assumes that the audit firm provide homogenous audit service in each category. Moreover, Gerakos and Syverson (2015) and Guo et al., (2017) uses discrete choice model to discuss the client's choice of the audit firm and considers non-Big Four audit firms as one in the framework.

Since the market share of the non-Big Four audit firms is less than 10 percent in audit fee and less than 30 percent in number of clients, the assumption of non-Big Four audit firm providing homogenous audit service is considered to be applicable and the result would not be biased with such assumption.

Assumption 3: Clients will receive the price of audit service from every audit firms and select one of the audit firms based on all information.

In the U.S., listed companies need to reveal the audit fee in the yearly audited report after SOX 2002. However, the remaining audit fee offered by other audit firms could not be observed by the researchers. However, it would be reasonable to assume that the client would receive the offer from different audit firms including the bidding price. Since the audit fee is one of the major factors determining utility, this research will follow the approach proposed by Gerakos and Syverson (2015) to have the predicted audit fee beforehand in order to conduct the estimation.

With the assumptions made above, the utility model illustrated in equation (4.1) could represent the utility of each client for the audit service. Because the ε_{ijt} follows the type 1 extreme value distribution and the probability of client choice could be examined by logit transformation. The

random coefficient in the utility function can be estimated with the density $f(\beta)$. Therefore, the probability of client i choosing audit firm j at time t could be written as

$$s_{ijt} = \frac{e^{\beta_0 + \left(\beta_i^n + x'_{it}\beta_i^k\right)x'_{jt} + \beta_i^p p_{ijt} + \psi_{jt}}}{\sum_j e^{\beta_0 + \left(\beta_i^n + x'_{it}\beta_i^k\right)x'_{jt} + \beta_i^p p_{ijt} + \psi_{jt}}} \tag{4.2}$$

4.3.2 Supply-Side Problem

In contrast with the demand side, in the traditional marketing and economic theory, the objective of the supplier is to maximise its profit by subtracting cost to the price (e.g. Yang et al., 2003). Following the similar concept, the audit firm is considered as the supplier in the audit market whose ultimate goal is to maximise its profit by providing audit service to the client. The decision problem for the suppliers is to determine the price for each product/service. Different from the suppliers in other industry, the audit service is assumed to be differentiated and so as the audit fee. Therefore, the audit firm j needs to decide the audit fee p_{ijt} for each client $i \in \mathcal{L}(I)$ to maximise its total profit. The additive profit function for audit firm j providing services to client i at period t can be written as:

$$\pi_{ijt} = \sum_{i \in \mathcal{L}(I)} s_{ijt}\left(p_{ijt} - f(\alpha, x_{it}, x_{jt})\right) + \sum_{k \neq j} \sum_i \phi_i s_{ikt}\left(p_{ikt} - f(\alpha, x_{it}, x_{kt})\right) \tag{4.3}$$

where $f(\alpha, x_{it}, x_{jt})$ is the cost function for the audit service, which includes the characteristic of the client, x_{it}, and the audit firm, x_{jt}. The equation (4.3) shows that the expected profit that audit firm j would earn from client i at period t would be based on the probability of the client i choosing the audit firm j and the margin for providing audit service to the client i.

In addition, this framework has aimed to discuss two scenarios on the supply side. Besides considering that the audit firm will strive to maximise its profit, the market may exist collusion among audit firms. Therefore, this research follows the model by Yang et al. (2003) and proposes two arguments in the supply side. First. if ϕ_i in the equation (4.3) equals to zero, the Bertrand competition is considered in the audit market, where the audit firm would only consider the profit maximisation based on the probability of client selection and the audit fee offered to the client. On the other hand, when ϕ_i equals to one, the framework assumes that the audit firms in the market are involved in tacit collusion. In such cases, the audit firm does not only contemplate the probability of client choice and the audit fee, but also take the pricing strategies of the competitors into consideration.

Based on the equation (4.3), the optimal price can be derived via the first-order condition. The optimal price for the audit firm j to charge for audit service to the client i at period t can be written as:

$$p_{ijt}^* = \arg\max_{p_{ijt}} \pi_{jt} \tag{4.4}$$

Accordingly, the optimal price for every audit firm $j \in \mathcal{L}(J)$ to client i can be illustrated in the equation (4.5) below and the detailed calculation is in Appendix D:

$$[p_{ijt}]_{J\times 1} = \left[\, f(\alpha, x_{it}, x_{jt}) \,\right]_{J\times 1} + \begin{bmatrix} \frac{\partial s_{i1t}}{\partial p_{i1t}} & \phi_i \frac{\partial s_{i2t}}{\partial p_{i1t}} & \cdots & \phi_i \frac{\partial s_{iJt}}{\partial p_{i1t}} \\ \phi_i \frac{\partial s_{i1t}}{\partial p_{i2t}} & \frac{\partial s_{i2t}}{\partial p_{i2t}} & \cdots & \phi_i \frac{\partial s_{iJt}}{\partial p_{i1t}} \\ \vdots & \vdots & \ddots & \vdots \\ \phi_i \frac{\partial s_{i1t}}{\partial p_{iJt}} & \phi_i \frac{\partial s_{i2t}}{\partial p_{iJt}} & \cdots & \phi_i \frac{\partial s_{iJt}}{\partial p_{it}} \end{bmatrix}_{J\times J}^{-1} \begin{bmatrix} -s_{i1t} \\ -s_{i2t} \\ \vdots \\ -s_{iJt} \end{bmatrix}_{J\times 1} + \begin{bmatrix} \eta_{i1t} \\ \eta_{i2t} \\ \vdots \\ \eta_{iJt} \end{bmatrix}_{J\times 1} \tag{4.5}$$

where p_{ijt} here is a vector representing all audit fee offered by every audit firms to the client i. From the equation (4.5), the audit fee is considered to be the audit cost plus the factor that the audit firm consider its probability of client choice.

However, because the probability of client i choosing over the audit firms, s_{ijt}, consists of audit fee which affects the utility, the equation (4.5) is regarded as the implicit function which could not be solved directly. Being that the researchers could not observe the distribution of audit fee, p_{ijt}, the assumption of random shock , η_{jt}, in the equation (4.5) is made. η_{jt} is assumed to be normally distributed with zero mean and Σ_η standard deviation. Hence, for obtaining the distribution of the audit fee, p_{ijt}, the method of change-of-variable would be carried out during the estimation.

By considering both demand and supply sides in the audit market, the framework in this study is aimed to examine the simultaneous effect on the client utility of choosing the audit firm and audit firm pricing strategy. Moreover, with the assumptions of Bertrand competition and tacit collusion, the model in this research could investigate the pricing strategies in both scenarios.

4.4   Statistical Specification

Due to the nature of the audit market, only the audit fee of the actual client choice is required to disclose in the financial report. However, it is reasonable to believe that the client would receive offers from different audit firms and choose the one with all available information, including the audit fee. Therefore, to better examine the auditor choice with the utility model, the audit fee that could not be observed by the researchers should be implemented before the estimation. Numerous existing research discusses the factors that would influence audit fee (e.g. client size and financial

condition) and this study will adopt certain client characteristics to predict the unobserved audit fee.

Following the research conducted by Gerakos and Syverson (2015), which attempts to examine the client utility in the audit market, ordinary least squares (ols), lasso regression, ridge regression, partial least squares, recursive partitioning and random tree approach (RandomForest) are applied to predict the audit fee. By using the real data of actual choice and its audit fee, the audit fee function can be estimated by different methods and compared by the root mean square error (RMSE). Table 4.1 shows the RMSE for all methods. The unobserved audit fee is therefore implemented with the prediction by the RandomForest approach with the lowest RMSE.

Table 4.1 RMSE for All Methods of Audit Fee Prediction

Method	RMSE
Ordinary Least Squares (ols)	0.6370
Lasso Regression	0.6383
Ridge Regression	0.6457
Partial Least Squares	0.6382
Recursive Partitioning	0.6559
RandomForest	0.5469

In order to allow the audit clients to have different preferences when selecting the audit firm, the random utility model is applied on the demand side. In equation (4.1), each audit client could have various preferences for the audit firm, the interaction between client characteristics and the auditor, and audit fee. By allowing such heterogeneity in the framework, the structural estimation would hence be carried out by the Bayesian approach. The estimation is conducted by iterative sampling from the full conditional distribution of all estimated parameters. Being that the framework includes both the demand and supply sides with a different set of parameters, the estimation procedure is divided into several steps. In addition, since the framework allows the random

coefficient in the demand side, the hierarchical form of the priors is needed to be specified. The detailed Markov Chain Monte Carlo estimation is delineated in the Appendix C.

First, in order to carry out the estimation in the demand side, the choice probability of the client i choosing the audit firm j at period t is specified in equation (4.2) as to obtain the likelihood in the Bayesian approach. As mentioned in the previous section, this research assumes that there is no outside suppliers/audit firm or non-purchase decision in the framework. First, to estimate the parameters in the random utility model, the Metropolis-Hasting algorithm with random walk approach is conducted for each client. The demand shock ψ_{jt} is assumed to be normally distributed with zero mean and variance of Σ_ψ. The conjugate prior for random coefficient β_i is considered to be normal distribution as $N(\bar{\beta}, \Sigma_\beta)$.

$$\beta_i \sim N(\bar{\beta}, \Sigma_\beta) \tag{4.6}$$

$$\psi_{jt} \sim N(0, \Sigma_\psi) \tag{4.7}$$

On the other hand, the profit function for the audit firm, which is defined as equation (4.3), shows that the audit firm j would consider the probability of client choice in order to maximise its expected profit. In addition, as illustrated in the framework, there is a simultaneous effect between client utility and pricing strategy of the audit firm, where the audit fee will affect client utility, but the utility could also influence the audit pricing. From the equation (4.5), the audit fee function consists of the choice probability and the audit cost. After estimating the parameters in the demand model, the coefficients in the supply side function could be estimated based on the updated coefficients obtained from the previous estimation. The estimated coefficients in both demand- and supply-side model will be updated from the iteratively sampling and the results are expected to converge after the burn-in iterations.

The cost function $f(\alpha, x_{it}, x_{jt})$ is based on the characteristics of the client and the audit firm. By assuming that the coefficient in cost function α as a fixed coefficient, $f(\alpha, x_{it}, x_{jt})$ can be viewed as linear regression and the estimation could be carried out by linear programming. With the estimated parameters in the equation (4.5), the value and the covariance of the supply shock, η_{jt}, could be estimated. The distribution of the audit fee could then be determined by the change-of-variable approach from the distribution of η_{jt}. The distribution of η_{jt} can be written as

$$\eta_{jt} \sim N(0, \Sigma_\eta) \tag{4.8}$$

By iteratively sampling from the estimation process, the coefficient in both supply and demand side, including the hyperparameters in hierarchical form of random coefficient could be estimated. Owing to the complex of the framework, the iterations for both tacit collusion and Bertrand game

are set to 20,000 times. Due to a vast number of clients in the sample, the burn-in iterations are then set to 16,000 iterations and the final results are calculated from the last 4,000 iterations.

