ESSAYS ON SELLERS' INCENTIVE FOR INFORMATION DISCLOSURE

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ABSTRACT

David Seung Huh: Essays on Sellers' Incentive for Information Disclosure
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This dissertation attempts to provide a framework for understanding information asymmetry in markets by verifying the economic incentives for sellers with low-quality products to fully disclose their types, through analytic models, experimental analysis, and market data analysis. This study achieves this goal by focusing on how risk intermediaries such as third-party certifications can reduce the perceived risk of customers and encourage sellers to voluntarily reveal weaknesses of their products or services.

Essay 1 explains whether, when, and how a seller with a low-quality product can disclose quality information to enhance his profitability and also increase the market demand through an analytic model and lab experiments. Essay 2 confirms the predictions of Essay 1 by verifying the economic incentives to disclose low-quality information from the sales data of various collectible items, and also shows that revealing weaknesses helps sellers more when they are selling products of higher than average quality, and that this incentive for information disclosure differs across different market circumstances. Essay 3 explicitly investigates the effect of certifications of different qualities on various market outcomes through an analytic model and an economic experiment and finds that an inaccurate certification is worse than no certification for sellers but beneficial to buyers. This essay also shows that using certification and fully disclosing quality information is the best way to increase profit under information asymmetry.

Overall, this dissertation aims to contribute to both academia and industry through presenting an important theoretical basis and empirical evidences regarding various market dilemmas under information asymmetry, as it is one of the first attempts to analyze the economic incentives for sellers with low-quality products to reveal their types and understand how to design an optimal certification system to solve adverse selection issues.

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1. INTRODUCTION

1.1 Motivation

What should sellers do with negative aspects of their products or services that customers cannot easily find out? Conventional wisdom holds that sellers should conceal negative information as much as possible in order to maximize profit, particularly in markets where the level of information asymmetry is high. In other words, people generally believe that revealing low quality hurts, and thus most sellers try to claim higher than actual quality when possible. For example, when more than 500 new cars in the U.K. market were tested for their fuel figures in 2012, 95.5 percent showed lower miles per gallon (MPG) than officially claimed figures even under manufacturers' suggested driving conditions.[1] In this case, most car manufacturers were found to be concealing the fact that actual MPG figures were smaller than their claims, believing that customers would not be able to fully test MPG figures under proper conditions. Fraud in the olive oil market was also found to be a big issue, as a recent study found that 69 percent of imported olive oils labeled "extra virgin" did not actually meet the standard (Frankel et al. 2010). In this case, sellers were hiding the fact that the actual grades of their olive oils were lower than "extra virgin," since most customers could not accurately evaluate the grade. Similar examples of incomplete information disclosure under informational asymmetry can be readily observed in many other markets.

What we find interesting is that it is also not uncommon to witness sellers voluntarily disclosing unfavorable information about their products and services. Many online retailers,

[1] http://www.whatcar.com/car-news/car-true-mpg-winners-losers/1200728

including Amazon.com, disclose information about weaknesses of the products they offer through various routes such as customer reviews on their own websites. Woot.com is especially famous for its preemptive revelation of the disadvantages of listed products. On their website they clearly state that they would prefer that customers not buy from them than to have customers regret their purchases.[2] Traditional firms also show willingness to communicate weaknesses about their products to customers. In 2012, Four Seasons Hotels renovated their websites and included customer reviews for each of their 80+ properties directly from Twitter, Facebook, and TripAdvisor, without censoring any of the unfavorable comments. Chipotle Mexican Grill's website not only explains positive aspects of their ingredients, but also clearly indicates drawbacks of the ingredients through a "Room for Improvement"' section. Perhaps one of the most successful examples of communicating information about low quality with customers is the case of Hans Brinker Hotel in Amsterdam, the Netherlands. Hans Brinker is famous for its strategy of honestly revealing its low quality to customers, and actively explaining negative aspects of their services such as rooms without a view and no hot water, through pictures and detailed descriptions. Nevertheless, a lot of travelers visiting Amsterdam still choose to stay at this hotel and leave positive reviews.[3]

As these examples show, some sellers do voluntarily share information about weaknesses of their products or services, thereby raising a question: When and how can sellers benefit from such disclosures? The question is both interesting and important, as some of the decisions to hide unfavorable information in markets often cause various issues to customers, sellers, and the society. However, the incentive for the sellers with low-quality products ("low-type" sellers) to

[2] http://www.woot.com/faq?ref=ft_wiw_faq (accessed on November 14, 2015). Archived version: https://archive.is/b9cxI

[3] http://abcnews.go.com/Travel/proud-worlds-worst-hotels/story?id=17696356 (accessed on November 14, 2015). Archived version: https://archive.is/N9ZhL

fully disclose quality information has not been investigated much in the literature. This dissertation thus attempts to question this conventional wisdom regarding sellers' hiding weaknesses and provide more precise understanding about the incentive for low-type sellers to voluntarily reveal their types.

1.2 Literature Review

Some primary understandings about the market failures caused by information asymmetry have been provided by Akerlof (1970)'s argument on "the market for lemons." Akerlof (1970) has claimed that the adverse selection caused by information asymmetry will drive good products out of the market and significantly undermine buyers' willingness to pay, eventually leading to a market failure. More specifically, he has used an example of used car markets where the sellers have more knowledge about the quality of a car than the buyers. In this market, good cars and bad cars are sold at the same price since buyers cannot tell the difference between a good car and a bad car. Therefore, the owners of good cars do not want to participate in this market as they cannot receive the true value of their cars, resulting in bad cars driving good cars out of the market. He has also argued that the situation can be really disastrous if the grades of the products are more continuous, as the market eventually reaches the condition where no sellers would want to trade their products. He has shown this result using an analytic model where the demand for the products depends on the price of the product and the average quality of the products in the market, and both the supply of the products and the average quality depend on the price. He has assumed that the quality of the products is uniformly distributed and that the sellers have more knowledge about the quality of the products than the buyers. The analysis of this model has shown that, under information asymmetry, the average quality of supplied products at any given price will be low enough to make the total demand in the market zero. In

other words, information asymmetry makes the sellers provide the products with lower than a certain quality level at a given price, causing both the price and the average quality to decline until no trade takes place in the market. He has also applied this adverse selection issue to the insurance market and explained that the average medical conditions of insurance applicants deteriorate as the price increases. In other words, just as the average quality of used cars falls as the price decreases, only those people who are increasingly certain that they need the insurance will insure themselves as the price level rises, and the price eventually reaches the level at which no one would purchase insurances. Through these findings, Akerlof (1970) has shown that information asymmetry in markets will cause adverse selection issues which may eventually harm the entire market structure. He has listed guarantee, brand names, chains, and licensing as possible institutions which will solve adverse selection issues.

Since this seminal work, there have been numerous studies in economics and marketing that have attempted to provide possible solutions to the lemon problems from various perspectives. These studies have investigated what types of mechanisms are keeping the market system alive, and more specifically, under what circumstances sellers may resolve the problems occurring from information asymmetry in markets.[4]

1.2.1 Full Disclosure

The series of studies on information disclosure has first shown how verifiable disclosure can solve the adverse selection problems of Akerlof (1970), arguing that full disclosure naturally happens in markets under information asymmetry. The most important findings have come from the seminal studies of the Grossman-Milgrom framework (Grossman and Hart 1980; Grossman 1981; Milgrom 1981), which is also very closely related with this dissertation. The main result of

[4] Dranove and Jin (2010) have provided a more detailed literature review on information disclosure and quality certification.

these three studies is that the seller will voluntarily reveal the quality information as long as fraudulent disclosure is prohibited and information disclosure is costless.

First, Grossman and Hart (1980) have provided a theoretical finding that mandatory disclosure is not necessary to solve adverse selection issues as long as making false statements is prohibited. They have analyzed the standard information asymmetry case where sellers know the quality of the product while prospective buyers have no information about the quality, and buyers only know that the sellers have the information about the quality. In particular, there are many buyers and many sellers providing different products, and the price is assumed to follow the quality level where the product with the lowest quality has the lowest price and the product with the highest quality has the highest price. More importantly, the cost of information disclosure is assumed to be negligible in this case. They have shown that, under these circumstances, the only possible disclosure is full disclosure where the seller provides the true quality information because of the following logic. If the seller does not disclose the quality, then the buyer will assume that the quality is the lowest in the set of possible quality levels, since the seller could have made more profit by disclosing true quality and charging higher price if the true quality is not the lowest in the subset. They have also shown that a full disclosure is forthcoming even when the seller does not have perfect information about the quality, as the seller will still try to be as optimistic as possible regarding his claim. Therefore, as long as fraud is illegal and the cost of disclosing information is negligible, sellers will fully disclose quality information even without mandatory disclosure policy. One interesting aspect of their finding is that it does not require the buyers to be particularly sophisticated or have repeated interactions with sellers, as a very simple understanding that sellers will always try to be as optimistic as possible will let the buyers determine the pattern of sellers' information disclosure. In a subsequent analysis, they

have relaxed the assumption of negligible disclosure cost and found out that only those sellers with higher than certain quality will fully disclose quality information and none of the bad sellers will pay the cost of information disclosure, as the sellers have to consider the fact that the price they can charge differs according to the true quality of the product. With these findings, Grossman and Hart (1980) have provided a primary theoretical understanding of full disclosure by showing that the market will always end up with voluntary full disclosure of the quality. More specifically, they have argued that no mandatory disclosure is necessary as hiding information will always be interpreted as having low quality, as long as there is a law against lying. However, their assumption of no lying or negligible disclosure cost is somewhat strong, and the literature on mandatory disclosure, which is examined in a following section, thus argues that a full disclosure is not forthcoming in real markets.

Second, Grossman (1981) has developed the idea of full disclosure further by considering the monopoly situations where the monopolistic seller has the greatest incentive to mislead consumers by less than full disclosure since consumers have had no experience with the seller before and the product is sold at the consumer's reservation price. He has first assumed that the monopolistic seller's statement about the quality is not costly to communicate or verify *ex post*. For this assumption, he has provided the example of a diamond seller making statements about the weight of the diamond he is selling. As consumers can check the actual weight of the diamond after purchase, this statement about the weight of a diamond is *ex post* verifiable. He has shown that, under these circumstances, consumers with rational expectations will suppose that the monopolistic seller has the worst possible product if he does not make a full disclosure, and this makes the monopolist engage in a full disclosure. He has also considered the situation where the monopolistic seller's statement about the quality is costly to communicate or verify *ex*

post. However, even in this case, he argues that there should be certain attributes that are observable and related with true quality, and it is thus still possible for sellers to make *ex post* verifiable statements about the quality. According to his example, a patient may not fully understand the medical care he receives from a doctor, but he can at least observe the recurrence of an illness after the treatment. Therefore, although it is very costly to communicate the information about the actual medical treatment to the patient without proper medical knowledge (compared to the situation where a diamond seller shares information about a diamond's weight), the doctor can still communicate the quality of his service through *ex post* verifiable patient's status. He has shown that, even with the non-negligible cost of communicating and verifying true quality, the seller can still make *ex post* verifiable statement about the quality, and the consumers with rational expectations will thus conclude that the monopolistic seller tries to mislead the customers when he does make less than a full disclosure. Therefore, he has shown that even a monopolistic seller will voluntarily engage in full disclosure either because *ex post* verification of true quality is not costly for consumers or because there is at least some characteristic of the product which is observable, even when *ex post* verification of true quality is costly. In other words, he has basically considered the case where the product has certain attributes of which consumers can verify the true quality either directly or indirectly.[5] Another important assumption behind his analysis is that he has restricted his attention to truthful disclosure and does not consider fraudulent disclosure, which is still a strong assumption. These results and assumptions are also consistent with Grossman and Hart (1980).