4.5   Empirical Analysis

The sample includes 1,284 publicly listed companies in the U.S. manufacturing industry from the years 2010-2012. Prior literature suggests that the services provided by audit firms are differentiated, while the audit firm would have varied pricing strategies to lower its cost by the economies of scale (e.g. Owhoso, Messier and Lynch, 2002). Instead of including all publicly listed firms in the U.S. market, the data included in the sample is classified by the two-digits SIC code. The data of audit fee and client characteristics is collected from Audit Analytics and Compustat.

In the research, the non-Big Four audit firms are classified as one audit firm, while assuming that all non-Big Four audit firms provide homogeneous audit service to a certain client. Therefore, the audit firms examined in the supply side are PricewaterhouseCoopers LLP (PwC), Ernst & Young LLP (E&Y), Deloitte & Touche LLP (Deloitte), KPMG LLP (KPMG) and non-Big Four. Table 4.2 shows the market share based on the audit fee and the number of clients possessed by each audit firm. Being that the audit work required is based on the complex of the client and audit fee is believed to be charged according to the audit effort, the market share calculated by audit fee could represent the relative audit work that each audit firm provides.

Compared to the non-Big Four audit firm with only around four percent of the market share, the PwC is considered to be the specialist in auditing manufacturing companies with the highest market share. On the other hand, the E&Y is considered to be the lead in the industry by providing around 25 percent of clients in the industry. The table also justifies the assumption made in the framework that non-Big Four audit firms should be viewed as one, since the importance of the small audit firms in the estimation may be trivial.

Table 4.2   Average Market Share of Audit Firms in the U.S. Manufacturing Industry (2010-2012)

Audit Firm	Audit Fee	Number of Clients
PricewaterhouseCoopers LLP (PwC)	38.48%	20.92%
Ernst & Young LLP (E&Y)	24.58%	25.16%
Deloitte &Touche LLP (Deloitte)	15.88%	12.46%
KPMG LLP (KPMG)	16.82%	12.67%

Audit Firm	Audit Fee	Number of Clients
Non-Big Four Audit Firms	4.24%	28.79%

On the demand side, the utility model suggests that the audit client will have different preferences for each audit firm and the choice would also be influenced by its characteristics. Based on the concept of the discrete choice problem, the customer will choose the supplier/product which has the higher utility. Similarly, the audit client will choose one of the audit firms to maximise its utility based on the audit firm, its characteristics and the audit fee. Meanwhile, because the audit service is differentiated, the audit firm would have various pricing strategies based on the complex of the client.

Table 4.3 shows the descriptive statistics of the sample included in the research. Due to the problem of identification, the utility model in this framework only considers the attributes that may influence the client choice, especially in the manufacturing industry. In most of the manufacturing companies, the effectiveness of the operation is one of the major concern. Therefore, the utility model in the demand side includes client sale and inventory turnover as the factors which may influence the client preference when selecting the audit firm. The remaining attributes are believed to influence the audit fee, including the size of the client and financial performance.

From the descriptive statistics, the range of the audit fee is from $10,000 to $87,100,000, showing that different level of audit work is included in the sample. Being that the research intends to include all publicly listed manufacturing companies in the U.S., the varied sizes of the client with a different level of characteristics are expected to be found in the dataset. The companies of larger size are more likely to have higher sales. However, the inventory turnover and current ratio may not be positively related to the total assets since operational efficiency and financial conditions depend on the strategies of the companies. In addition, even though the clients have varied significantly in the dataset, the random utility model will overcome the problem of bias by examining individual preferences.

Table 4.3   Descriptive Statistics for Audit Clients in the U.S. Manufacturing Industry (2010-2012)

Variable	Mean	Standard Deviation	Minimum	Maximum
Audit Fee (US dollar)	2,785,202	5,861,671	10,000	87,100,000
Total Assets (thousands)	7,085,013	31,132,570	0	717,242,000
Sales (thousands)	5,676,257	24,119,360	-5,087	475,793,482
Inventory Turnover	7.72	50.57	-5.24	2064

Variable	Mean	Standard Deviation	Minimum	Maximum
Current Ratio	3.56	3.74	0	82.56
Restatement	0.1033	0.30	0	1
COGS to Sales	275.33	4547.45	0	157838.89
EPS	1.241	2.77	-11.56	94.94

Table 4.4 shows the posterior mean of the coefficient in the utility model. The outcomes under the assumption of Bertrand competition and tacit collusion are slightly different amongst the audit firms. Under the Bertrand game, where audit firms are independent in offering the price, the clients prefer to choose Big Four audit firms. The results show that when the brand name is the only consideration, the client would prefer Big Four audit firms, especially PwC with the parameter of 1.037 compared to the non-Big Four audit firm. Being that PwC is considered as the specialist in the manufacturing industry, the reputation of specialization may intrigue the client to choose.

However, the choice for Big Four audit firms becomes less appealing to the client when the client assumes that the audit firms would have the act of collusion. While the price is expected to be negotiated among the audit firms, the independence of the Big Four may be compromised. Therefore, PwC may not be the first choice for the client because the fact of being specialised may not be neutral considering the combination of the market is built by the strategies of the audit firms.

However, the posterior mean of E&Y becomes higher under tacit collusion, showing that the clients seem to have more positive preferences to the audit firm. One reason for this trend may be the vast number of clients possessed by E&Y. Being that the audit fee is no longer viewed as the benchmark of specialisation, the number of clients is another criterion for the audit firm to consider. As E&Y provides audit services to most of the companies in the manufacturing industry, the clients may prefer to choose based on the knowledge of auditing in the same industry. On the other hand, it is worth noticing that Deloitte is not favourable to the audit client compared to the non-Big Four audit firm, with the negative parameters of -0.378 and -1.345 under the assumptions of Bertrand competition and tacit collusion. In the sample, Deloitte provides less audit work and owns fewer clients compared to the other Big Four, so the client may see Deloitte similar to other medium-sized audit firms and is more willing to choose the medium audit firms with preferable prices and services.

Being that this research focuses on the manufacturing industry, the utility model in the framework includes the inventory turnover and total sales of the client. Since the operational effectiveness and efficiency are the major concern to manufacturing companies, it is believed that the client would consider its selection accordingly. Based on the posterior mean in Table 4.4, the clients with larger sales are more likely to choose Big Four audit firms. There are two possible reasons for this trend: first, because the large amount sales could lead to a high volume of transactions and complicated financial records, the client may be inclined to hire auditors from Big Four to investigate the accuracy of the transactions and the internal control of the financial system and therefore to increase the effectiveness of the operations. As the Big Four may have more resources, including human resources and advanced technology, the clients would choose Big Four to detect any fraud and misstatement to improve its performance.

Moreover, the companies with large sales may be of a bigger size or have a greater reputation. By hiring the Big Four audit firms, the companies could show the stakeholders (e.g. debt holders and investors) that they are concerned with audit quality and so as reducing information asymmetry. On the other hand, the results of the interaction between the audit firm and inventory turnover show that the companies with higher inventory turnover are less likely to choose Big Four. Even though the coefficient for E&Y and inventory turnover has a positive association with client utility, the value is close to zero, indicating that the preference for E&Y is similar to other non-Big Four audit firms.

The high inventory turnover in manufacturing companies shows that the companies have relatively high efficiency in operational performance. Therefore, such companies may take the efficiency of the operation as the major concern when selecting the audit firm. In order to have high audit quality, the Big Four may have more comprehensive inventory check and therefore the warehouse of the companies may be needed to shut down for detailed examination. In such a situation, the company with a high inventory turnover may consider choosing the medium or small audit firms to maintain its operational performance.

However, there is a possibility that the company runs with high sales and high inventory turnover, and it may not be possible to conclude the client choice based on a single factor. Compared to the previous literature, the results of the audit fee are different when considering the pricing strategies of audit firms. With the coefficient of 0.724 and 2.095 under Bertrand game and tacit collusion respectively, the outcomes show that the clients are willing to pay higher price for higher audit quality. When the clients take the behaviour of collusion into consideration, they may be more likely to pay higher audit fee because the companies may value the audited reports and believe that they will only receive higher audit quality when the audit fee is higher than the others.

Table 4.5 and Table 4.6 show the covariance matrices for the random coefficients in equation (4.1) under the scenarios of Bertrand competition and tacit collusion in the audit market. In the framework, the client has its own preference for the different options offered by the audit firms. The covariance matrix of the coefficient in Table 4.5 shows that the preference of the companies in the manufacturing industry does not vary significantly. However, the variance listed in Table 4.6 has higher value. It shows that the clients would have varied preferences when they consider that the audit firms collude, suggesting that the clients would act differently when they perceive the audit firms are undergoing collusion.

It may also indicate that some clients may not take collusion in the market seriously and still consider their choice similar to the situation that the audit firms are independent of pricing strategies. However, the results of the posterior mean and the covariance matrix may only explain the mean effect of the utility model instead of the individual behaviour. With the advantage of applying the Bayesian approach in this research, the individual coefficient for every audit client in the sample can be examined and will be applied in the next discussion.

Table 4.4   Posterior Mean of the Demand Estimation $\bar{\beta}$

Variable	Mean (Standard Deviation)	
	Bertrand Competition	**Tacit Collusion**
$Intercept$	-1.91395699	-2.61652608
	(0.02544590)	(0.10822755)
PwC	1.03728842	-0.85088246
	(0.03733991)	(0.09269787)
$E\&Y$	0.89382737	1.37361475
	(0.03299547)	(0.07482137)
$Deloitte$	-0.37621822	-1.34522674
	(0.03620318)	(0.09478047)
$KPMG$	0.39282737	-0.69662085
	(0.03453965)	(0.07214387)
$PwC \times SALES\ (STD)$	0.99508462	0.87709688
	(0.02600659)	(0.05980988)
$E\&Y \times SALES\ (STD)$	1.78062704	1.76610086
	(0.04865420)	(0.06683821)
$Deloitte \times SALES\ (STD)$	1.63345341	2.70203955
	(0.02938780)	(0.06095193)
$KPMG \times SALES\ (STD)$	0.57078010	1.69803325
	(0.04758285)	(0.05191911)
$PwC \times INV\ TURN\ (STD)$	-0.09803422	-0.09359322
	(0.02614500)	(0.06232327)
$E\&Y \times INV\ TURN\ (STD)$	0.01429812	0.06103686
	(0.03211620)	(0.05492182)
$Deloitte \times INV\ TURN\ (STD)$	-0.17718035	-0.52654414
	(0.02349170)	(0.05723570)
$KPMG \times INV\ TURN\ (STD)$	-0.24058983	-0.64026989
	(0.03742760)	(0.09138650)
$Audit\ Fee\_Log$	0.72377131	2.09521540
	(0.00859435)	(0.01493927)

Table 4.5   Posterior Mean of Heterogeneity Covariance Matrix Σ_β (Betrand Competition)