Third, Milgrom (1981) has explained that full disclosure is forthcoming by observing the incentive for the sellers with high quality product to communicate favorable information. More

[5] This can be regarded as the case of search or experience attributes which is explained more in detail later in this dissertation.

specifically, he has provided a way to model how a signal follows true quality by incorporating a single unknown variable representing “quality” or “intrinsic value” and showing how this variable influences signaling. The model has explained that even when a party cannot observe the true quality, one can still observe the signals that are influenced by the actual quality levels, thus a full disclosure is naturally forthcoming. He has then applied this model to various different settings and shown how signaling good quality leads to favorable results for the interested party. First, he has analyzed how public announcement of good news about the future returns on a security affects the stock price. In his comparison of the effect from a favorable signal and an unfavorable signal, a favorable signal affects the expected value of random return more positively, and thus leads to higher prices. Second, he has considered the principal-agent problem where an agent expends a certain effort level and then influences the profit. In this case, as the actual effort level is unobservable, there is the possibility of moral hazard and a contract based on a specified level of effort is not enforceable. However, the principal can instead observe the profit level of the venture which is influenced by the effort. Therefore, the agent with higher effort level is willing to signal that information through achieving higher profit, which leads to the fee schedule increasing in the profit level. Third, a more general case of persuasion game, where one party tries to influence a decision maker by providing relevant information, has been analyzed. The interested party is assumed to have several pieces of data and may report or conceal any of these, but is not allowed to misreport them either because the information is verifiable or lying is prohibited by laws. The model shows that, at equilibrium, any withhold information by the interested party is regarded as unfavorable since the decision maker adopts the strategy of extreme skepticism, and the interested party’s best strategy to persuade the decision maker is thus a full disclosure. Therefore, through providing the relevant model and

application to different settings, Milgrom (1981) has shown that signaling effectively shows true quality or intrinsic value and thus encourages the interested party to communicate favorable information as much as possible, leading to a full disclosure in markets. Throughout the analysis, he has assumed that lying is impossible either because of the verification or regulations, just like the other studies on full disclosure reviewed above.

In summary, these three seminal studies have provided an important finding that mandatory disclosure is not necessary to solve adverse selection issues, as rationality of consumers or the effectiveness of signaling mechanism encourages the sellers to fully disclose quality information. However, these papers have based their findings on one strong assumption that lying is not possible either because it is prohibited by laws or *ex post* verification is readily available. Therefore, we believe that one of the potential contributions of this dissertation is relaxing the no-lying assumption and considering the situation where sellers can fraudulently disclose false information. Moreover, while these studies on full disclosure have focused on the incentive for the sellers with high quality products ("high-type" sellers) to engage in a full disclosure (i.e., the incentive to communicate favorable information), this dissertation attempts to find whether voluntary disclosure can still solve adverse selection issues without the no-lying assumption by analyzing the incentive for the sellers with low-quality products to disclose quality information (i.e., the incentive to communicate unfavorable information). The potential contributions of this dissertation are discussed more in detail in a following section.

Other than these seminal studies, several other studies have also argued that voluntary disclosure is forthcoming in markets. Jovanovic (1982) has even argued that more than the optimal amount of disclosure will happen in the market when there is disclosure cost and thus the government should encourage sales *without* disclosure. This finding is based on the assumption

that it is impossible for the seller to lie about the quality of his product, not because there is a law against lying but because the sellers worry about future business or litigation. Viscusi (1978) has called it an "unraveling process" when the disclosure of information happens top down, in such a way that full disclosure starts from the player with the highest quality and goes down to players with lower quality until the cost of information disclosure exceeds the benefit. This study has shown that unraveling happens not only in the product market with lemons but also in the labor market with potentially hazardous jobs, as the firms with better job outcomes will first invest in revealing true characteristics. Overall, the studies predicting full disclosure suggest that voluntary disclosure can solve adverse selection problems of Akerlof (1970), based on the assumption that sellers do not lie. These findings are summarized in Table 1.1.

Table 1.1: Literature on Voluntary Disclosure

Literature	Key Findings	Assumptions
Grossman and Hart (1980)	The market will always end up with voluntary full disclosure of the quality as hiding information will be interpreted as having low quality. If there is cost for disclosure, then only the sellers with product quality higher than a certain level will disclose.	▪ Lying is prohibited by law. ▪ There is no mandatory disclosure. ▪ The cost of disclosure is either positive or zero.
Grossman (1981)	A monopolistic seller always makes a full disclosure about the quality of his product, as rational consumers will assume that the seller's product has the worst possible quality if he makes less than a full disclosure.	▪ Lying is prohibited. ▪ Customers can verify seller's statement ex post. ▪ Disclosure cost is negligible.
Milgrom (1981)	Favorable information works as an effective signaling method which communicates true quality information. This favorable effect is shown in four different situations: a share price, an agent's bonus, a buyer's expectation about products, and a bidder's expectation in a sealed-bid auction. Sellers are thus willing to commit to a full disclosure.	▪ Lying is prohibited by law. ▪ There is no cost of disclosure.
Jovanovic (1982)	More than the optimal amount of disclosure will happen in the market when there is disclosure cost, and thus the government should encourage sales without disclosure.	▪ It is impossible for the seller to lie about the quality of his product, not because there is a law against lying but because the sellers worry about future business or litigation.
Viscusi (1978)	The disclosure of information happens top down in an "unraveling process", in such a way that full disclosure starts from the player with the highest quality and goes down to players with lower quality until the cost of information disclosure exceed the benefit. The unraveling also happens in the labor market with potentially hazardous jobs.	▪ There is no lying. ▪ The cost of disclosure is positive.

1.2.2 Incomplete Disclosure

Although the studies reviewed above have claimed that sellers will voluntarily commit to full disclosure, there is also a substantial literature that finds evidence that disclosure cannot be complete if it is not mandatory. These studies have listed various market factors such as disclosure costs, cost of acquiring quality information, customer's misunderstanding of seller's disclosure, customer's ignorance, and market structure as possible reasons why voluntary disclosure is not sufficient to solve adverse selection problems.

Disclosure cost. Basically, the Grossman-Milgrom framework (Grossman and Hart 1980; Grossman 1981; Milgrom 1981) reviewed above has claimed that the firms will follow full disclosure if the disclosure cost is negligible, implying that full disclosure is not possible with a certain level of disclosure cost as only the sellers with product quality higher than a certain level will disclose. Verrecchia (1983) has argued that the disclosure cost provides noise in interpreting firm's disclosure effort. More specifically, when there is disclosure cost and certain information is withheld, the observers are unsure whether the information is bad or just not as good for the seller to incur disclosure costs. Therefore, there exists an equilibrium threshold level of disclosure. Although Viscusi (1978) has explained how unraveling happens and most firms disclose, the paper also explained that if disclosure is costly, then only sellers with quality higher than a threshold level will disclose relevant information.

Market structure. Board (2009) has considered the competition in the market to explain the failure of full disclosure. This paper has shown that a firm may not disclose information in a competitive environment, as disclosing information may lead to stronger competition. Therefore, when one high-quality firm discloses, other firms should compare the cost of increased competition when they also disclose with the cost of reduced perceived quality when they do not

disclose. This paper thus has argued that it is possible that only high-quality firms choose to disclose, suggesting the need for mandatory disclosure. Cheong and Kim (2004) have argued that no firm will disclose information as the number of competing firms becomes infinity and the market is almost perfectly competitive, since the difference in the quality across different products becomes less evident. In other words, as there are more firms in the market, the benefit from information disclosure gets smaller due to price competition. Guo and Zhao (2009) have added another perspective to the consideration of the competition in understanding information disclosure by examining the sequential disclosing behavior in a duopoly setting. They have found that the leader reveals less information under sequential disclosure case than under simultaneous disclosure situation, while the follower may reveal more or less information depending on the disclosure cost. Hotz and Xiao (2013) have focused on the heterogeneity in the market in terms of product attributes and customer preferences. They have shown that neither high-types nor low-types would disclose information, as more information results in more elastic demand, which in turn leads to increased price competition among the firms. Therefore, they suggest that government intervention or mandatory disclosure may benefit customers in the market.

Overall, these studies have shown that competition leads to less information disclosure, which is somewhat counterintuitive. However, the literature has mixed opinion on the impact of competition on disclosure. Unlike other studies that have basically argued that competition leads to less information disclosure, Stivers (2004) has shown that when customers do not know that the quality information is commonly available among sellers, an increased number of sellers and stronger competition will lead to more information disclosure not only because the probability of all sellers having quality below a critical level and concealing relevant information falls, but also

because sellers are willing to reveal information and make competitors look worse in this condition.

Ignorance. Fishman and Hagerty (2003) have questioned the assumption that all customers understand the seller's disclosure and analyzed the case where only some customers understand it. They have found that voluntary disclosure is not forthcoming when the ratio of customers who understand the disclosure is low, and mandatory disclosure is thus necessary for the markets where the product information is difficult for customers to fully understand.

Cognitive errors. On the other hand, Hirshleifer, Lim, and Teoh (2004) have focused on the observer's limited attention and cognitive processing power. Therefore, instead of the assumption that people cannot understand the disclosed information, they have assumed that people neglect either the signal or the implications of non-disclosure, which has resulted in less than full information disclosure and excessive amount of optimism about the quality. Schwartz (2008) has come up with similar findings focusing on the cognitive errors of customers, in that some customers are more naïve and prone to err than others. Therefore, the naïveté of customers discourages the firms from disclosing relevant information, and the likelihood of socially desirable disclosure increases with the number of sophisticated customers in the market.

Customer's confusion. Focusing on the case of eco-labels, Harbaugh, Maxwell, and Roussillon (2011) have shown that when customers are unsure of the disclosed information, then full disclosure may not be forthcoming. More specifically, they have shown that consumer confusion is aggravated when the label is used by a product with bad reputation, when there is proliferation of the label, and when the firms strategically use it based on the customer doubt. According to this finding, mandatory labeling may be one way to reduce the confusion and solve disclosure issues.

Cost of quality assessment. Both Matthews and Postlewaite (1985) and Shavell (1994) have provided an interesting finding by considering the case of sellers having to incur costs to test their own products and acquire quality information. These studies have found that even certain imperfect mandatory disclosure laws can actually reduce the amount of information disclosed by the firm, as the firms do not invest in obtaining quality information because they worry that negative information might be revealed. For example, a car manufacturer may not invest in the research to find potential defects if they have to disclose all of their findings.