Variable	Intercept	PwC	E&Y	Deloitte	KPMG	PwC × SALES (STD)	E&Y × SALES (STD)	Deloitte × SALES (STD)	KPMG × SALES (STD)	PwC × INVTURN (STD)	E&Y × INVTURN (STD)	Deloitte × INVTURN (STD)	KPMG × INVTURN (STD)	Audit Fee _Log
Intercept	0.4141 (0.0658)													
PwC	-0.2674 (0.0323)	1.3223 (0.0583)												
E&Y	-0.1771 (0.0269)	0.9066 (0.0437)	0.9681 (0.0427)											
Deloitte	-0.1947 (0.0336)	0.8680 (0.0478)	0.6448 (0.0373)	0.9156 (0.0489)										
KPMG	-0.2057 (0.0376)	0.9808 (0.0561)	0.7671 (0.0438)	0.7595 (0.0480)	1.1583 (0.0601)									
PwC × SALES (STD)	-0.0517 (0.0317)	0.2276 (0.0350)	0.0699 (0.0310)	0.0515 (0.0265)	0.0810 (0.0302)	0.5492 (0.0367)								
E&Y × SALES (STD)	0.0983 (0.0252)	-0.2936 (0.0313)	-0.2236 (0.0277)	-0.2853 (0.0325)	-0.3583 (0.0321)	0.0941 (0.0268)	0.5430 (0.0351)							
Deloitte × SALES (STD)	0.1171 (0.0316)	-0.4131 (0.0623)	-0.3107 (0.0581)	-0.1836 (0.0650)	-0.3435 (0.0652)	-0.0681 (0.0273)	0.0806 (0.0427)	0.6162 (0.0481)						
KPMG × SALES (STD)	-0.0093 (0.0361)	0.0439 (0.0633)	-0.0614 (0.0654)	0.0598 (0.0435)	0.3013 (0.0494)	0.0237 (0.0308)	-0.1079 (0.0449)	0.0100 (0.0510)	0.8577 (0.0991)					
PwC × INVTURN (STD)	0.0282 (0.0275)	-0.1842 (0.0458)	-0.1692 (0.0450)	-0.1096 (0.0386)	-0.0980 (0.0351)	-0.2034 (0.0251)	-0.1078 (0.0263)	0.0587 (0.0337)	0.0534 (0.0283)	0.5208 (0.0628)				
E&Y × INVTURN (STD)	-0.0281 (0.0380)	-0.0666 (0.0301)	-0.0682 (0.0260)	-0.0019 (0.0308)	-0.0090 (0.0421)	-0.2269 (0.0540)	-0.1828 (0.0320)	0.0292 (0.0355)	0.0042 (0.0228)	0.3553 (0.0342)	0.5711 (0.0838)			

Variable	Intercept	PwC	E&Y	Deloitte	KPMG	PwC × SALES (STD)	E&Y × SALES (STD)	Deloitte × SALES (STD)	KPMG × SALES (STD)	PwC × INVTURN (STD)	E&Y × INVTURN (STD)	Deloitte × INVTURN (STD)	KPMG × INVTURN (STD)	Audit Fee _Log
Deloitte × INVTURN (STD)	0.0513	-0.1016	-0.0815	-0.0442	-0.0386	-0.1163	-0.0510	-0.0113	0.0658	0.1560	0.1595	0.3065		
	(0.0148)	(0.0397)	(0.0365)	(0.0219)	(0.0291)	(0.0269)	(0.0211)	(0.0350)	(0.0210)	(0.0210)	(0.0360)	(0.0199)		
KPMG × INVTURN (STD)	0.0048	-0.2623	-0.1894	-0.2174	-0..1511	-0.2615	-0.1181	0.0292	-0.0157	0.2642	0.3498	0.0764	0.7406	
	(0.0342)	(0.0454)	(0.0435)	(0.0494)	(0.0427)	(0.0289)	(0.0254)	(0.0355)	(0.0281)	(0.0294)	(0.0522)	(0.0306)	(0.0611)	
Audit Fee_Log	-0.0227	0.1523	0.1233	0.0923	0.1340	0.0082	-0.0470	-0.0462	0.0416	-0.0198	-0.0113	-0.0123	-0.0234	0.0727
	(0.0113)	(0.0112)	(0.0103)	(0.0090)	(0.0110)	(0.0073)	(0.0081)	(0.0082)	(0.0101)	(0.0068)	(0.0085)	(0.0099)	(0.0093)	(0.0039)

Table 4.6   Posterior Mean of Heterogeneity Covariance MatrixΣ_β (Tacit Collusion)

Variable	Intercept	PwC	E&Y	Deloitte	KPMG	PwC × SALES (STD)	E&Y × SALES (STD)	Deloitte × SALES (STD)	KPMG × SALES (STD)	PwC × INVTURN (STD)	E&Y × INVTURN (STD)	Deloitte × INVTURN (STD)	KPMG × INVTURN (STD)	Audit Fee _Log
Intercept	0.7516 (0.6869)													
PwC	-0.2862 (0.4696)	8.6709 (0.8801)												
E&Y	-0.3147 (0.6325)	5.1043 (0.6195)	5.3920 (0.3109)											
Deloitte	-0.5910 (0.3706)	5.6255 (0.8455)	3.7412 (0.4536)	6.5190 (0.7806)										
KPMG	-0.1052 (0.5474)	5.0900 (0.4442)	3.6870 (0.4341)	4.3439 (0.3502)	5.6722 (0.3601)									
PwC × SALES (STD)	0.2505 (0.6096)	-2.4827 (0.5691)	-1.2742 (0.4649)	-2.4044 (0.4132)	-1.2113 (0.2112)	2.2278 (0.4499)								
E&Y × SALES (STD)	-0.0933 (0.6618)	-2.7863 (0.3610)	-2.1768 (0.3005)	-1.6412 (0.2789)	-1.9794 (0.3991)	0.5868 (0.4643)	1,6901 (0.7059)							
Deloitte × SALES (STD)	0.1722 (0.2884)	-2.5624 (0.7984)	-0.9977 (0.3338)	-1.7326 (0.2330)	-1.3369 (0.3545)	1.0084 (0.2486)	0.7640 (0.2859)	2.1280 (0.3029)						
KPMG × SALES (STD)	0.0675 (0.4453)	-1.8707 (0.4937)	-1.0582 (0.6385)	-1.0440 (0.6860)	-1.1065 (0.4540)	0.9652 (0.6504)	0.6089 (0.5045)	0.4800 (0.3668)	1.4827 (0.9540)					
PwC × INVTURN (STD)	0.3486 (0.3643)	-0.6999 (0.3139)	-0.6042 (0.4575)	-0.7905 (0.5478)	-0.7831 (0.5073)	0.1478 (0.2493)	0.2001 (0.3798)	0.2133 (0.2090)	0.2515 (0.3551)	1.1076 (0.5382)				
E&Y × INVTURN (STD)	0.2892 (0.3012)	0.2504 (0.479)	-0.2036 (0.2426)	-0.1580 (0.3986)	-0.7089 (0.3611)	-0.6453 (0.4560)	0.0488 (0.2228)	-0.2413 (0.3708)	-0.0123 (0.2440)	1.0954 (0.2691)	2.5125 (0.3922)			

Variable	Intercept	PwC	E&Y	Deloitte	KPMG	PwC × SALES (STD)	E&Y × SALES (STD)	Deloitte × SALES (STD)	KPMG × SALES (STD)	PwC × INVTURN (STD)	E&Y × INVTURN (STD)	Deloitte × INVTURN (STD)	KPMG × INVTURN (STD)	Audit Fee _Log
Deloitte × INVTURN (STD)	0.2547 (0.8118)	-0.4465 (0.6068)	-0.2388 (0.4543)	-0.0378 (0.5475)	-0.3440 (0.3500)	-0.2702 (0.4956)	0.2030 (0.3761)	0.0092 (0.1586)	0.0211 (0.4003)	0.5170 (0.3496)	1.1552 (0.4049)	1.5184 (1.1827)		
KPMG × INVTURN (STD)	0.2282 (0.5044)	-0.0154 (0.3881)	-0.0647 (0.4645)	0.6621 (0.5831)	0.1927 (0.2821)	-0.3467 (0.6674)	0.2069 (0.5399)	0.1559 (0.3026)	-0.0565 (0.7861)	0.5508 (0.2434)	1.0414 (0.2844)	0.9695 (0.4430)	1.8263 (0.6510)	
Audit Fee_Log	-0.0198 (0.8365)	0.2421 (0.6325)	0.1737 (0.4979)	0.0388 (0.8433)	0.1525 (0.7939)	0.0346 (1.1643)	-0.0709 (0.6177)	-0.1316 (0.8218)	0.0067 (1.2151)	-0.0242 (0.8697)	-0.0041 (0.3816)	0.0124 (1.0872)	-0.0497 (0.8724)	0.1582 (1.4824)

Table 4.7   Covariance Matrix Σ_ψ for Demand Shock ψ_{jt} (Bertrand Competition)

	PwC	E&Y	Deloitte	KPMG	Non-Big Four
PwC	0.4889				
	(0.1960)				
E&Y	0.0952	0.4377			
	(0.1363)	(0.1865)			
Deloitte	0.0221	0.0499	0.4363		
	(0.1300)	(0.1237)	(0.1747)		
KPMG	0.1527	0.0982	0.0124	0.5353	
	(0.1512)	(0.1411)	(0.1331)	(0.2201)	
Non-Big Four	0.0676	0.0720	0.0706	0.0636	0.4393
	(0.1307)	(0.1236)	(0.1236)	(0.1340)	(0.1787)

Table 4.8   Covariance Matrix Σ_ψ for Demand Shock ψ_{jt} (Tacit collusion)

	PwC	E&Y	Deloitte	KPMG	Non-Big Four
PwC	0.3844				
	(0.1530)				
E&Y	-0.0613	0.6271			
	(0.1388)	(0.2523)			
Deloitte	0.0398	-0.1314	0.4298		
	(0.1110)	(0.1478)	(0.1704)		
KPMG	0.0165	-0.0311	0.0208	0.3619	
	(0.1057)	(0.1306)	(0.1079)	(0.1438)	
Non-Big Four	0.0294	-0.0865	0.0506	0.0141	0.3964
	(0.1098)	(0.1424)	(0.1165)	(0.1044)	(0.1694)

4.6   Discussion

This research develops the framework of the simultaneous effect of supply and demand in the audit market. On the demand side, the client would choose the audit firm based on client characteristics, the audit firms and the audit fee. On the other hand, the audit firm would have pricing strategies considering the probability of client choice.

Moreover, this research has estimated the parameters under two assumptions. First, assuming that the pricing strategies of the audit firm would be completely based on the expected profit that the

audit firm may earn, which is Bertrand competition. On the contrary, the second argument in this research supposes that the audit firms in the market would collude with each other and therefore set the price based on the total profit in the market. With these two assumptions, the framework could observe two different sets of parameters. In addition, by allowing heterogeneity among the clients and applied Bayesian approach for estimation, this research could observe the individual coefficient for every client in the sample.