Seller's risk averseness. Milgrom and Roberts (1986) have indicated the seller's concern of affecting customer's knowledge of quality distribution as the reason for why voluntary disclosure is not happening. According to their explanation, sellers do not always know what information is favorable, and they worry that any information revealed will downgrade all possible alternatives in the market as customers become more skeptical. For this reason, firms may be reluctant to disclose any kinds of information.

Reputation of reticence. Grubb (2011) has focused on the dynamic context and provided an interesting explanation about why some sellers try to conceal even favorable information. Sellers may try to get the reputation of reticence, withholding some good information either to improve the credibility of prior nondisclosures or to make the customers less skeptical of future nondisclosures.

Seller capacity. Gavazza and Lizzeri (2007) have focused on the public sector settings and shown that high-quality service providers may be reluctant to disclose quality information, as doing so can lead to increased demand for their services and cause capacity issues, which makes it different from the outcome for private sector firms. They have suggested some reforms

of the incentives facing the bureaucrats and claimed that this may also be applied to some private sectors where prices do not fully adjust.

Strategic decision on multi-dimensional product. Bar-Isaac, Caruana, and Cuñat (2012) have examined the monopolistic market where a seller sells a good with two characteristics and found the following: When there is an exogenous change in the cost of information gathering and the relevant information becomes easier to obtain, that change may affect customer welfare negatively. If an intermediary appears to reduce risk on one characteristic, it affects the firm's investment in such a way that it only improves the dimension that it has to disclose the information about, and reduces investment on the other dimension, thereby hurting some customers' welfare. Therefore, even a standard mandatory disclosure may not solve this problem unless the relevant policy considers this multi-dimensional aspect of the product and firm's strategic considerations.

Overall, these studies have provided various reasons why full disclosure is not easily observed. In other words, contrary to the primary findings of the literature which predict full disclosure, there seem to be considerable amount of issues in markets that suggest the need for mandatory disclosure. Moreover, several studies (Bar-Isaac, Caruana, and Cuñat 2012; Matthews and Postlewaite 1985; Shavell 1994) reviewed above have even argued that imperfect mandatory disclosure can worsen the situation. These studies are summarized in Table 1.2.

Table 1.2: Literature Supporting Mandatory Disclosure

Literature	Key Findings	Reason for Failed Disclosure
Verrecchia (1983)	The disclosure cost provides noise in interpreting a firm's disclosure effort and creates an equilibrium threshold level of disclosure.	Disclosure cost
Viscusi (1978)	If disclosure is costly, then only sellers with quality higher than a threshold level will disclose relevant information.	
Board (2009)	A firm may not disclose information in a competitive environment, as disclosing information may lead to stronger competition. Therefore, it is possible that only high-quality firms choose to disclose.	Market structure (Competitive environment)
Cheong and Kim (2004)	No firm will disclose information as the number of competing firms becomes infinity and the market is almost perfectly competitive, since the difference in the quality across different products becomes less evident.	
Guo and Zhao (2009)	In a duopoly setting, the leader reveals less information under sequential disclosure case than under simultaneous disclosure situation, while the follower may reveal more or less information depending on the disclosure cost.	
Hotz and Xiao (2013)	Neither high-type nor low-type would disclose information, as more information results in more elastic demand, which leads to increased price competition among the firms. Therefore, a government intervention or mandatory disclosure may benefit customers in the market.	
Stivers (2004)	When customers do not know that the quality information is commonly available among sellers, increased number of sellers and stronger competition will lead to more information disclosure because sellers are willing to reveal information and make competitors look worse in this condition.	

Table 1.2: Literature Supporting Mandatory Disclosure (Continued)

Literature	Key Findings	Reason for Failed Disclosure
Fishman and Hagerty (2003)	Voluntary disclosure is not forthcoming when the ratio of customers who understand the disclosure is low, and mandatory disclosure is thus necessary for markets where the product information is difficult for customers to fully understand.	Ignorance
Hirshleifer et al. (2004)	When customers have limited attention and cognitive processing power and thus either ignore the signal or the implications of non-disclosure, there is less than full information disclosure and an excessive amount of optimism about the quality.	Cognitive errors
Schwartz (2008)	The naïveté of customers discourages the firms from disclosing relevant information, and the likelihood of socially desirable disclosure increases with the number of sophisticated customers in the market.	
Harbaugh, Maxwell, and Roussillon (2011)	Consumer confusion is aggravated when the ecolabel is used by a product with bad reputation, when there is proliferation of the label, and when the firms strategically uses it based on the customer doubt. According to this finding, mandatory labeling may be one way to reduce the confusion and solve disclosure issues.	Customer's confusion

Table 1.2: Literature Supporting Mandatory Disclosure (Continued)

Literature	Key Findings	Reason for Failed Disclosure
Matthews and Postlewaite (1985); Shavell (1994)	Imperfect mandatory disclosure law can reduce the amount of information disclosed by firms, as the firms do not invest on obtaining quality information out of concern that negative information might be revealed.	Cost of quality assessment
Milgrom and Roberts (1986)	Sellers do not always know what information is favorable, and they worry that any information revealed will downgrade all possible alternatives in the market as customers become more skeptical.	Seller's risk averseness
Grubb (2011)	Sellers may try to get the reputation of reticence, withholding some good information either to improve the credibility of prior nondisclosures or to make the customers less skeptical of future nondisclosures.	Reputation of reticence
Gavazza and Lizzeri (2007)	High-quality public sector service provider may be reluctant to disclose quality information as it can lead to increased demand for their services and cause capacity issues.	Seller capacity
Bar-Isaac, Caruana, and Cuñat (2012)	If an intermediary appears to reduce risk on one characteristic, it affects the firm's investment in such a way that it only improves the dimension that it has to disclose the information about, and reduces investment on the other dimension, thereby hurting some customers' welfare.	Strategic decision on multi-dimensional product

1.2.3 Empirical Findings on Information Disclosure

The literature on information disclosure is more focused on theoretical analysis, as is shown in the reviews above, and the number of empirical studies is relatively small. Most of these empirical studies on information disclosure have claimed that mandatory disclosure is necessary to solve adverse selection issues of Akerlof (1970), while some studies have shown how voluntary disclosure can be an effective solution for information asymmetry in market.

Need for mandatory disclosure. Mathios (2000) has examined the information disclosure of the salad dressings market before Nutrition Labeling and Education Act (NLEA) and found that while all of the sellers of low-fat dressings voluntarily disclosed fat content information, only 9 percent of the sellers of high-fat dressings did so. From this result, he has argued that mandatory disclosure of relevant product information will have a positive impact on consumer behavior and health. Edelman (2009) has observed adverse selection with trust certifications used by many Internet websites. He has examined SiteAdvisor's measurement data of various websites' safety and found that TRUSTe-certified websites are actually more than twice as likely to be untrustworthy as uncertified sites. He has explained that this happens because a trust authority currently benefits from that error and thus ignores it. Therefore, he has suggested policies to alter the authorities' behavior such as sanctions, laws, or regulations. Jin (2005) has shown why voluntary disclosure is not complete, focusing on the competition effects. She has observed health maintenance organizations' (HMOs) voluntary disclosure of product quality and found that the disclosure decision differs depending on the level of competition. HMOs use information disclosure as means to differentiate themselves and disclosure propensity declines with the degree of competition, which is consistent with some of the theoretical findings about the impact of competition on information disclosure reviewed above. Jin and Leslie (2003) have

done an interesting natural experiment by comparing health inspection scores, consumer demands, and the number of foodborne illness hospitalizations before and after Los Angeles County forced restaurants to display hygiene quality grade cards. They have found a lot of evidence of positive impact of mandatory disclosure, such as increased health inspection scores and decreased hospitalizations due to foodborne illness. Bennear and Olmstead (2008) have also found similar positive effects of mandatory disclosure. They have studied how 517 drinking water suppliers in Massachusetts provide customers with the information about the quality of drinking water they purchase and found that the suppliers who serve more than 10,000 customers and thus are mandated to directly mail the reports had significantly lower violations of drinking water standards, and also reduced health violations by 40 to 57 percent. Xiao (2010) has investigated the effect of quality accreditation in the childcare market through a structural model of demand allowing consumers to gather quality information from both accreditation status and firm reputation. The result has shown that consumers do not get meaningful information out of accreditation status considering the effect of reputation, and its contribution to consumer welfare is merely 2 percent, suggesting overall ineffectiveness of the accreditation mechanism.

Jin and Kato (2006) have shown evidences that voluntary disclosure may not work in an online setting, and is very closely related with the Essay 2 of this dissertation. By analyzing sales data of collectible baseball cards from eBay and also purchasing and observing the actual products, they have found that while higher-quality claim cards yield price premium, the average quality from high-claim cards is indistinguishable from cards with more modest claims, and reputable sellers do not provide better-quality products either. These results have shown that there is actually a considerable amount of fraud in this online market under information asymmetry and the information disclosure mechanisms do not work properly to prevent adverse

selection issues in this marketplace. In particular, this study has some similarities with Essay 2 of this dissertation, as both use the data from same product category and investigate the relationship between claimed quality and information disclosure. However, the focus and findings are different, as Jin and Kato (2006) basically show how low-type sellers fraudulently claim higher quality (i.e., conceal their types) and achieve higher profit, while Essay 2 explains how low-type sellers fully disclose quality information and increase profit. More detailed discussion on the comparisons between these papers is followed in a later section.

Support for voluntary disclosure. Lewis (2011) has examined the effect of online information disclosure through observing nearly 50,000 car transactions on eBay Motors. The study found that text and photos posted online work as enforceable contract and thus alleviate information asymmetry, strongly influencing prices. It has also found that disclosure cost affects how much information a seller decides to post. Li, Srinivasan, and Sun (2009) have investigated how product quality indicators such as picture postings and money-back guarantees and seller credibility indicators such as seller rating and third-party payment alleviate dual information asymmetry (uncertainty about product quality and seller credibility) in an auction setting by observing eBay's paintings and silver plates market. They have found that those indicators encourage bidder participation, and the effect is even stronger when both types of indicators are used simultaneously.

Overall, while most of the empirical findings have argued that mandatory disclosure is necessary, some other studies have shown that voluntary disclosure may help alleviate information asymmetry in markets. These mixed results are summarized in Table 1.3.