In order to compare which assumption is better, Akaike information criterion (AIC) and Bayesian information criterion (BIC) are adopted to examine the relative quality of the statistical models. Both information criteria are based on the maximum likelihood calculated in the estimation procedure, where the model with the lowest value is preferred. When comparing the statistical models with likelihood, overfitting is often considered a concern in building a model where more independent variables are more likely to increase the likelihood. To resolve the problem, AIC and BIC introduce a penalty term into the formula by considering the number of parameters in the model, where BIC addresses the penalty term in a more significant term. Table 4.9 shows the value of AIC and BIC under two scenarios in the research.

Table 4.9   Comparison of Information Criteria under Two Assumptions

	AIC	BIC
Bertrand Competition	2201.296	4846.725
Tacit Collusion	2319.283	4964.712

Table 4.9 shows the value of the information criteria, AIC and BIC, under two scenarios. The difference between AIC and BIC is due to a large number of data including in the sample which causing the high penalty term. The value of the information criteria shows that under the assumption that the audit market behaves as Bertrand competition, where the audit firms are independent when setting price, the framework fits the sample better than assuming the auditors engage in tacit collusion. The result is also consistent with the nature of auditing where the auditor should act as a monitoring role in the market. However, since the framework allows heterogeneity in client utility, the information criteria adopted could only examine the overall effect. Therefore, it is worth considering if the audit firm would have varied pricing strategies for different clients.

The advantage of the Bayesian approach with the random-walk algorithm allows the estimation to be conducted on an individual level. By retrieving the parameters in the utility model for each client, it could enable the research to compare the predicted choice based on the estimated coefficients and the actual choice. This additional examination includes the same manufacturing companies with the sample used in the estimation from the years 2013-2015. First, the utility for each client

can be built from the equation (4.1) where the individual coefficients are obtained from the estimation. Since the demand shock ψ_{jt} and error term ε_{ijt} are is varied with time t, they could be drawn from the distributions written as follows:

$$\psi_{jt} \sim N\left(0, \Sigma_\psi\right) \tag{4.9}$$

$$\varepsilon_{ijt} \sim EV(0,1) \tag{4.10}$$

where the covariance matrices Σ_ψ under two assumptions are listed in Table 4.7 and Table 4.8.

According to the concept of utility maximisation, the client would choose the audit firm which could maximise its utility. With generating 1000 draws from the normal distribution for demand shock and extreme value distribution for error term, the predicted choice could be obtained based on the random utility model. By comparing the actual choice and estimated choice based on maximal utility, the percentages of the framework of Bertrand competition and tacit collusion could possibly estimate are around 35 percent and 50 percent of choices respectively. The possible reasons for deficient prediction are as follows.

First, the client considers more aspects when choosing the auditor. Owing to the random coefficient included in the demand-side model, there are only a few client characteristics considered in the utility model in order to prevent the problem of identification. However, due to the efficiency of the estimation, the sample year and the number of variables are limited. It is expected that the prediction could be more precise when the sample size, especially the time, gets larger. Second, because of the concept of discrete choice, the prediction only consider which audit firm could provide the highest utility to the client. It is likely that the probabilities between the client choosing different audit firms are close, but the prediction rules out the other possible choice based on the assumption that the client will only choose one audit firm.

In addition, there are some feasible inferences with regard to the prediction. The tacit collusion among audit firms does not affect the preference of the client. Even though the posterior means of the parameters in the utility model are different under two assumptions, it is possible that the individual coefficient does not vary significantly. In such case, both frameworks may predict the choice successfully. On the other hand, it is probable that the audit firms will only consider colluding with each other when providing audit service to the certain client. Since there are numerous companies in the industry, the audit firm may focus on the reputable companies which could enhance its reputation by providing services. Therefore, the individual difference should be taken into consideration when conducting the prediction.

4.7   Summary

This research has aimed to examine the simultaneous effect on the demand and supply sides in the audit market. The research assumes that the client would choose the audit firm based on utility maximisation and the probability of the client choice can be calculated with the discrete choice model. On the other hand, the pricing strategy of the audit firm is dependent on the expected profit that the audit firm would get, which is determined by the probability of client choice and the marginal profit. Considering that the audit fee would influence the client utility and therefore the client choice and on the other hand, the client choice will also have an impact on the audit pricing, while the simultaneous effect is developed in the framework.

In the random utility model, the setting of random coefficients allows heterogeneity among the clients instead of only examining the mean effect. In addition, this research assumes that the audit service is differentiated and the clients would consider the audit firms, especially the Big Four, respectively. In addition, this research proposes two arguments with regard to the strategy of the audit firm. With the concept of profit maximisation of the supplier, the first estimate is carried out by assuming that the audit market acts as the Bertrand game where the audit firm would determine the audit fee based on its expected profit. The other proposition assumes that the audit firms in the market would behave in tacit collusion which lets the suppliers set the price based on the total profit in the audit market.

The results in the posterior mean of the parameters show that the client is more likely to choose the PwC, which is viewed as the specialist in the industry, under the Bertrand competition. The client may consider that by hiring the specialist, the audit quality would be enhanced because of auditor's knowledge and experience. However, the Big Four audit firms, especially the specialist, do not appear more favourable than the non-Big Four audit firm when the audit firms are presumed to undergo collusion. Since the price may increase due to the tacit collusion among the audit firms, the client may have doubts with the benchmark of being as a specialist since the audit fee may be overcharged.

On the other hand, Deloitte, which has less market share among the Big Four audit firms in the manufacturing industry, is not preferred by the client in either proposition. Even though there are some medium audit firms in the market which is considered to be non-Big Four, the client may view them similar to Deloitte because their market share may be close. Therefore, instead of choosing Deloitte, the client may prefer to hire other medium audit firms to maintain a long-term relationship with the auditors. In addition, the results indicate that the client with higher sales is more likely to choose the Big Four audit firms. These companies tend to be large and reputable,

and they would consider hiring the trustworthy audit firms in order to get better audit quality and increase its operation management if necessary.

However, the companies with high inventory turnover prefer to stay with the non-Big Four audit firms. This may be due to the fact that the inventory check for the Big Four may be more complex which causing the delay of the operations in the companies, so the companies would rather consider the medium or small audit firms to maintain its operational efficiency. With regard to the audit fee, the client is willing to pay higher audit fee when choosing the audit firm. Since the role of auditing is to detect any material misstatement and detect any fraud within the corporation, the company is willing to pay higher price for better audit quality. Besides, it is possible that the stakeholders would consider the audit fee as the proxy for the quality of financial reports and the high audit fee may send a signal of reduced information asymmetry.

This research is aimed to introduce the simultaneous effect on the demand and supply sides in the audit market. Considering the past research on both sides of the market (e.g. auditor choice on the demand side and the audit fee analysis on the supply side) are extensive but separate, this research intends to fill the discrepancies. It is believed that this research is one of the few papers to discuss the interaction between auditor and clients with simultaneous effect in accounting and auditing literature. Moreover, by applying the random coefficient in the utility model, this study is expected to shed more light on heterogeneity among clients, which should be taken into consideration in future research.

Chapter 5   Conclusion

5.1   The demand and supply in the audit market

Professional service is viewed as deploying knowledge in a work setting and this thesis has focused on the audit service. Compared to other service industries, the audit market is relatively unique because of its regulatory environment. The publicly listed companies in the United States are required to disclose the audit fee after the U.S. passed SOX in 2002. This mandatory regulation enables the researchers to obtain the fee for each audit service and the detailed information of both supplier and client, which the traditional operation research lacks. Being that the audit service is differentiated based on the audit firm and the audit client, the transparency of the audit market will be beneficial to the research with the individual data rather than the aggregate data. Therefore, this thesis intends to examine the supply and demand in the audit market.

Different from other professional services, the auditor is believed to be an independent monitoring role to detect any material misstatement, fraud and operation inefficiency in the corporate. The publicly listed companies are mandated to choose one of the audit firms to have an audited financial report periodically which thus creates the stable supply and demand in the audit market. In past accounting and auditing literature, the supply and demand side of the audit market has been discussed extensively but separately.

On the demand side, the auditor choice and the auditor switch have been examined by logistic regression to determine the factors that would influence the client's choice. Recent studies of Gerakos and Syverson (2015) and Guo et al. (2017) apply the discrete choice model with utility maximisation to inspect the client utility and further discuss the policy implementation in the audit market. On the supply side, there is a number of research investigating the factors and the effects of auditor resignation and client dismissal. Different from the supplier in other industry, it is believed that the auditor would assess the risk of engagement rather than only consider the profit. Moreover, some researchers also propose that the audit firm will measure the risk based on the client portfolio instead of an individual client (e.g. Simunic and Stein, 1990; Shu, 2000). Besides the auditor's decision of acceptance and resignation, the audit fee has been researched thoroughly, including the lowballing effect and the contribution to the audit fee premium.

However, there are discrepancies in the research of incorporating the supply and demand sides in the audit market, whereas the previous studies only focus on the single aspect. Therefore, this thesis intends to examine the demand and supply sides in the audit market respectively with the

related counterfactual analysis and further discusses the simultaneous effect on both sides in the market.

5.2   Discussion

Instead of using logistic regression and ordinary least squares to examine the demand (e.g. auditor choice) and the supply (e.g. client portfolio) in the audit market, this thesis incorporates utility maximisation model stemmed from utility theory with structural estimation. By adopting the utility model, the individual, including the audit client and the audit firm, is expected to make the decision in order to maximise its utility. This approach has been used extensively in marketing and operation research but rarely discussed in the stream of accounting literature.

In addition, apart from traditional accounting and auditing literature, this thesis applies Bayesian approach to address the heterogeneity among the client and the audit firm. With traditional frequentist approach, the audit firm and the audit client is assumed to be homogenous where the estimated coefficients are fixed. On the demand-side problem, prior research uses client characteristics to examine the association between the client's attributes with auditor choice. However, the fixed parameters could only demonstrate the relationship between client characteristics and the probability of the client choosing the specific audit firm. By allowing heterogeneity in the utility model, the framework assumes that each client could its own consideration and it is expected that the client would act differently. The research often classifies the audit firms by Big Four/non-Big Four with the brand name and specialist/non-specialist with the market share that each audit firm owns. Recent studies of Gerakos and Syverson (2015) and Guo et al. (2017) apply the discrete choice model and suggest that the audit firm would provide heterogeneous audit service.

Therefore, in this thesis, the structural estimation is used while the concept of utility maximization is applied to examine both the demand and supply sides in the audit market. The following are the remarks of the three studies in this thesis respectively.