Table 1.3: Empirical Literature on Information Disclosure

Literature	Key Findings	Context	Support for Mandatory Disclosure
Mathios (2000)	While all of the sellers of low-fat dressings voluntarily disclosed fat content information, only 9% of the sellers of high-fat dressings did so without mandatory disclosure. Therefore, mandatory disclosure of relevant product information will have positive impact on consumer behavior and health.	Salad dressings	Yes
Edelman (2009)	TRUSTe-certified websites are actually more than twice as likely to be untrustworthy as uncertified sites. This happens because a trust authority currently benefits from that error and thus ignores it.	Internet websites	Yes
Jin (2005)	Health maintenance organizations (HMOs) use information disclosure as a means to differentiate themselves and disclosure propensity declines with the degree of competition.	Healthcare service	Yes
Jin and Leslie (2003)	After Los Angeles County forced restaurants to display hygiene quality grade cards, a lot of evidence of positive impact of mandatory disclosure have been observed, such as increased health inspection scores and decreased hospitalizations due to foodborne illness.	Restaurants	Yes
Bennear and Olmstead (2008)	The drinking water suppliers who serve more than 10,000 customers and thus are mandated to directly mail the reports had significantly lower violations of drinking water standards, and also reduced health violations by 40–57%.	Drinking water	Yes

Table 1.3: Empirical Literature on Information Disclosure (Continued)

Literature	Key Findings	Context	Support for Mandatory Disclosure
Jin and Kato (2006)	There is a considerable amount of fraud in the online collectible goods market under information asymmetry, and the information disclosure mechanisms do not work properly to prevent adverse selection issues in this market.	Collectible goods (Online)	Yes
Xiao (2010)	Consumers do not get meaningful information out of accreditation status considering the effect of reputation, and its contribution on consumer welfare is merely 2%, suggesting overall ineffectiveness of the accreditation mechanism.	Childcare service	Yes
Lewis (2011)	In an online car market, text and photos posted online work as enforceable contract and thus alleviate information asymmetry, strongly influencing prices. Disclosure cost affects how much information a seller decides to post.	Used cars (Online)	No
Li, Srinivasan, and Sun (2009)	In eBay's paintings and silver plates market, product quality indicators such as picture postings and money-back guarantees and seller credibility indicators such as seller rating and third-party payment alleviate dual information asymmetry (uncertainty about product quality and seller credibility).	Antiques (Online)	No

1.2.4 Literature on Certification

The literature has indicated that the consequence of information disclosure depends mostly on the effectiveness of signaling methods employed by sellers. Among various signaling methods, information disclosure literature has focused on the effect of third-party certifications, as reputation is not easy to establish in the short run, a seller's own signaling is generally not trustworthy, and warranty is usually not appropriate for credence attributes that customers cannot evaluate. Some studies on certification have empirically checked the effectiveness of certification and focused on whether it solves adverse selection issues in a market or not, and some other studies have explained what makes the mechanism work poorly.

The effect of certification. Anderson, Daly, and Johnson (1999) have investigated 514 publicly held firms that obtained ISO 9000 certificates and found that the firms used the certificates in order to send a credible public signal about their quality management practices and not simply sought to meet some regulatory standards, which is contrary to the views of critics of ISO 9000. Therefore, this study has shown that certification works as an effective risk intermediary. On the other hand, Xiao (2010), as reviewed above, has shown that the effect of accreditation in the childcare market is not significant, by observing that consumers do not get meaningful information out of accreditation and its contribution on consumer welfare is merely 2 percent.

The bias of certifiers. Feinstein (1989) has investigated the result of more than 1,000 Nuclear Regulatory Commission (NRC) inspections of nuclear power plants over three years and found that NRC inspectors' rates of detecting violations differ significantly. Interestingly, detection rates increased abruptly after Three Mile Island incident in 1979. They have also found that these undetected violations had a significant impact on the number of abnormal occurrences

at the power plants, indicating that the biased certification system caused by incompetent certifiers may harm the entire system. As is explained above, Edelman (2009) has observed the trust certifications of Internet websites and shown that TRUSTe-certified websites are actually more untrustworthy than uncertified sites because a trust authority benefits from that error and ignores it. Prendergast (2007) has explained that some government certifiers show bureaucratic bias depending on whether they advocate for the clients or the principal.

The analysis of third-party certifiers in the finance industry has also shown interesting findings. By analyzing the career concerns of security analysts, Hong and Kubik (2003) have found that optimism helped the analysts covering stocks underwritten by their houses more than accuracy did. The analysts who issue more optimistic forecasts on the stocks are 38 percent less likely to move down the hierarchy and 90 percent more likely to move up. This suggests that analysts who care about their careers may have some positive bias on their forecasts. On the other hand, Lim (2001) has argued that the reason financial analysts make optimistic and inaccurate forecasts is that they try to obtain management access and improve their overall forecast precision. He has also provided empirical evidence supporting this argument by examining forecasts of quarterly earnings reported by analysts at more than 300 brokerage firms. This has suggested that the positive bias actually comes from the analysts' rational and strategic consideration to improve their overall performances. Michaely and Womack (1999) have shown that "buy" recommendations by affiliated underwriters are biased and thus inferior to the recommendations by unaffiliated, non-underwriters because of the investment bank's relationship with the IPO firm, thus making suboptimal effects to the public. This suggests that conflict of interest among the analysts, their firm, and the investing clients may be the reason for the bias of the analysts.

A similar conflict of interest can be found in Waguespack and Sorenson (2011) in a different industry. They have found that the Motion Picture Association of America (MPAA)'s parental guidance classification of movies is biased in that movies distributed by its own members or created by more influential producers or directors are classified more leniently than others. This again suggests that conflict of interest may bias the third-party certification mechanism, leading to negative impact on the public, and in particular in this case, on independent movie distributors or producers.

Other reasons of certification ineffectiveness. Other than the certifier's own concern, the literature has listed customer-side issues and market structure as reasons why certification is not effective. As reviewed above, Harbaugh et al. (2011) have shown that consumer confusion is exacerbated when the certification is used by a product with a bad reputation, when there is proliferation of the label, and when the firm strategically uses it based on the customer doubt, leading to a less trustworthy certification mechanism. Lizzeri (1999) has explained that the competitive environment for risk intermediary impacts the quality of certification. Its analytic model has shown that a monopoly certifier would only disclose whether the quality is above certain standard, while competition encourages full disclosure.

Overall, the literature on certification has explained that many factors related with certifier, customer, and market structure can impact the effectiveness of a certification mechanism, and some have recommended mandatory disclosure for resolving possible adverse selection issues under information asymmetry. These results are summarized in Table 1.4.

Table 1.4: Literature on Certification

Literature	Key Findings	Context	Subject
Anderson et al. (1999)	The firms have used the certificates in order to send a credible public signal about their quality management practices and not simply sought to meet some regulatory standards, which is contrary to the views of critics of ISO 9000.	ISO 9000 certificates	Certification effectiveness
Xiao (2010)	Consumers do not get meaningful information out of accreditation and its contribution to consumer welfare is merely 2%.	Childcare service	Certification ineffectiveness
Feinstein (1989)	The Nuclear Regulatory Commission (NRC) inspectors' rates of detecting violations differ significantly. Interestingly, detection rates increased abruptly after Three Mile Island incident in 1979. These undetected violations had a significant impact on the number of abnormal occurrences at the power plants, indicating that the biased certification system caused by incompetent certifiers may harm the entire system.	Nuclear power plants	
Edelman (2009)	TRUSTe-certified websites are actually more untrustworthy than uncertified sites because a trust authority benefits from that error and ignores it.	Internet websites	Bias of certifier
Prendergast (2007)	Some government certifiers show bureaucratic bias depending on whether they advocate the clients or the principal.	Public service	

Table 1.4: Literature on Certification (Continued)

Literature	Key Findings	Context	Topic
Hong and Kubik (2003)	The analysts who issue more optimistic forecasts on the stocks are 38% less likely to move down the hierarchy and 90% more likely to move up. This suggests that analysts who care about their careers may have some positive bias on their forecasts.	Financial advisory service	Bias of certifier
Lim (2001)	The reason financial analysts make optimistic and inaccurate forecasts is that they try to obtain management access and improve their overall forecast precision. This suggests that the positive bias actually comes from the analysts' rational and strategic consideration to improve their overall performance.	Financial advisory service	
Michaely and Womack (1999)	"Buy" recommendations by affiliated underwriters are biased and thus inferior to the recommendations by unaffiliated, non-underwriters because of the investment bank's relationship with the IPO firm, thus making suboptimal effects to the public.	Financial advisory service	
Waguespack and Sorenson (2011)	The Motion Picture Association of America (MPAA)'s parental guidance classification of movies is biased in that the movies distributed by its own members or created by more influential producers or directors are classified more leniently than others.	Movie rating	
Harbaugh et al. (2011)	The consumer confusion is exacerbated when the certification is used by a product with bad reputation, when there is proliferation of the label, and when the firm strategically uses it based on the customer doubt, leading to less trustworthy certification mechanism.	Theoretical	Consumer confusion
Lizzeri (1999)	The competitive environment for risk intermediary impacts the quality of certification. Its analytic model has shown that a monopoly certifier would only disclose whether the quality is above certain standard, while competition encourages full disclosure.	Theoretical	Competitive environment

1.3 Contribution of the Dissertation

1.3.1 Economic Incentive for Disclosing Low Quality

As is explained above, the literature has provided diverse understanding regarding how information disclosure may or may not solve the adverse selection issues in markets. This essay attempts to provide another perspective to the literature that has not been considered but is very important in understanding information asymmetry in markets. More specifically, this dissertation investigates the economic incentive for sellers with low-quality products to voluntarily disclose quality information.

The inclination of low-type sellers to conceal quality information has been regarded as one of the fundamental reasons why full disclosure is not forthcoming in reality. As is explained above, the literature supporting mandatory disclosure has argued that full disclosure does not happen because low-types try to withhold quality information under various circumstances, such as high disclosure cost (Verrecchia 1983; Viscusi 1978), highly competitive environment (Board 2009; Cheong and Kim 2004; Guo and Zhao 2009; Hotz and Xiao 2013; Stivers 2004), irrational customers (Fishman and Hagerty 2003; Harbaugh, Maxwell, and Roussillon 2011; Hirshleifer, Lim, and Teoh 2004; Schwartz 2008), and others (Bar-Isaac, Caruana, and Cuñat 2012; Gavazza and Lizzeri 2007; Grubb 2011; Matthews and Postlewaite 1985; Milgrom and Roberts 1986).

The literature has also generally agreed that there exist incentives for high-type sellers to reveal their types, but not for low-type sellers. In his seminal paper, Spence (1973) has suggested the education as signaling strategy and shown that high-quality employees always try to separate themselves from low-quality employees through higher education. Milgrom (1981) has called it a monotonicity property that higher-quality types always try to signal or disclose information more than lower-quality types, as disclosing the information about low quality will result in

lower valuation than no disclosure. Akerlof (1976) has shown how more talented workers try to work faster than the socially optimal pace to differentiate themselves from less talented workers. Milgrom and Weber (1982) have developed a model of competitive bidding in an auction setting and shown that although more information improves revenues on average and thus disclosure generally helps, unfavorable news will decrease revenues below a non-disclosure situation.