First, the thesis starts from discussing the auditor choice in the demand side. Following Gerakos and Syverson (2015), the auditor choice could be adapted to the discrete choice problem, where the client would choose the audit firm with the highest utility. Besides considering the auditor choice, the framework attempts to investigate whether switching the audit firm would have an impact on the client's utility. Consistent with the research outcome of Gerakos and Syverson (2015), the posterior mean shows that the client prefers lower price when selecting the audit firm. However,

since the framework allows heterogeneity among the audit clients, the result shows that there is a significant variance in the clients' preference, which has not been discovered by previous research. With the consideration of the auditor switch, the result shows that the client does not prefer to switch audit firm, which justifies the prior research that the client would incur switching cost when switching the auditor (DeAngelo, 1981; Chu, Simunic, Ye and Zhang, 2018).

With the utility maximisation theory and the application of the discrete choice model, the first research question is addressed in Chapter 2:

Remark 1: The switch has a negative association with the auditor choice, showing that the switching cost is significant for the client.

Besides adopting the client's utility model to examine the auditor choice, the adoption of Bayesian approach with the random-walk algorithm allows the estimation process to estimate the individual parameters. That is, the researcher could able to evaluate each client's preference rather than examining the mean effect. With the estimated parameters in the client's utility model, the discussion of auditor choice is further extended to examine the behaviour of auditor switch. As observed in the posterior mean and variance of the coefficients in the utility model, even though the mean effect shows that the client prefers lower price when selecting audit firm, the significant variance should be taken into consideration where some clients would consider higher audit fee preferable when selecting the audit firm. Coherent with previous research suggesting that the client would receive higher audit quality with higher audit fee (DeFond and Zhang, 2014; Fung et al., 2012; Dao et al., 2012), the analysis in Chapter 2 shows that the client would act differently when choosing the auditor, which is different from the previous literature. The analysis further differentiates the client behaviour into three groups: preferring higher price, willing to negotiate and being loyal. By comparing the incumbent and the competing audit firm, the result shows that the client with higher total assets and sales has the tendency to pay higher audit fee. Since the company with higher sales is considered as the leader in the industry, the client may seek to receive higher-quality audit in order to enhance its credibility to its stakeholders.

On the other hand, the clients with higher current ratio are more willing to negotiate the price and switch to the competing audit firm if the fee discount is favourable. Higher current ratio may represent that the client has higher organizational slack and better liquidity ability, which could enhance the client's bargaining power for its healthy financial performance. In the analysis, the result shows that there are clients who are loyal to its incumbent auditor, where the fee discount needed to offer is inapplicable. When the client's incumbent auditor belongs Big Four audit firm, the companies with higher EPS and inventory turnover are shown to be loyal to its incumbent auditor. Since switching auditor may be considered as opinion shopping to the public (Chow and

Rice 1982; DeFond, Zhang and Zhao, 2018), which will deteriorate the company's reputation, the client may choose the same audit firm to prevent bad news in the market. However, for the companies who have high inventory turnover, the outcomes show that they may act differently according to their incumbent and competing audit firm. Rather than being loyal to the incumbent auditor, the companies hire non-Big Four audit firm as incumbency may be more willing to switch to Big Four audit firm if the discount is favourable. The client may perceive Big Four auditor as the specialist because of the large number of clients audited in the same industry and the resources and consider to switch from non-Big Four audit firm to Big Four as to enhance the efficiency of the inventory inspection and its operation. With the counterfactual analysis discussed in Chapter 2, the second research question in this thesis could be handled:

Remark 2: Despite the switching cost, the clients would have different reactions (e.g. preferring higher price or being loyal to the incumbent auditor) when receiving the audit fee discount offer from the competing audit firm.

After discussing the demand-side problem, this thesis continues to examine the supply side in the audit market by applying utility theory. Different from the supplier in other industries whose target is to maximise the profit, accounting research has argued that the auditor would take other factors into consideration, such as the risk, including the client's financial risk and audit risk, because the auditor is expected to be independent to alleviate the agency problem between the company and its stakeholders. Therefore, rather than using the model of profit maximisation with the audit fee, the utility model is considered to better examine the audit firm's strategy, which has been discussed in prior research on auditor's decision (e.g. Kinney, 1975; Lewis, 1980). In addition, when examining the audit firm's client portfolio, prior research often adopts the traditional frequentist approach (e.g. ordinary least square and logistic regression) to discuss the auditor resignation and acceptance (e.g. Johnstone, 2000; Johnstone and Bedard, 2003; Shu, 2000; Gendron, 2001; Ghosh, 2015; Lennox and Kausar, 2017). However, some researchers suggest that the audit firm would evaluate the prospective client according to its existing client portfolio rather than individually, which would justify the additive utility model applied in the second stream of the research in this thesis.

Following the utility theory, the audit firm is expected to maximise its utility by providing service to different categories of the client under limited resources, including human resource and technology. Under the framework, the clients are classified into five groups by the total sales each company has. With the adoption of the additive utility function, the audit firm's utility is the sum of the utilities that the audit firm provide service to each category of client, where the audit firm is allowed to audit more than one client in the specific category and more than one category. Based on the

market share calculated by the audit fee and the number of the client, there are numerous of audit firm providing services in the market but some audit firms own a large share in the industry, especially Big Four audit firm. Since Big Four and medium-sized audit firm may have more resources, their strategy is believed to be differentfrom others. Therefore, instead of using the frequentist approach (e.g. maximum likelihood) to estimate the fixed effect, the framework allows heterogeneity among the audit firms, where they could have various strategies of forming its client portfolio.

To address the third research question, the Bayesian approach with the random-walk algorithm is used to estimate the audit firm's utility. The posterior mean of the results shows that the audit firm providing service to the manufacturing industry prefer to bid for the clients with lower sales. Compared to prior literature that the auditor would not prefer to resign from the client with a larger size, including more total assets and sales, the mean effect shows opposite outcomes. The difference in the outcomes may result from the sampling method. Prior research examines the association between client characteristics and auditor resignation where the Big Four audit firms provide service to more than 70% of the client. On the other hand, the framework here considers the client portfolio by examining the audit firm's utility model. Since there are numerous small audit firms in the market, the posterior mean may be biased.

However, the advantage of the random-wall algorithm is that the research would be able to retrieve the estimated coefficients for every individual. Despite the posterior mean shows that the audit firm prefers to audit the client with sales lower than average, the variance of the random coefficient is large, representing that there is a significant difference in the audit firm's strategy toward its client portfolio, which has not been discussed in the previous literature.

Remark 3: The audit firms prefer to provide audit service to the company whose sales are below average but for whom the individual difference is significant, especially for the Big Four audit firms.

Because the results of the estimation could allow the researcher to observe the estimated coefficients for each audit firms, the research further extends to discuss the optimal client portfolio when the cost of audit work changes. After the U.S. passed Sarbanes-Oxley 2002, the audit firm is expected to carry out more audit work (e.g. more audit hour) when providing the service, which would increase the cost of each engagement and therefore, may impact the client portfolio due to limited resources. Based on the utility theory, the individual would maximise its utility considering the budget limited, which in this case is the total resources the audit firm has.

The analysis starts from examining the Big Four audit firm's client portfolio because they have the most clients in the industry and estimated coefficients are different than the mean effect. From the

results of individual coefficients, Big Four audit firms prefer to provide audit service to the client with higher sales, which is consistent with previous literature that the auditor prefers not to resign from clients whose size is bigger. However, even though the Big Four has the similar preference, the analysis shows that their optimal strategies for the client portfolio are different. PwC, which is considered as the specialist in the sample because of the highest audit fee earned, are less likely to drop the clients with the highest sales. Because the reputation of being the specialist is based on the total audit fee earned, PwC is more likely to keep as many large clients as possible to maintain its reputation, which is more consistent with the argument of audit firm's commercialism raised by Gendron (2001). From the economic perspective, PwC is more likely to consider its strategy based on the economic of scale where the audit firm tends to serve as many clients with higher sales as possible since they may have similar audit procedure.

On the other hand, E&Y's, which owns most of the clients in the sample, client portfolio is slightly different from PwC. Rather than only putting focuses on the clients with most sales, economies scope is considered to be E&Y's strategy where it strives to provide audit service to as many clients as possible. The audit firm may consider the trade-off between the number of the client and the client size in its client portfolio. Therefore, instead of resigning from the clients with lower sales, E&Y will attempt to withdraw from the high sales client to maintain as many clients as possible in its client portfolio. Without considering the existing client portfolio and the factor of the audit firm, the research has biases on the determinants of auditor resignation and acceptance.

Besides Big Four audit firms, the analysis examines two medium-sized audit firm, Grant Thornton and BDO, which have more than 50 clients in the manufacturing industry. Since the medium-sized audit firm does not have as much resource as the Big Four audit firms have, it is believed that the optimal client portfolio will be different when the cost of auditing changes. The counterfactual analysis shows Grant Thornton and BDO are more likely to resign from the clients whose sales is around average when the cost increases. Due to the limited resource, the audit firms would not be able to maintain auditor-client relationship with all companies with higher sales. However, the audit firm may still attempt to keep the largest client in the portfolio in order to maintain its reputation and profit.

The analysis in the research on the supply side shows part of the inconsistency with the prior research where the audit firms may not prefer the large clients when the resource is limited considering its existing client portfolio. Moreover, even among Big Four audit firms which own most of the resource would have varied strategies in forming the client pool, including economic of scale

and economic of scope. This research justifies the prior literature that the audit firm would assess the prospective client in portfolio context rather than individually.

Remark 4: Due to the individual difference, the audit firms have a varying strategy when the cost of auditing increases (e.g. economies of scale versus economies of scope).

Based on the economic theory of supply and demand, the price in the market is determined by the demand and the supply in the trading market. With such concept, the third research follows the similar framework proposed by Yang et al. (2003) where the price of the product is determined by the maximisation of customer's utility and the supplier's profit. To examine the simultaneous effect on both demand and supply side in the audit marketm, the similar utility model in the first reseach of this thesis is adopted on the demand side, where the audit firm and the audit fee is considered as one of the determinants that would influence the client's selection. On the other hand, as mentioned is the supply-side problem, besides considering the relevant risk, the audit firm would attempt to maximise its profit by increasing the audit fee, lowering the audit cost. In addition, to calculate the possible earnings, the audit firm would consider the expected profit, which would take the probability of the client choosing the audit firm into consideration. Since the client would consider the audit fee in its utility and therefore impact the probability of the choice of each audit firm, and the audit fee would also be influenced by the probability of the choice based on expected value, there is a simultaneous effect on both client's selection and audit firm's profit maximisation due to the interlink of the audit fee. This is consistent with the theory of supply and demand where the price in the market will reach to an optimal point due to the interaction of supply and demand side.

As delineated in the previous part of the demand problem in the audit market, there is limited research examining the auditor choice in the framework of discrete choice (Gerakos and Syverson, 2015; Guo et al., 2017) but the traditional logistic regression are used extensively to examine the association between the client's choice and auditor-client determinants. On the other hand, audit fee has been discussed thoroughly with different indicators, including the auditor's characteristics (e.g. Big Four and specialist) and the client's attributes (e.g. client size), but few literature applies the concept of expected profit into consideration where the probability of the client choice should be taken into consideration. Therefore, the third research extends the framework in the first research on client's utility model with the application of the theory of profit maximisation in audit firm's pricing strategies and examine the simultaneous effect on both demand and supply side in the audit market.