Moreover, the findings from the literature on voluntary disclosure are somewhat limited in explaining what happens in real markets, as they have basically assumed that lying is impossible either because it is prohibited by law (Grossman and Hart 1980; Grossman 1981; Milgrom 1981) or because sellers care about reputation (Jovanovic 1982). In particular, the reputation or trust motive in a market relationship has also been supported throughout various studies in economics and marketing. Some have claimed that repeated purchases and reputations can solve the "lemons" problem since firms prefer to maintain their reputations and thus honestly share quality-related information (Farrell 1980; Heal 1976; Riordan 1986; Shapiro 1982, 1983; Smallwood and Conlisk 1979; Wilson 1985). Shapiro (1983) has analyzed the market where customers cannot evaluate the quality of products before purchase and shown that, although sellers can benefit from reducing quality and not disclosing in the short run, the sellers who sold high-quality products in the past have an incentive to maintain their reputation as they will be rewarded with high prices and high profits. On a similar note, the studies on trust in marketing relationships have also provided further insight about why sellers try to be honest to maintain relationships with other players in the market. According to Geyskens, Steenkamp, and Kumar (1998), most of major empirical studies about trust in marketing channel relationships have specified honesty as an operational factor of trust. However, the explanation based on reputation or trust in relationships may not apply to one-off purchase or non-repeated purchase situations,

and even under repeated-purchase situations where reputation matters, it seems that many sellers are actually myopic and do overstate their product qualities possibly because they only care about short-term profit. Moreover, the regulatory mechanism to prevent deceit of sellers may not work well either, as we can still observe numerous cases of seller-side frauds, including the examples shown at the beginning of this dissertation. Sellers' fraud has also been verified by the empirical investigation of Jin and Kato (2006), who have observed a considerable amount of fraud in the market for collectible baseball cards. Accordingly, if low-type sellers fraudulently mislead customers, then the no-lying assumption is hard-pressed to withstand the challenges from reality and the argument of full disclosure thus becomes invalid.

Therefore, if we can figure out whether, why, and under what circumstances low-type sellers voluntarily disclose their types, a full disclosure argument can be supported even without no-lying assumptions. The understanding of the economic incentives for low-type sellers to disclose quality information will provide useful knowledge on how we can encourage voluntary disclosure and achieve full disclosure in the market, and whether mandatory disclosure and government intervention are really necessary to solve adverse selection problems. Nevertheless, there have not been sufficient efforts to understand how unfavorable information helps sellers or the existence of economic incentive for low-types to voluntarily reveal their qualities, except for a few recent studies. Berger, Sorensen, and Rasmussen (2010) have shown the circumstances where negative publicity can benefit sellers. In their study, they have found that negative reviews in the *New York Times* actually raised awareness of some less-known books, resulting in the increased sales. Tadelis and Zettelmeyer (2015) have found that negative information can act as a matching mechanism and increase sales for low-quality products when there exist separate markets for products with different quality levels. While these papers have focused on the special

cases, such as when the product has low awareness or there is a separate market for the customers who prefer low-quality products, a more universal explanation on the incentive for low-type sellers to voluntarily disclose unfavorable information in markets is still lacking.

Facing these gaps in the literature, this study attempts to provide a different framework for understanding information asymmetry in markets through verifying the economic incentives for low-type sellers to fully disclose their types. We especially believe that an important missing piece in the stream of related research is the understanding of the effect of customer's perceived risk of purchase since newly revealed information, either positive or negative, is expected to influence the perceived risk of a customer and affect customer's purchasing decisions. As we focus on the effect of perceived risk on purchase, we also consider the role of risk intermediaries, such as third-party certification, that can affect the perceived risk of purchase. Moreover, we investigate the effect of the risk propensities of customers, as some customers are more sensitive to risk from purchase than others. We believe the findings from this study can be generally applied to most market situations where sellers have to deal with the information about their weaknesses, and thus provide better advice on the need for mandatory vs. voluntary disclosure and how to solve adverse selection issues in the market for lemons (Akerlof 1970).

1.3.2 Impact of Certification on Information Disclosure

In addition to examining the incentive for information disclosure for low-type sellers, this study examines how the characteristics of a third-party certification help the market achieve full disclosure. As explained above, the literature on certification mostly focuses on the conditions under which certain certification is biased or provides inaccurate information. More specifically, they have listed the bias of human certifiers (Edelman 2009; Feinstein 1989; Hong and Kubik 2003; Lim 2001; Michaely and Womack 1999; Prendergast 2007; Waguespack and Sorenson

2011), consumer confusion (Harbaugh, Maxwell, and Roussillon 2011), and the competitive environment (Lizzeri 1999) as reasons why certification does not function effectively. However, there has not been sufficient understanding regarding how specific types of certification impact market outcomes, and the optimal design of the certification that accomplishes full disclosure. Therefore, after investigating how low-type sellers can benefit from information disclosure through information intermediary such as certification, this study investigates how the noise of certification affects seller and customer decisions under information asymmetry, with the intention of providing guidance on the design of effective certification mechanism. Once we can figure out both the incentive for low-type sellers to disclose their types and the optimal design of certification for full disclosure, then we may find whether mandatory disclosure or government intervention is necessary to solve adverse selection problems.

1.4 Dissertation Structure and Preview

This dissertation pursues this research object theoretically, experimentally, and empirically. In Essay 1, we attempt to provide a new theoretical understanding about the information asymmetry in markets by showing that there exist economic incentives for low-type sellers to fully disclose their types. The essay explains whether, when, and how a low-type seller's information disclosure can enhance both sellers' profitability and customers' welfare and also increase the market demand and the demand for the high-type seller through an analytic model and observations from lab experiments. This essay is thus expected to present an important theoretical basis to solve various market dilemmas under information asymmetry, possibly supporting the literature on voluntary disclosure. Essay 2 primarily confirms the counterintuitive predictions from Essay 1 through observing sales data of collectible baseball cards, coins, and stamps from one of the major online sellers in the U.S., focusing on measuring

and comparing the sizes of economic incentives to disclose vs. conceal low-quality information. This essay also relaxes the original assumption of uniform distribution of customers' risk sensitivity and shows that voluntarily revealing weakness is more effective when selling higher-than-average-quality products than when selling lower-than-average-quality products. One more interesting finding from this essay is that the incentive for full disclosure and the effect of certification differ across different markets, which provides a motivation for the next essay. Based on this observation, Essay 3 attempts to assess the effect of certifications of varying qualities on various market outcomes such as seller profit, buyer profit, and the level of information disclosure. Through the analytic model and economic experiments, this essay finds that an inaccurate certification is even worse than having no certification for sellers, as it provides the lowest profit, but it helps buyers through increasing their profits as sellers disclose more information than when there is no certification, even though the certification is inaccurate. By analyzing various drivers of seller and buyer profit under information asymmetry, this essay also suggests that using certification and disclosing information is generally the best method to increase profit for sellers under information asymmetry. Therefore, the result of Essay 3 is consistent with the findings from previous essays that the certification provides economic incentives for sellers to fully disclose and increases social welfare, and that the economic incentive for information disclosure differs across different product categories.

Overall, this study has important implications, ranging from the analysis of "lemons" markets to regulatory policies about market frauds, as this is one of the first attempts to understand the economic incentives for low-type sellers to reveal their quality, and suggest the optimal design of certification to solve various issues in markets under information asymmetry.

This dissertation concludes with more detailed discussion of the contributions and managerial implications.

2. ESSAY 1: THE ECONOMIC INCENTIVE FOR LOW-TYPE SELLERS' INFORMATION DISCLOSURE

2.1 Introduction

As explained in the previous chapter, this essay attempts to provide a theoretical framework for understanding sellers' disclosure of quality information to customers. In particular, we are interested in whether, when, and how sellers of low-quality products disclose quality information. In order to do that, this essay focuses on the effect of the customer's perceived risk of purchase, as newly shared information influences the perceived risk of a customer and affects her purchasing decisions. Therefore, the concepts of perceived risk of purchase and search, experience, and credence attributes, which are discussed more in detail in a following section, play key roles in developing the theories and analytic models of this essay.

Ever since Bauer (1960) first identified the concept of risk as a major influence on customer choice, various researchers have produced some general understanding about perceived risk of purchase (Dowling 1986; Markin, Jr. 1974; Ross 1975; Stone and Winter 1985; Taylor 1974). Perceived risk of purchase has been generally defined as the function of the probability of possible loss and the size of loss from purchase (Dowling 1986; Markin, Jr. 1974; Peter and Ryan 1976; Peter and Tarpey, Sr. 1975; Ross 1975; Srinivasan and Ratchford 1991; Taylor 1974). Perceived risk has a pseudo-vertical characteristic since customers usually try to decrease the probability rather than the size of loss when attempting to reduce the risk before purchase (Cox 1967; Markin, Jr. 1974; Peter and Ryan 1976; Ross 1975). Therefore, information search is an often-used risk-reduction method by customers since the probability of loss diminishes with more information. This linkage between information search and risk and how information

acquisition affects a customer's purchase decision process have been explained in various studies (Murray 1991; Putsis, Jr. and Srinivasan 1994; Srinivasan and Ratchford 1991; Zeithaml 1981).

In this essay, we examine the impact of the low-quality seller's information disclosure through an analytic model that investigates the tradeoff between expected benefit and perceived risk from purchase. The model observes a duopoly situation where there is one seller who always claims high quality and another seller with low-quality products who claims either high quality (incomplete disclosure) or low quality (full disclosure). This allows us to analyze the impact when a low-type seller shares his quality information and reveals his type. Moreover, we assume the sellers are myopic and base all of the analyses on a non-repeating, one-time purchase situation in order to eliminate the effect of reputation motive. We also assume that price is fixed because we observe only one stage and want to focus on the factors of interest of this essay such as perceived risk and claimed quality level. We relax the assumption of fixed price in Essay 3.

2.2 Analytic Model

2.2.1 Risk-Return Framework

For the analytic model, we adopt the concept of perceived risk from marketing literature and use the risk-return framework (Sarin and Weber 1993; Weber, Blais, and Betz 2002), where the impacts of both the expected benefit and perceived risk on customer's utility are considered, and in particular, where perceived risk is treated as a separate variable. The utility function when a buyer *i* purchases a product *j* has the following elements.

2.2.1.1 Claimed Quality and Price

First, the utility from purchase will be determined by the expected value of the claimed quality of product *j* (v_j^C) and its price (p_j) (where $v_j^C \geq p_j$).

2.2.1.2 Perceived Risk

The perceived risk of purchase also affects the utility level of this buyer, as he or she will prefer the product with less perceived risk. Applying the definition of perceived risk explained above, perceived risk is represented here as the function of the probability of loss and the size of loss from purchase, i.e., the expected loss from the purchase. We assume that the buyer worries about possible purchase failure of product *j*, which will cost c_j^F (cost of purchase failure). Therefore, $E\left(c_j^F\right)$ represents the perceived risk in this case.

We have also defined q_j as the probability of purchase failure of product *j* ($0 \leq q_j \leq 1$), and the total perceived risk from the purchase can be represented as $E\left(c_j^F\right) = q_j \cdot (c_j^F)$. Moreover, when the probability of purchase failure is q_j, then the probability that the actual quality of product *j* equals the claimed quality is $(1 - q_j)$. Therefore, the expected value of the claimed quality can be denoted as $E(v_j^C) = (1 - q_j) \cdot v_j^C$.

2.2.1.3 Risk Sensitivity

The level of risk sensitivity of the buyer *i* is denoted as s_i and is equivalent to the concept of perceived-risk attitude from Weber and Milliman (1997) and risk repugnance from Yates and Stone (1992). If a buyer is more risk-sensitive and s_i is higher, then the same perceived risk will impact the total utility more negatively than the case of a less risk-sensitive buyer with lower s_i. For our analysis, we suppose that no customer is risk-loving and therefore $s_i \geq 0$. We assume that the customers are uniformly distributed in terms of their risk sensitivities, and therefore s_i follows $\mathrm{U}[0, S]$ with unit frequency, where *S* denotes the risk sensitivity of the customer with highest risk sensitivity in the market.

2.2.1.4 Information Search Cost

Our model has also included an element that represents information search cost. More specifically, c_j^I is defined as the information search cost for the product *j*. As is explained above, to reduce the perceived risk before purchase, customers usually try to decrease the probability of loss rather than the size of loss (Cox 1967; Markin, Jr. 1974; Peter and Ryan 1976; Ross 1975), and information search is an often-used risk-reduction method as the probability of loss diminishes with more information. Therefore, we also examine the effect of information search cost on the information disclosure of sellers.

More specifically, we employ the framework of search, experience, and credence attributes, which has been introduced by Nelson (1970) and Darby and Karni (1973), who have used information search cost to distinguish product attributes. According to Nelson (1974), a customer can determine search attributes prior to purchase but cannot determine experience attributes prior to purchase. Darby and Karni (1973) have also contributed to this approach and referred to those attributes that cannot be evaluated even after purchase as "credence attributes." Therefore, we regard the search cost related to credence attributes to be almost infinite ($c_{credence}^I \approx \infty$), because, by definition, customers can never find out the information about credence attributes even after purchase. On the other hand, we regard the search cost related to search or experience attributes to be positive and smaller than the search cost for credence attributes ($0 \leq c_{search}^I, c_{experience}^I < c_{credence}^I$). By observing how market outcome differs between search, experience, and credence attributes, we expect to understand the effect of information search cost on the incentive for information disclosure.

2.2.2 The Model

Based on this framework, we present the utility function when a buyer *i* purchases a product *j* as follows:

$$\mathrm{U}_{i,j} = E\left(v_j^C\right) - p_j - s_i \cdot c_j^I \cdot E\left(c_j^F\right)$$

$$= (1 - q_j) \cdot v_j^C - p_j - s_i \cdot c_j^I \cdot q_j \cdot c_j^F$$

As explained, the probability of purchase failure of the product (q_j), the claimed quality of the product (v_j^C), the price of the product (p_j), the risk sensitivity of the customer (s_i), the information search cost related with the product (c_j^I), and the cost of purchase failure (c_j^F) determine the utility from purchase. In particular, the same level of perceived risk ($q_j \cdot c_j^F$) has higher negative impact with higher risk sensitivity of the customer (higher s_i) or higher information search cost in the market (higher c_j^I).

We first apply this utility function to a simple monopoly case and then analyze a duopoly situation to understand the incentive for low-type sellers to disclose their types.

2.2.3 Application

2.2.3.1 Monopoly Case

2.2.3.1.1 Overview

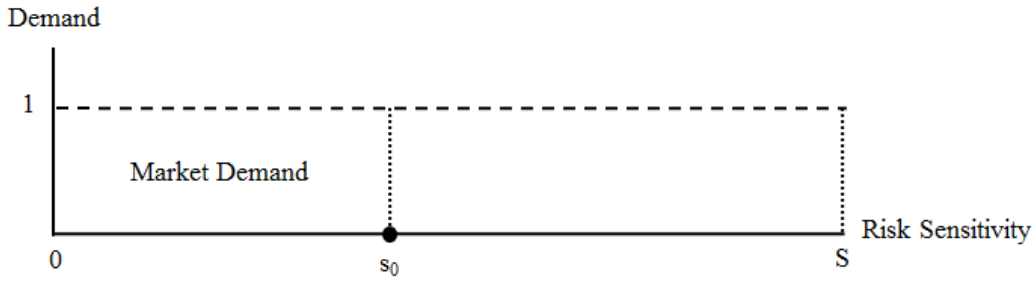
There is only one seller in this market and the customers either choose to purchase this product or not, according to their utility levels; that is, a customer will purchase the product if the utility from purchase is positive. In the utility function presented above, there is only one variable that is heterogeneous among various customers, which is the sensitivity to risk (s_i). As other factors are same for all customers (such as probability and cost of purchase failure, claimed quality and price of the product, and information search cost), the level of sensitivity to risk will

differentiate the purchase decisions for the same product. In Figure 2.1, the equilibrium point in this market is represented by the risk sensitivity of the indifferent customer, s_0.

2.2.3.1.2 Market Equilibrium

The indifferent customer with risk sensitivity s_0 has the same utility from either purchasing the product or not purchasing the product. This is the situation where a customer decides whether to make a purchase or not according to the level of perceived risk of the product, since a customer's information stock can affect her purchase/no purchase decision (Putsis, Jr. and Srinivasan 1994). For example, some people hesitate to visit car mechanics since they do not know much about their cars and want to avoid the possibility of getting "ripped off." Therefore, the customers who have lower risk sensitivity than s_0 will all purchase the product, while none of the customers who have higher risk sensitivity than s_0 will make a purchase in this market. This represents the equilibrium point of this market.

Figure 2.1: Equilibrium of Monopoly Market



v_M^C denotes the claimed value and q_M denotes the probability of purchase failure for this monopoly product *M*. As explained, the price and information search cost of the product are fixed at p and c^I throughout our analysis. We will also fix the cost of purchase failure at c^F, as we assume the same product category for our analysis. Then the utility of the indifferent customer with the risk sensitivity of s_0 from purchasing product M is calculated as follows:

$$u_{0,M} = E(v_M^C) - p - s_0 \cdot c^I \cdot E\,(c^F)$$

$$= (1 - q_M) \cdot v_M^C - p - s_0 \cdot c^I \cdot q_M \cdot c^F = 0$$

As explained, the utility of this customer equals zero as this customer is indifferent between purchasing and not purchasing in this market. From this equation, we can calculate the market demand as follows:

$\therefore$ Market demand[6]

$$= s_0 - 0 = \frac{(1 - q_M) \cdot v_M^C - p}{c^I \cdot c^F \cdot q_M}$$

We can find some primary observations about the demand for the product from this result. The demand for the monopolistic seller's product will be larger as the probability of purchase failure (q_M) is smaller and the claimed quality of the seller's product (v_M^C) is higher. Moreover, the demand will be larger as the information search cost (c^I) gets smaller. Therefore, it is better for the monopoly firm to increase the claimed quality and decrease the perceived risk of purchase, and the demand will be smaller for the products with credence attributes than those with search or experience attributes.

2.2.3.2 Duopoly Case

Now let's investigate the duopoly case where one seller always claims high quality while the other seller either claims high or low quality. We first examine how various factors in our model, such as the perceived risk and the claimed quality, affect the demand for each seller and the entire market demand.

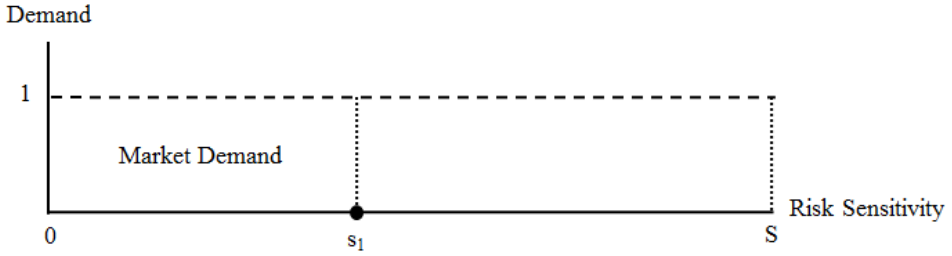
[6] We assume that the price is low enough to make the market demand positive. In other words, we assume the condition that $p \leq (1 - q_M) \cdot v_M^C$ to hold for our analysis. We discuss more about this assumption in a following section.

2.2.3.2.1 Observation on the Size of Demands

2.2.3.2.1.1 Market Equilibrium under Information collusion

In this first case of duopoly, we assume that both firms claim high quality and the low-quality seller does not disclose its type. In other words, it is just as if both firms engage in tacit collusion in terms of negative information sharing, and we call this scheme as "information collusion." Information collusion can be found in many instances in real market situations, especially with respect to those attributes with high information search costs. The examples presented in the previous chapter, the overstated fuel figures of the cars in the U.K. market and the unreliable grades of olive oils, are good examples of how "information collusion" actually works in practice. Therefore, these products have high claimed quality (v_H^C) and also have high level of perceived risk with high chance of purchase failure (q_H), compared with the market without information collusion which is analyzed in the following section. Figure 2.2 illustrates the equilibrium of this duopoly market with information collusion.

Figure 2.2: Equilibrium of Duopoly Market with Information Collusion



Market equilibrium. Let's assume that the indifferent customer in this market has the risk sensitivity of s_1. From analyzing the utility of this indifferent customer, we can find the level of s_1 as follows.

$$u_{1,H} = E(v_H^C) - p - s_1 \cdot c^I \cdot E\,(c^F)$$

$$= (1 - q_H) \cdot v_H^C - p - s_1 \cdot c^I \cdot q_H \cdot\ c^F = 0$$

$$s_1 = \frac{(1 - q_H) \cdot v_H^C - p}{c^I \cdot c^F \cdot q_H \cdot}$$

∴ Market demand[7]

$$= \mathrm{s}_1 - 0 = \frac{(1 - q_H) \cdot v_H^C - p}{c^I \cdot c^F \cdot q_H}$$

So far it is exactly same with the monopoly case. The only difference is that there are two products in this market, and therefore each product will take the half of the entire market demand.

∴ Demand for each product

$$= \frac{1}{2} \cdot \left\{ \frac{(1 - q_H) \cdot v_H^C - p}{c^I \cdot c^F \cdot q_H} \right\}$$

Therefore, we can come up with the following proposition regarding market demand and the demand of each product.

Proposition 1. In a duopoly market with information collusion, the market demand and the demand for each seller's product will be larger as the perceived risk of the products of those sellers is smaller, the claimed quality of the products of those sellers is higher, and the information search cost is smaller.