Because of the implication on the supply side, two different assumptions are implemented under the framework, including Bertrand competition and tacit collusion. Under the assumption of

Bertrand competition, the audit firm is expected to maximise its profit by making the trade-offs between increasing its market share and the price of the service. On the other hand, the audit firms are assumed to undertake collusion with other audit firms in the market and the ultimate target of profit maximisation would take other audit firms into account rather than its own profit.

The results under two assumptions are expected to be different. When the audit firm is expected to be independent with others, the client prefers to choose PwC, which is considered as the specialist in the industry. However, the audit client would not value the specialist as much when assuming the market is undergoing tacit collusion. Since the specialist is defined by the market share that the audit firm owns, each audit firm's market share may be the product of the collusion rather than the audit effort that the audit firm carries out. Different from the previous research on the auditor choice, the outcomes show that the client is more willing to pay higher audit fee when choosing the audit firm when taking the simultaneous effect of both supply and demand side in the market. Moreover, the preference in paying higher fee is more significant under the assumption of tacit collusion. Since the client would be able to receive higher-quality audit when paying higher fee, it may be more willing to choose the audit service with higher audit fee in order to increase the credibility of the financial reports. In addition, when assuming that the audit firms are undertaking tacit collusion, the client may intend to pay more to the audit service because it may need to pay more premium to the audit firm in order to have the same level of audit quality.

In order to examine which scenario captures the audit market better, the analysis further adopts information criteria, including Akaike information criterion (AIC) and Bayesian information criterion (BIC) to compare the framework under the assumption of Bertrand competition and tacit collusion. The analysis shows that the framework assuming that the audit firms are independent under Bertrand competition could better depict the audit market. This result justifies that the audit firm should be independent considering it serves as the role of reducing information asymmetry in the market. However, by allowing the heterogeneity in the market, the research also implements the individual coefficients to conduct the predictive analysis, which shows the opposite outcome as the information criteria. The deficiency of the prediction may due to the fact that some audit clients may not consider whether the audit firms are under collusion and would have the same selection and the audit firms may also consider colluding with respect to a certain client. This result is expected to raise the attention to the authority in concern with the independence of the audit firm.

Remark 5: The clients will consider the factors (e.g. the audit firm) differently when choosing the audit firm under two scenarios. The information criteria indicate that the audit firm is considered to be independent rather than engaging in tacit collusion.

5.3   Summary

As to examine the demand and supply in the audit market, this thesis follows the utility maximisation theory to discuss the demand-side and supply-side problem, including the auditor choice and audit firm's client portfolio. Different from previous accounting research adopts ordinary least squares the logistic regression to discuss the association between the client's and the audit firm's choice and the auditor-client relationship, the theory of utility maximisation assumes that the individual would attempt to select the options to maximise its utility. Such approach has been widely used in marketing and operation research but only a few accounting literatures discuss the audit market with examining the client's and audit firm's utility.

Besides adopting the theory of utility maximisation to conduct the structural estimation, this thesis further allows heterogeneity in the framework. That is, instead of assuming they are homogenous and have the same utility model, the clients could have different preference and consideration when selecting the audit firm and the audit firm could also have different strategies for its client portfolio. The concept of heterogeneity has been widely used in the marketing and operation research while few accounting literatures has considered. In order to carry out the structural estimation with random coefficients, the Bayesian approach with Markov Chain Monte Carlo is adopted in this thesis. Different from the traditional frequentist approach (e.g. ordinary linear regression) in prior accounting research, the estimation is carried out by iteratively sampling from the full conditional likelihood, and the advantage of the random-walk algorithm allows me to examine the parameters for every individual in the sample rather than the posterior mean and variance.

The first research in this thesis starts from the demand side, where the client is assumed to choose one of the audit firms in the market due to the mandatory requirement. Following the similar framework proposed by Gerakos and Syverson (2015), the first stream of research in Chapter 2 examines the utility model that the client has when selecting the audit firm. With regard to the coefficient in price, the result is consistent with prior literature that the client prefers lower price when purchasing the audit service. However, by allowing the heterogeneity among the audit clients, the outcome shows that there is a significant variance in the coefficients, suggesting that the audit clients have varied preferences when considering the audit fee. Since this issue has not been discussed in the previous literature due to the fixed effect, the analysis further examines the client's behaviour in consideration with the price effect on auditor switch. As mentioned in the previous paragraph, the advantage of adopting the random-walk algorithm is that the individual parameters would be recorded during the estimation process, which allows the researchers to further examine. Therefore, the counterfactual analysis in Chapter 2 implements the estimated coefficients and

compares the audit fee of the incumbent audit firm and competing audit firm according to the theory of utility maximisation. By the audit client's behaviour toward audit fee discounting, the analysis further classifies the clients into three categories: preferring higher price, willing to negotiate and being loyal. Coherent with the similar research showing that the client prefers lower price, the analysis shows that there are some clients prefer lower price, especially the clients with higher current ratio. Because the companies are believed to have better financial performance, they may be more capable of bargaining with the audit firm.

Besides negotiating with the audit firm, the results show that there are companies which are willing to pay higher audit fee in order to receive better audit quality and enhance the credibility of its financial reports. The companies with bigger size (e.g. higher sales and total assets) are more likely to pay higher fee because they may intend to deliver good signal to its stakeholders to maintain its reputation and enhance its efficiency of the operation by asking the audit firm to conduct more audit work. On the other hand, the analysis also finds that the clients with higher EPS and inventory turnover are less likely to switch audit firm considering the audit fee discount. Since the market may perceive the auditor switch as a bad signal, the companies may attempt to maintain the auditor-client relationship in order to prevent bad news affecting its EPS and stock performance. However, there is an inconsistency for the client to switch audit firm with respect to the inventory turnover. The analysis shows that the client hiring non-Big Four audit firm as incumbent auditor are more willing to switch to Big Four if the audit fee offered is favourable to have better inspection to its operation and increase the efficiency, but the companies which already hire Big Four would be loyal to its incumbent audit firm since switching the auditor may increase the time for the client and new auditor getting familiar with each other.

The second research in Chapter 3 in this thesis switch the focus to the supply side of the audit market. Consistent with the previous chapter where the client would choose the audit firm with the highest utility, this research also applies the theory of utility maximisation to examine the audit firm's strategy of the client portfolio. Different from the supplier in other industries whose target is to maximise the profit, the auditor is expected to be independent from the client and to reduce the information asymmetry between the company and its stakeholders. Previous accounting and auditing research suggests that the audit firm would consider both professionalism and commercialism (Gendron, 2001) when accepting the prospective client. In addition, when accepting prospective client and resigning from the existing client, the audit firm would assess the client, including the risk, and researchers argue that the auditor may evaluate the client in accordance to its client portfolio rather than to individual. For example, since the audit firm may provide more

than one client in the industry, the audit firm may be able to spread the individual client risk to its client pool. Therefore, instead of following the prior accounting research using ordinary least square approach to examine the association between auditor's behaviour and the client characteristics, each audit firm is assumed to maximise its total utility by examining the client in the portfolio context.

Similar as the research on demand-side, this research on audit firm's client portfolio also assumes that the audit firm would have different utility model. The assumption is believed to be applicable because there are numerous audit firms providing audit service to the publicly listed companies but each audit firm would have varied strategies based on its size and the resources. The research divides the companies in the manufacturing industry into different categories based on the total sales following the concept that the companies with larger size may require more audit effort by the auditor, where the framework assumes that each audit firm would have limited resource to provide audit service. Different from the previous research, the posterior mean of the research shows that the audit firm prefers to bid for the client whose sales is below average. However, the result also suggests that there is significant variance among the audit firms. Therefore, the analysis further examines six audit firms' utility model, including Big Four audit firms and two medium-sized audit firms, Grant Thornton and BDO. Because the large audit firms, especially the Big Four, have more resources, including advanced technology and human resources, they are higher preference in providing audit service to the clients with higher sales. Compared to the clients with smaller size, auditing the client with high sales could increase the audit firm's reputation. Such approach is expected to eliminate the bias in the fixed effect where there are numerous small accounting firms in the market which is not able to provide service to the large company due to limited resource.

Furthermore, with the individual coefficients for six audit firms, the research discusses the change in the audit firm's optimal client portfolio assuming that the cost (e.g. resource) of each engagement increases in auditing. By following the utility maximisation theory, the audit firm's optimal client portfolio is expected to change due to the increasing cost. Even though large audit firms tend to bid for the large client, the counterfactual analysis shows that the audit firms would still have different strategies considering its existing client portfolio. For example, the specialist audit firm is more willing to drop the clients with fewer sales and strive to maintain the auditor-client relationship with the clients with bigger size. Since the specialist audit firm earns the most in the market, it would attempt to retain its reputation by keeping reputable clients in the portfolio. On the other hand, the audit firm who owns most clients in the industry would prefer the strategy of economies of scope by providing service to all sizes of clients more equally rather than focusing on reputable clients. With such strategy, the audit firm is expected to increase the total number of clients to maximise its utility rather than the profit.

After discussing the demand-side and supply-side problem respectively, the third research in this thesis focuses on both the demand and supply in the audit market. According to the economic theory of supply and demand, the quantity demanded/supplied and the price offered/agreed will be determined by both the supplier and customer in the market, which is referred to the equilibrium. However, such approach has not yet been considered in the audit market since the audit firms are believed to provide heterogeneous service to different clients. Following the similar framework proposed by Yang et al. (2003), the research extends the client's utility model in Chapter 2 to examine the simultaneous effect of demand and supply in the audit market.

In the client's utility model, there are several attributes that would affect the client's selection, including the audit fee. With the framework of discrete choice modelling, the probability of the client's choice would be based on the client's utility to each audit firm, and therefore the audit fee. On the other hand, by assuming that the audit firm would attempt to maximise its profit, the expected profit of the audit firm would depends on the probability of the client's choice and the price, leading to the interlink between the demand and supply in the framework where the audit firm may have to make trade-offs between increasing the price and the probability of being chosen. To discuss the simultaneous effect more thoroughly, two assumptions are raised for the estimation respectively. First, the audit market is believed to be Bertrand competition where the audit firm would attempt to maximise its own profit based on the expected value. On the contrary, the second proposition is assumed that the audit firms are in tacit collusion, where the audit firms in the industry will attempt to negotiate the price with others to maximise its profit. These two assumptions are believed to represent the audit firm's pricing strategy and also influence the client's choice based on the market competition.