2.2.3.2.1.2 Market Equilibrium Under No Information Collusion

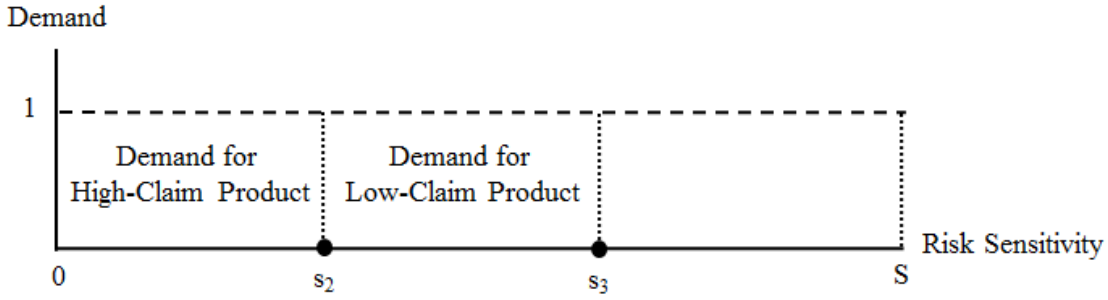
In this second case of duopoly, we assume that a low-type seller reveals its type, shares its quality information, and decreases perceived risk of purchase through certain risk intermediaries such as quality certification. We examine the size of demand for the low-type seller in a market with no information collusion and then also observe the market demand and the demand for the other seller who maintains the claim of high quality. In the following section,

[7] Just like the monopoly case, we assume that the price is low enough to make the market demand positive. In other words, we assume the condition that $p \leq (1 - q_H) \cdot v_H^C$ to hold for our analysis. The observation from the experimental analysis also confirms this assumption, as the demand for sellers under information collusion is always positive.

we observe how the sizes of demand change with this information disclosure by comparing the market with information collusion and the market with no information collusion.

The product of the low-type seller who reveals his type now has low claimed quality ($v_L^C \leq v_H^C$) and also has a low level of perceived risk with a low chance of purchase failure ($q_L \leq q_H$), compared with the market with information collusion. Figure 2.3 illustrates the equilibrium of this duopoly market without information collusion.

Figure 2.3: Equilibrium of Duopoly Market Without Information Collusion



Market equilibrium. In this market there are two types of indifferent customers.

First, there is a customer who is indifferent to purchasing either product. Let's assume that this indifferent customer has the risk sensitivity of s_2. From analyzing the utility of this indifferent customer, we can find the level of s_2 as follows.

$$\mathrm{u}_{2,H} = E(v_H^C) - p - s_2 \cdot c^I \cdot E\,(c^F) = (1 - q_H) \cdot v_H^C - p - s_2 \cdot c^I \cdot q_H \cdot c^F$$

$$= \mathrm{u}_{2,L} = E(v_L^C) - p - s_2 \cdot c^I \cdot E\,(c^F) = (1 - q_L) \cdot v_L^C - p - s_2 \cdot c^I \cdot q_L \cdot c^F$$

$$\therefore \mathrm{s}_2 = \frac{(1 - q_H) \cdot v_H^C - (1 - q_L) \cdot v_L^C}{c^I \cdot c^F \cdot (q_H - q_L)}$$

Second, there is a customer who is indifferent between purchasing the low-type product and making no purchase. Let's assume that this indifferent customer has the risk sensitivity of s_3. From analyzing the utility of this indifferent customer, we can find the level of s_3 as follows.

$$\mathrm{u}_{3,L} = E(v_L^C) - p - s_3 \cdot c^I \cdot E\,(c^F) = (1 - q_L) \cdot v_L^C - p - s_3 \cdot c^I \cdot q_L \cdot c^F = 0$$

$$\therefore s_3 = \frac{(1-q_L)\cdot v_L^C - p}{c^I \cdot c^F \cdot q_L}$$

From these results, we can figure out the sizes of market demand and the demand for both products in equilibrium as follows:

Demand for the low-type product[8]

$$= s_3 - s_2 = \frac{(1-q_L)\cdot v_L^C - p}{c^I \cdot c^F \cdot q_L} - \frac{(1-q_H)\cdot v_H^C - (1-q_L)\cdot v_L^C}{c^I \cdot c^F \cdot (q_H - q_L)}$$

$$= \frac{1}{c^I}\left\{\frac{(1-q_L)\cdot v_L^C - p}{c^F \cdot q_L} - \frac{(1-q_H)\cdot v_H^C - (1-q_L)\cdot v_L^C}{c^F \cdot q_H - c^F \cdot q_L}\right\}$$

Proposition 2. In a duopoly market without information collusion, the demand for the product of the low-type seller will be larger as the perceived risk of the product of the low-type seller is smaller, the claimed quality of the product of the low-type seller is higher, and the information search cost is smaller.

Market demand[9]

$$= s_3 - 0 = \frac{(1-q_L)\cdot v_L^C - p}{c^I \cdot c^F \cdot q_L}$$

Proposition 3. In a duopoly market without information collusion, the market demand will be larger as the perceived risk of the product of the low-type seller is smaller, the

[8] We should note that s_2 can be higher than s_3 if price is higher than a certain level, and in this case the demand for the low-type seller's product can be less than zero. Therefore, price should be lower than a certain level and we assume the condition $p \leq \frac{q_H v_L^C - q_L v_H^C - q_H q_L (v_L^C - v_H^C)}{q_H - q_L}$ to hold for our analysis. The observation from the experimental analysis confirms this assumption, as the demand for the low-type seller's product under no information collusion is always positive.

[9] Just as explained above, we assume that the price is low enough to make the market demand positive. In other words, we assume the condition that $p \leq (1-q_L)\cdot v_L^C$ to hold for our analysis. The observation from the experimental analysis confirms this assumption, as market demand under no information collusion is always positive.

claimed quality of the low-type seller is higher, and the information search cost is smaller.

Demand for the high-claim product[10]

$$= s_2 - 0 = \frac{(1 - q_H) \cdot v_H^C - (1 - q_L) \cdot v_L^C}{c^I \cdot (c^F \cdot q_H - c^F \cdot q_L)}$$

Proposition 4. In a duopoly market without information collusion, the demand for the product of the seller that claims high quality will be larger as the perceived risk of the product of the low-type seller is bigger, the claimed quality of the low-type seller is lower, and the information search cost is smaller.

2.2.3.2.2 Impact of Low-Type Seller's Information Disclosure

Now that we have observed the duopoly markets under information collusion vs. no information collusion, we can figure out the effects of low-type seller's information disclosure on market outcomes by comparing the sizes of demands between two market conditions.

2.2.3.2.2.1 Impact on Demand for the Low-Type Seller's Product

We can calculate the impact of low-type seller's information disclosure on his own demand by subtracting the demand under information collusion (*IC*) from the demand under no information collusion (*NIC*) as follows:

$$\text{Difference in Demand for Low Type Product} = \text{Demand for Low Type Product}_{\text{NIC}} - \text{Demand for Each Product}_{\text{IC}}$$

$$= \frac{1}{c^I} \left\{ \frac{(1 - q_L) \cdot v_L^C - p}{c^F \cdot q_L} - \frac{(1 - q_H) \cdot v_H^C - (1 - q_L) \cdot v_L^C}{c^F \cdot q_H - c^F \cdot q_L} \right\} - \frac{1}{2} \cdot \left\{ \frac{(1 - q_H) \cdot v_H^C - p}{c^I \cdot c^F \cdot q_H} \right\}$$

[10] In order for the demand for the high-claim seller's product to be positive, the condition that $(1 - q_H)v_H^C \geq (1 - q_L)v_L^C$ should be met. Therefore, we assume that the expected value of the high-claim seller's product is higher than the expected value of the low-type seller's product for our analysis. The observation from the experimental analysis confirms this assumption, as the demand for high-claim seller's product under no information collusion is always positive.

$$= \frac{1}{c^I} \left\{ \frac{(1-q_L)\cdot v_L^C - p}{c^F \cdot q_L} - \frac{(1-q_H)\cdot v_H^C - (1-q_L)\cdot v_L^C}{c^F \cdot q_H - c^F \cdot q_L} - \frac{1}{2} \cdot \frac{(1-q_H)\cdot v_H^C - p}{c^F \cdot q_H} \right\}$$

Therefore, from this result, we can establish some predictions regarding the impact on the demand for the low-type seller's product as follows.

Proposition 5. In a duopoly market with information collusion, when a low-type seller reveals its type, the change in demand for the product of the low-type seller will be larger as the perceived risk of the product of low-type seller is smaller and the claimed quality of the product of the low-type seller is higher, and the absolute size of the change will be higher with smaller information search cost.

One important finding from this result is that, when a low-type seller reveals its type and reduces perceived risk sufficiently (so that $q_L \approx 0$), then the change in demand for the low-type seller's product will be positive. In other words, the low-type seller can increase its own demand by disclosing its own type, when it can appropriately reduce the perceived risk.

2.2.3.2.2.2 Impact on Market Demand

We can calculate the impact of low-type seller's information disclosure on market demand by subtracting the market demand under information collusion (*IC*) from the market demand under no information collusion (*NIC*) as follows:

$$\text{Difference in Market Demand} = \text{Market Demand}_{\text{NIC}} - \text{Market Demand}_{\text{IC}}$$

$$= \frac{(1-q_L)\cdot v_L^C - p}{c^I \cdot c^F \cdot q_L} - \frac{(1-q_H)\cdot v_H^C - p}{c^I \cdot c^F \cdot q_H}$$

$$= \frac{1}{c^I} \left\{ \frac{(1-q_L)\cdot v_L^C - p}{c^F \cdot q_L} - \frac{(1-q_H)\cdot v_H^C - p}{c^F \cdot q_H} \right\}$$

Again, from this result, we can establish some predictions regarding the impact on market demand as follows.

Proposition 6. In a duopoly market with information collusion, when a low-type seller reveals its type, the change in market demand will be larger as the perceived risk of the product of the low-type seller is smaller and the claimed quality of the product of the low-type seller is higher, and the absolute size of the change will be higher with smaller information search cost.

As in the case of low-type seller's product, we can see that when a low-type seller reveals its own type and reduces perceived risk sufficiently ($q_L \approx 0$), then the change in market demand will be positive. In other words, the low-type seller can increase the market demand by disclosing its own type, when it can appropriately reduce perceived risk.

2.2.3.2.2.3 Impact on Demand for the High-Claim Seller's Product

Again, we can calculate the impact of low-type seller's information disclosure on the demand for high-claim seller's product by subtracting the demand under information collusion (*IC*) from the demand under no information collusion (*NIC*) as follows:

$$\text{Difference in Demand for High Quality Claim Product}$$

$$= \text{Demand for High Quality Claim Product}_{\text{NIC}} - \text{Demand for Each Product}_{\text{IC}}$$

$$= \frac{(1-q_H)\cdot v_H^C - (1-q_L)\cdot v_L^C}{c^I \cdot (c^F \cdot q_H - c^F \cdot q_L)} - \frac{1}{2}\cdot\left\{\frac{(1-q_H)\cdot v_H^C - p}{c^I \cdot c^F \cdot q_H}\right\}$$

$$= \frac{1}{c^I}\left\{\frac{(1-q_H)\cdot v_H^C - (1-q_L)\cdot v_L^C}{c^F \cdot q_H - c^F \cdot q_L} - \frac{(1-q_H)\cdot v_H^C - p}{2\cdot c^F \cdot q_H}\right\}$$

From this result, we can establish some predictions regarding the impact on the demand for high-claim seller's product as follows.

Proposition 7. In a duopoly market with information collusion, when a low-type seller reveals its type, the change in the demand for the product of the firm which maintains a high-quality claim will be larger as the perceived risk of the product of the low-type

seller is bigger and the claimed quality of the product of the low-quality seller is lower, and the absolute size of the change will be higher with smaller information search cost.