By comparing the estimated coefficients under two scenarios, the results show that the client are more willing to pay higher price when considering the audit firms are engaged in tacit collusion. Since the audit firms are not fully independent under collusion, the client may consider paying higher premium to the audit firm in order to receive the same quality audit as when the market is in Bertrand competition. In addition, the client is more willing to hire specialist audit firm when the market is believed to be in Bertrand game since the market share may not be a reliable indicator for the specialist when it is the product of the audit firms' collusion. To further determine which framework better fits the sample, two methods are applied in the analysis, including information criteria and predictive analysis. Information criteria, AIC and BIC show that the assumption of the audit market being Bertrand competition better fits the sample in the research; however, the framework of tacit collusion could better predict the further auditor choice better. The possible

reason for such difference may be following. First, some clients may not consider the difference in the audit market being under Bertrand competition or tacit collusion, and therefore the individual coefficients may not be different under two assumptions. Second, since there are numerous clients in the industry, the audit firms may only undergo collusion with respect to a specific client rather than the whole industry. In such case, the predictive analysis may be biased when considering all companies in the industry.

The aim of this thesis is to discuss the demand and the supply of the audit market in a different approach. By adopting the theory of utility maximisation and applying structural estimation, this thesis first discusses the auditor choice and auditor switch in the first stream of research. Secondly, by differentiating the auditor with the supplier in other industries, the second stream of research discusses the audit firm's strategy of evaluating the client in the portfolio context to maximise its additive utility. Chapter 4 incorporates the demand and supply side of the audit market by interlinking the client's utility model and the audit firm's profit maximisation and examine the simultaneous effect of audit fee on both client's choice and audit firm's pricing strategy.

Unlike the past accounting literature, this research introduces random coefficients into the utility model which allows heterogeneity among the audit clients and the audit firms. In the audit market, audit clients are expected to have different preferences when purchasing the audit service because of the difference in scale and complexity. On the other hand, it is well understood that the Big Four audit firms would have varied concerns when accepting the new client or resigning from the existing engagement and the Big Four audit firms tend to charge for higher fee premiums, but the previous research usually distinguishes the Big Four audit firms from others.

By allowing the random coefficients, the research can examine the difference between auditor's strategy of the client portfolio and audit fee setting. In order to discuss the estimated individual effects, the Bayesian approach with the random-walk algorithm is conducted in the estimation. Distinct from the frequentist approach which is widely used in traditional accounting and auditing studies, the Bayesian approach carries out the estimation by iterative sampling and the individual coefficients could be stored and examined rather than only the fixed coefficients.

This thesis is believed to fill the gap of the simultaneous effect on supply and demand side in the audit market with structural estimation instead of reduced-form modelling. The results of the random coefficients suggest that there is significant heterogeneity among the audit clients and the audit firms, which should be taken into consideration in future research.

5.4   Limitation

This thesis attempts to match the demand and supply side in the audit market by applying the theory of utility maximisation. By adopting the Bayesian approach with the random-walk algorithm, the estimation is carried out by Markov Chain Monte Carlo simulation. The advantage of such approach is that the researchers could retrieve individual coefficients rather than the fixed effect only. Since the thesis assumes that the audit clients would have heterogeneous utility model when selecting the audit service, the company in different industries may also have varied consideration based on the nature of the operation and the industry. Therefore, this research focuses on the publicly listed companies in the U.S. manufacturing industry and the estimated coefficients could only be interpreted to the manufacturing companies.

5.5   Future Research

This thesis is considered to be the research on the interface of operation research and accounting where the audit market has not be discussed extensively in line with the operation research due to the complexity of the market. On the other hand, this thesis applies structural estimation, including the discrete choice modelling and the theory of utility maximisation to examine the client's choice and audit firm's client portfolio where only a few accounting research has considered. During the audit engagement, the client's choice and the auditor's behaviour are believed to take place simultaneously. By following the similar framework in Chapter 4, future research is expected to examine the interaction between the audit client and the audit firm more closely rather than discussing both parties respectively.

In addition, because of the mandatory disclosure of the audit market, this thesis further adopts Bayesian approach to allow heterogeneity among the audit clients and the audit firms. Even though the posterior mean shows the similar results as prior research, this thesis finds that there is a significant variance in the client's utility model and the audit firm's strategy which should be taken into consideration. Therefore, future research should consider the individual difference, not only the difference between the industries but also the characteristics that the company possess.

Word count: 51417 words (excluding Appendix and List of reference)

Appendix A　　Markov Chain Monte Carlo Estimation-Auditor Switch with Audit Fee Discounting

In the framework, it is assumed that the parameter on the demand side is a hierarchical model where the model can be included in the following parts.

1. Observed demand $y_{ijt}|p_{ijt}, \beta_i, \psi_{jt}, \varepsilon_{ijt}$

    The observed demand in the research is the client's choice, and the probability of client i choosing the audit firm j is the logit choice probability where the ε_{ijt} follows Type 1 Extreme Value distribution.

$$\Pr(\text{choice}) = \prod_{j=1}^{J} \left(\frac{e^{\beta_0 + (\beta_i^n + x'_{it}\beta_i^k)x'_{kt} + \beta_i^p p_{ijt} + \beta_i^w w_{ijt} + \psi_{jt}}}{\sum_k e^{\beta_0 + (\beta_i^n + x'_{it}\beta_i^k)x'_{kt} + \beta_i^p p_{ikt} + \beta_i^w w_{ikt} + \psi_{kt}}} \right)^{I(y_{ijt}=1)}$$

2. Demand shock $\psi_{jt}|\Sigma_\psi$

    To draw the demand shock ψ_{jt} in random utility model, demand shock is assumed to follow a multivariate normal distribution, which could be written as: $\psi_{jt} \sim MVN(0, \Sigma_\psi)$. By integrating the likelihood of choice and prior density of the demand shock, the posterior density of demand shock is

$$\pi(\psi_{jt}|\Sigma_\psi) \propto \prod_i \Pr(\text{choice}) \cdot (\psi_{jt} \sim MVN(0, \Sigma_\psi))$$

    The Metropolis-Hastings algorithm with random walk approach is adopted to generate ψ_{jt}.

3. Heterogeneity in random utility $\beta_i|\bar{\beta}, \Sigma_\beta$, where $\beta_i = [\beta_{0i}, \beta_i^n, \beta_i^k, \beta_i^p, \beta_i^w]$

    To generate the random coefficient, each client is assumed to have the same coefficient each year, while Metropolis-Hastings algorithm with the random walk is used to draw the parameters in the random utility framework.

$$\pi(\beta_i|\bar{\beta}, \Sigma_\beta,) \propto \prod_i \Pr(\text{choice}) \cdot (\beta_i \sim N(\bar{\beta}, \Sigma_\beta))$$

4. Generate $\bar{\beta}$

$$\bar{\beta}|\beta_i, \Sigma_\beta \sim N\left(\frac{\sum_i \beta_i}{I}, \frac{\Sigma_\beta}{I}\right)$$

5. Generate Σ_β

$$\Sigma_\beta|\beta_i, \bar{\beta} \sim Inverted\ Wishart\left(I + F, \sum_i^I (\beta_i - \bar{\beta})(\beta_i - \bar{\beta})' + g\right)$$

    where g is 10 times the identity matrix with dimensions equal to the random coefficient in the random utility model and F is 10.

Appendix A

6. Generate Σ_ψ

$$\Sigma_\psi | \psi_{jt} \sim Inverted\ Wishart \left(T + F, \sum_t^T \psi'_t \psi_t + g \right)$$

Where g is set to be 5 times the identity matrix with dimensions equal to J (professional service firms) and F is set to 5.

Appendix B   Markov Chain Monte Carlo Estimation-

Client Portfolio of the Audit Firm

The estimation is carried out by the Metropolis-Hastings algorithm with the random-walk approach. In the framework, the audit firm $i = 1, \dots I$ provides the audit service to different categories of client $j = 1, \dots J$, at each fiscal year $t = 1, \dots T$. From equation (3.16), the likelihood that the audit firm i provides audit service to n of k categories of audit clients at period t can be written as:

$$L_{it} = P_i(X_{irt}^* > 0 \ and \ X_{ist}^* = 0; r = 2, \dots n \ and \ s = n + 1, \dots, J)$$

$$= \int_{-\infty}^{\pi_{ik}} \dots \int_{-\infty}^{\pi_{i(n+1)}} \phi\big(\pi_{i2}, \dots \pi_{in}, \mu_{i(n+1)}, \dots \mu_{ik}\big|0, \Omega\big) |J| d\mu_{i(n+1)} \dots d\mu_{ik}.$$

The estimation process is conducted by generating random draw iteratively, so the detailed procedures are illustrated as follows.

1. Generate $\{\beta_{ij}, i = 1, \dots, I\}$, where $\beta_{ij} = \ln(\varphi_{ij}\alpha_j)$
   The posterior distribution can be written as:

   $$\tau\left(\beta_{ij}\Big|\{X_{ijt}, j = 1, \dots, J \ and \ t = 1, \dots T\}, \{\alpha_j, \bar{\beta}_j, V_{\beta_j}, j = 1, \dots, J\}\right)$$

   $$\propto \det |V_{\beta_j}|^{-1/2} \exp\left[-\frac{1}{2}\big(\beta_{ij} - \bar{\beta}_j\big)' V_{\beta_j}^{-1}\big(\beta_{ij} - \bar{\beta}_j\big)\right] \cdot \prod_{t}^{T} L_{it}.$$

   The random-walk algorithm proceeds by assuming that the next draw β_{ij}^{k+1} is given by the current draw β_{ij}^k and the random draw generated from $N(0, 0.75I)$ in the estimation. Therefore, the kth draw can be written as

   $$\beta_{ij}^{(k+1)} = \beta_{ij}^{(k)} + N(0, 0.75I)$$

   Based on the rule of random-walk approach, the probability of accepting the new draw β_{ij}^{k+1} is defined by

   $$\min\left[\frac{\exp\left[-\frac{1}{2}\big(\beta_{ij}^{(k+1)} - \bar{\beta}_j\big)' V_{\beta_j}^{-1}\big(\beta_{ij}^{(k+1)} - \bar{\beta}_j\big)\right] \cdot \prod_{t}^{T} L_{it}^{(k+1)}}{\exp\left[-\frac{1}{2}\big(\beta_{ij}^{(k)} - \bar{\beta}_j\big)' V_{\beta_j}^{-1}\big(\beta_{ij}^{(k)} - \bar{\beta}_j\big)\right] \cdot \prod_{t}^{T} L_{it}^{(k)}}, 1\right].$$

2. Generate $\bar{\beta}_j$
   The posterior distribution of $\bar{\beta}_j|V_{\beta_j}, \{\beta_{ij}, i = 1, \dots, I\}$ can be written as

   $$\tau\left(\bar{\beta}_j\Big|V_{\beta_j}, \{\beta_{ij}, i = 1, \dots, I\}\right) = N\left(\frac{\sum_{i=1}^{I}\beta_{ij}}{I}, \frac{V_{\beta_j}}{I}\right).$$

Appendix B

3. Generate V_{β_j}

   The posterior distribution of $V_{\beta_j}|\bar{\beta}_j, \{\beta_{ij}, i = 1, ..., I\}$ can be illustrated as follows, given the assumption that the prior follows Inverted Wishart distribution.

   $$\tau\left(V_{\beta_j}\middle|\bar{\beta}_j, \{\beta_{ij}, i = 1, ..., I\}\right)$$

   $$\propto Inverted\ Wishart\left(v_0 + I, V_0 + \sum_{i=1}^{I}(\beta_{ij} - \bar{\beta}_j)'(\beta_{ij} - \bar{\beta}_j)\right)$$

   where v_0 is the prior for degrees of freedom and V_0 is an identity matrix with dimension equals to $(J - 1)$.

4. Generate δ_j, where $\delta_j = \alpha_j - 1$

   By assuming that the prior for $\delta_j \sim N(\delta_0, V_{\delta_0})$, the posterior distribution can be illustrated as

   $$\tau(\delta_j|\{X_{ijt}, i = 1, ...I, j = 1, ..., J\ and\ t = 1, ...T\}, \{\beta_{ij}, i = 1, ..., I\ and\ j = 1, ...J\}\delta_0, V_{\delta_0}$$

   $$\propto \det |V_{\delta_0}|^{-1/2} \exp\left[-\frac{1}{2}(\delta_j - \delta_0)'V_{\delta_0}^{-1}(\delta_j - \delta_0)\right] \cdot \prod_{i}^{I}\prod_{t}^{T} L_{it}.$$

   With the random-walk algorithm, the $(k + 1)^{th}$ draw of δ_j is given by

   $$\delta_j^{(k+1)} = \delta_j^{(k)} + N(0, I).$$

   The probability of accepting the current draw $\delta_j^{(k+1)}$ would be

   $$\min\left[\frac{\exp\left[-\frac{1}{2}\left(\delta_j^{(k+1)} - \delta_0\right)' V_{\delta_0}^{-1}\left(\delta_j^{(k+1)} - \delta_0\right)\right] \cdot \prod_i^I \prod_t^T L_{it}^{(k+1)}}{\exp\left[-\frac{1}{2}\left(\delta_j^{(k)} - \delta_0\right)' V_{\delta_0}^{-1}\left(\delta_j^{(k)} - \delta_0\right)\right] \cdot \prod_i^I \prod_t^T L_{it}^{(k)}}, 1\right].$$

Appendix C   Markov Chain Monte Carlo Estimation-Simultaneous Effect of Supply and Demand in the Audit Market

In the model, it is assumed that the parameter on the demand side is a hierarchical model where the model can be included in the following parts.

1. Observed demand $y_{ijt}|p_{ijt}, \beta_i, \psi_{jt}, \varepsilon_{ijt}$

   The observed demand in the sample is the client's choice. The probability of client i choosing the audit firm j is the logit choice probability where the ε_{ijt} follows Type 1 Extreme Value distribution.

$$\Pr(\text{choice}) = \prod_{j=1}^{J} \left(\frac{e^{\beta_0 + (\beta_i^n + x'_{it}\beta_i^k)x'_{kt} + \beta_i^p p_{ijt} + \psi_{jt}}}{\sum_k e^{\beta_0 + (\beta_i^n + x'_{it}\beta_i^k)x'_{kt} + \beta_i^p p_{ikt} + \psi_{kt}}} \right)^{I(y_{ijt}=1)}$$

2. Observed price $p_{ijt}|\beta_i, \psi_{jt}, \alpha, \lambda_Z, \eta_{ijt}$

   From the last calculation, the probability of client i choosing the audit firm j is conditional on the price, but since the distribution of observed price cannot be observed, the change-of-variable approach is applied from the error term in the supply side.

$$|\text{Jacobian}_{it}| = \begin{vmatrix} \dfrac{\partial r_{1t}}{\partial p_{i1t}} & \dfrac{\partial r_{1t}}{\partial p_{i2t}} & \cdots & \dfrac{\partial r_{1t}}{\partial p_{iJt}} \\ \dfrac{\partial r_{2t}}{\partial p_{i1t}} & \dfrac{\partial r_{2t}}{\partial p_{i2t}} & \cdots & \vdots \\ \vdots & \vdots & \ddots & \vdots \\ \dfrac{\partial r_{Jt}}{\partial p_{i1t}} & \cdots & \cdots & \dfrac{\partial r_{Jt}}{\partial p_{iJt}} \end{vmatrix}$$

   where $r_{it} = p_{it} + f(p_{it}) - f(\alpha, x_{it}, x_{jt})$, and $f(p_{it}) = -s_{ijt} \cdot G^{-1}$ in Appendix D.

3. Demand shock $\psi_{jt}|\Sigma_\psi$

   To draw the demand shock ψ_{jt} in random utility model, it is assumed that $\psi_{jt} \sim MVN(0, \Sigma_\psi)$. By integrating the likelihood of choice and prior density of the demand shock, the posterior density of demand shock can be written as

$$\pi(\psi_{jt}|\Sigma_\psi) \propto \prod_i \Pr(\text{choice}) \cdot |\text{Jacobian}_{it}| \cdot (p_{it} + f(p_{it}) - f(\alpha, x_{it}, x_{jt}) \sim MVN(0, \Sigma_\eta))$$
$$\cdot (\psi_{jt} \sim MVN(0, \Sigma_\psi))$$

   This research adopt Metropolis-Hastings algorithm with random walk approach to generate ψ_{jt}.

4. Heterogeneity in random utility $\beta_i|\bar{\beta}, \Sigma_\beta$, where $\beta_i = [\beta_{0i}, \beta_i^n, \beta_i^k, \beta_i^p]$

   To generate the random coefficient, each client is assumed to have the same coefficient each year and the Metropolis-Hastings algorithm with the random walk is used to draw the parameters in the random utility framework.

$$\pi(\beta_i | \bar{\beta}, \Sigma_\beta,) \propto \prod_i \Pr(\text{choice}) \cdot |\text{Jacobian}_{it}| \cdot (p_{it} + f(p_{it})$$

$$- f(\alpha, x_{it}, x_{jt}) \sim MVN(0, \Sigma_\eta)) \cdot (\beta_i \sim N(\bar{\beta}, \Sigma_\beta))$$

5. Generate $\bar{\beta}$

$$\bar{\beta} | \beta_i, \Sigma_\beta \sim N(\frac{\sum_i \beta_i}{I}, \frac{\Sigma_\beta}{I})$$

6. Generate Σ_β

$$\Sigma_\beta | \beta_i, \bar{\beta} \sim Inverted\ Wishart \left(I + F, \sum_i^I (\beta_i - \bar{\beta})(\beta_i - \bar{\beta})' + g \right)$$

where g is 10 times the identity matrix with dimensions equal to the random coefficient in the random utility model, and F is 10.

7. Generate Σ_ψ

$$\Sigma_\psi | \psi_{jt} \sim Inverted\ Wishart \left(T + F, \sum_t^T \psi'_t \psi_t + g \right)$$

Where g is set to be 5 times the identity matrix with dimensions equal to J (professional service firms) and F is set to be 5.

8. Derive α

By assuming that the cost function $f(\alpha, x_{it}, x_{jt})$ is linear, the parameters α can be solved by linear regression.

Appendix D   Calculation of the Matrix used for Supply-Side Problem

$$\pi_{ijt} = \sum_{i \in \mathcal{L}(I)} s_{ijt}\left(p_{ijt} - f(\alpha, x_{it}, x_{jt})\right) + \sum_{k \neq j} \sum_i \phi_i s_{ikt}(p_{ikt} - f(\alpha, x_{it}, x_{kt}))$$

$$s_{ijt} + \left(p_{ijt} - f(\alpha, x_{it}, x_{jt})\right)\frac{\partial s_{ijt}}{\partial p_{ijt}} + \sum_{h \neq i}(p_{hjt} - f(\alpha, x_{ht}, x_{jt}))\frac{\partial s_{hjt}}{\partial p_{ijt}}$$

$$+ \sum_{k \neq j} \sum_i \phi_i(p_{ikt} - f(\alpha, x_{it}, x_{kt}))\frac{\partial s_{ikt}}{\partial p_{ijt}} = 0$$

$$s_{ijt} + \left(p_{ijt} - f(\alpha, x_{it}, x_{jt})\right)\frac{\partial s_{ijt}}{\partial p_{ijt}} + \sum_{h \neq i}(p_{hjt} - f(\alpha, x_{ht}, x_{jt}))\frac{\partial s_{hjt}}{\partial p_{ijt}}$$

$$+ \sum_{k \neq j} \phi_i(p_{ikt} - f(\alpha, x_{it}, x_{kt}))\frac{\partial s_{ikt}}{\partial p_{ijt}}$$

$$+ \sum_{k \neq j} \sum_{h \neq i} \phi_h\left(p_{hkt} - f(\alpha, x_{ht}, x_{jt})\right)\frac{\partial s_{hkt}}{\partial p_{ijt}} = 0$$

Since $\frac{\partial s_{hjt}}{\partial p_{ijt}} = 0$ and $\frac{\partial s_{hkt}}{\partial p_{ijt}} = 0$, the equation will be

$$s_{ijt} + \left(p_{ijt} - f(\alpha, x_{it}, x_{jt})\right)\frac{\partial s_{ijt}}{\partial p_{ijt}} + \sum_{k \neq j} \phi_i(p_{ikt} - f(\alpha, x_{it}, x_{kt}))\frac{\partial s_{ikt}}{\partial p_{ijt}} = 0$$

To simplify, the equation can be written as:

$$s_{ijt} + \sum_j \left(p_{ijt} - f(\alpha, x_{it}, x_{jt})\right)G = 0$$

where the diagonal element in the matrix, $G = \frac{\partial s_{ijt}}{\partial p_{ijt}}$, and in off-diagonal, $G = \phi_i \frac{\partial s_{ikt}}{\partial p_{ijt}}$.

Therefore,

$$p_{ijt} = cK_{ijt} - s_{ijt} \cdot G^{-1}$$

$$[p_{ijt}]_{J \times 1} = [cK_{ijt}]_{J \times 1} + \begin{bmatrix} \frac{\partial s_{i1t}}{\partial p_{i1t}} & \phi_i\frac{\partial s_{i2t}}{\partial p_{i1t}} & \cdots & \phi_i\frac{\partial s_{iJt}}{\partial p_{i1t}} \\ \phi_i\frac{\partial s_{i1t}}{\partial p_{i2t}} & \frac{\partial s_{i2t}}{\partial p_{i2t}} & \cdots & \phi_i\frac{\partial s_{iJt}}{\partial p_{i1t}} \\ \vdots & \vdots & \ddots & \vdots \\ \phi_i\frac{\partial s_{i1t}}{\partial p_{iJt}} & \phi_i\frac{\partial s_{i2t}}{\partial p_{iJt}} & \cdots & \phi_i\frac{\partial s_{iJt}}{\partial p_{it}} \end{bmatrix}_{J \times J}^{-1} \begin{bmatrix} -s_{i1t} \\ -s_{i2t} \\ \vdots \\ -s_{iJt} \end{bmatrix}_{J \times 1}$$

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