One interesting observation from this result is that, when the low-type seller cannot reduce the risk sufficiently and therefore $q_L \approx q_H$, the change in demand for the product of the firm which maintains a high-quality claim will always be positive, implying that the low-type seller's information disclosure may help the other firm through increasing its demand.

2.2.4 Summary

Overall, through the analytic model we have established some predictions on the sizes of demand under information collusion and no information collusion, and the impact of low-quality seller's information disclosure on market outcomes. The propositions are summarized in Table 2.1 and Table 2.2.

Table 2.1: Predictions on the Sizes of Demand

	Market Circumstances	Demand of Interest	Conditions for Higher Demand		
			Perceived risk of low-type product	Claimed quality of low-type product	Information search cost of the market
Proposition 1	Information collusion	Market	↓	↑	↓
Proposition 2	No information collusion	Low-type product	↓	↑	↓
Proposition 3		Market	↓	↑	↓
Proposition 4		High-type product	↑	↓	↓

Table 2.2: Predictions on the Impact of a Low-Type Seller's Information Disclosure

	Impacted Demand	Conditions for Higher Impact		Conditions for Higher Absolute Impact	Net Impact
		Perceived risk of low-type product	Claimed quality of low-type product	Information search cost of the market	
Proposition 5	Low-type product	↓	↑	↓	+ / –
Proposition 6	Market	↓	↑	↓	+ / –
Proposition 7	High-type product	↑	↓	↓	+ / –

2.3 Experimental Analysis

With the results from the analytic model, we now attempt to analyze the impact of information disclosure on actual demands by observing customer choices through laboratory experiments with the aim of providing specific answers about exactly where suggested theories succeed or fail (Lucking-Reiley 1999).

2.3.1 Procedure

2.3.1.1 Overview

For the experimental analysis, we suggested purchase scenarios to subjects and observed their purchase decisions, following numerous other marketing studies (Locander and Hermann 1979; Jackson, Keith, and Burdick 1984; Mowen, Keith, Brown, and Jackson, Jr. 1985; Puto, Patton, and King 1985; Murray 1991; White, Varadarajan, and Dacin 2003). Using purchase scenarios fits our purpose very well since this allows us to manipulate variables and contexts that cannot be controlled in a real-life environment (Murray 1991), avoid unnecessary bias associated with the selection of an actual seller (Duhan et al. 1997), and test all subjects with a standardized stimulus (White, Varadarajan, and Dacin 2003).

2.3.1.2 Experimental Design

We have designed 2-by-2 between-subjects experiments to test the theoretical findings regarding the economic incentive for low-type sellers to disclose information in markets. Unlike the market data analysis in the following essay, the experimental setting enables us to manipulate all of the key factors in the analytic model, i.e., perceived risk (low versus high) and information search cost (low versus high).

We selected the used-car market as the product of choice since the context of a used-car purchase matches the purpose of this essay very well; the market for used cars shows a clear information asymmetry between customers and sellers and the products can be presented with various levels of perceived risk. We chose a foreign imported used car as our target product to control the level of perceived risk, as it is hard for customers to obtain third-party vehicle history reports for this particular product category unless provided by the seller. Therefore, perceived risk was controlled in such a way that the seller provides the certification from a third-party certifier (manufacturer or car mechanic) and reduces perceived risk in a low risk case (q_L), while the seller does not provide any certification in a high risk case (q_H). In order to control the information search cost (c^I), the negative information was related with past accident history in a high-cost case ($c^I_{credence}$), while it was related with the noise from the car in a low-cost case ($c^I_{experience}$). The difference in these two conditions was supposed to control the level of information search cost, as accident history could be regarded as a credence attribute with extremely high information search cost while the noise from the car could be regarded as an experience attribute with moderate information search cost. In neither scenario was the negative information revealed by the seller at such a serious level that customers would regard it as a product failure. More specifically, the actual negative information provided to subjects was that

the car had "one minor accident in the past" in the high information search cost condition, and that the car had "a little noise that is not coming from the engine" in the low information search cost condition. This 2-by-2 design is explained in Table 2.3.

Table 2.3: 2×2 Experimental Design

	Search Cost (c^I)	
	Past accidents ($c^I_{credence}$)	Noise ($c^I_{experience}$)
Perceived Risk:		
Without certification ($c^F \cdot q_H$)	▪ High perceived risk ▪ High info search cost	▪ High perceived risk ▪ Low info search cost
With certification ($c^F \cdot q_L$)	▪ Low perceived risk ▪ High info search cost	▪ Low perceived risk ▪ Low info search cost

The subjects consisted of undergraduate students at a major public university in the southern United States, and 154 subjects for each experimental setting (616 subjects in total) were observed for this analysis. During these experiments, each subject was basically required to indicate which product he or she would like to purchase among the suggested options, or whether to postpone the purchase. More specifically, in each scenario, there were two used-car sellers selling the same products (i.e., same model, same color, same year, same mileage, etc.). Each subject was asked whether he or she wanted to purchase one of the products in the market under a first condition where there is information collusion (i.e., when both sellers claim high quality) and under a second condition where there is no information collusion (i.e., when a low-type seller discloses quality information).

The responses were collected for four different situations and enabled us to observe how the impact of low-type seller's information disclosure on demand varies according to the factors of our interest. Based on the subjects' purchase choices observed from the experiments, we can analyze what happens to market outcomes (market demand, demand for the low-type product,

and demand for the high-type product) according to different levels of perceived risk and information search cost when a low-type seller discloses quality information, and test the propositions established by the analytic model.

2.3.2 Results

The analytic model has provided various predictions regarding the equilibrium demand when everyone claims high quality versus when one low-type seller discloses his type. By analyzing the results from the experiments, we can check whether those predictions are consistent with what we observe in a real market. We check the predictions on three different cases as follows. First, we have observed the impact of information search cost on the market equilibrium under information collusion (i.e., when everyone claims high quality) (Proposition 1). In this case, the impact of perceived risk cannot be investigated, as every seller has the same perceived risk under information collusion (i.e., no seller shows certification). Second, we have observed the impact of perceived risk and information search cost on the market equilibrium under no information collusion (i.e., when a low-type seller reveals his type) (Propositions 2, 3, and 4). Third, we have observed the impact of perceived risk and information search cost on the change in demand between two market equilibria (information collusion vs. no information collusion) in order to understand whether voluntarily disclosing quality information helps a low-type seller (Propositions 5, 6, and 7).

2.3.2.1 Market Equilibrium Under Information Collusion

Proposition 1 of the analytic model has made several predictions regarding the size of market demand when everyone is claiming high quality. It predicted that the market demand will be bigger with lower information search cost and smaller with higher information search cost. The other factor, the level of perceived risk, is not controlled under information collusion since

no one is voluntarily disclosing information about low quality and thus everyone has same levels of perceived risk. Table 2.4 shows the observed market demand in the experiment, when everyone is claiming high quality.

Table 2.4: Observed Market Demand (Information Collusion)

	Higher Info Search Cost	Lower Info Search Cost
Demand	109	150
%	35.4	48.7

NOTE: Percentage values are calculated based on the total market size of 308.

According to the observed result, the market demand under information collusion shows the predicted pattern, as the demand is higher with lower information search cost (48.7% > 35.4%). Moreover, the chi-square test shows the difference in demand in two conditions is statistically significant ($p < 0.01$), suggesting that the market demand under information collusion is affected by the information search cost of the market. In other words, when the information about the product attribute is easier to obtain, more customers decide to purchase the product even when the sellers do not fully disclose quality information, providing support for Proposition 1.

2.3.2.2 Market Equilibrium Under No Information Collusion

The results of the analytic model also provide several predictions regarding the size of demand when a low-type seller discloses quality information. We can estimate how the demand for the product of low-type seller, market demand, and the demand for the product of the seller who claims high quality are affected by the levels of perceived risk and information search cost.

2.3.2.2.1 Demand for Low-Type Seller

Proposition 2 has proposed that the demand for the low-type seller who discloses his type will be higher with lower perceived risk of the product, and lower information search cost in the market. Table 2.5 shows the observed demand of the low-type seller who discloses his type.

Table 2.5: Observed Demand of the Low-Type Seller (No Information Collusion)

	Higher Info Search Cost	Lower Info Search Cost
Without Risk Reducer:		
Demand	25	19
%	16.2	12.3
With Risk Reducer:		
Demand	82	77
%	53.2	50.0

NOTE: Percentage values are calculated based on the total market size of 154.

According to the observed result, the demand for the low-type seller that reveals its type shows the predicted pattern only for perceived risk, as the demand is higher with lower perceived risk (53.2% > 16.2% and 50% > 12.3%) but also with higher information search cost (16.2% > 12.3% and 53.2% > 50%). The results of two-way ANOVA with the demand as the dependent variable has shown that the effect of perceived risk ($F(1,1) = 13225$, $p < 0.01$) is significant, while the effect of information search cost ($F(1,1) = 121$, $p = 0.058$) is only weakly significant. Therefore, the prediction regarding the impact of perceived risk is shown to be consistent with actual behavior, while the prediction regarding information search cost shows a different pattern that is not strongly significant. This result suggests that the demand of the low-type seller who discloses quality information is affected by perceived risk, while the impact of the information search cost of the market is not obvious, providing partial support for Proposition 2.

2.3.2.2.2 Market Demand

Proposition 3 has proposed that the market demand will be higher with lower perceived risk of the product of a low-type seller, and lower information search cost in the market, when the low-type seller reveals its type. Table 2.6 shows the size of market demand when a low-type seller shares quality information, observed from the experiment.

Table 2.6: Observed Market Demand (No Information Collusion)

	Higher Info Search Cost	Lower Info Search Cost
Without Risk Reducer:		
Demand	89	92
%	57.8	59.7
With Risk Reducer:		
Demand	113	120
%	73.4	77.9

NOTE: Percentage values are calculated based on the total market size of 154.

According to the observed result, the market demand shows the predicted patterns. First, the market demand is higher with lower perceived risk of the low-type seller's product (73.4% > 57.8% and 77.9% > 59.7%), as predicted by the analytic model. Moreover, the market demand is higher with lower information search cost (57.8% < 59.7% and 73.4% < 77.9%), which is also consistent with the prediction. We have also checked these results with two-way ANOVA with the demand as the dependent variable. ANOVA has shown that the observed effect of perceived risk is significant ($F(1,1) = 169$, $p < 0.05$), while the effect of information search cost is not ($F(1,1) = 6.25$, $p = 0.242$). Therefore, the market demand under no information collusion is affected by the level of perceived risk of the low-type seller's product, but the effect of information search cost does not seem to be significant, providing partial support for Proposition 3.

2.3.2.2.3 Demand for the Seller Claiming High Quality

Finally, Proposition 4 has proposed that the demand for the firm which claims high quality will be higher with higher perceived risk of the low-type seller's product, and lower information search cost in the market. Table 2.7 shows the demand of the firm that claims high quality observed from the experiment.

Table 2.7: Observed Demand of the Seller Claiming High Quality (No Information Collusion)

	Higher Info Search Cost	Lower Info Search Cost
Without Risk Reducer:		
Demand	64	73
%	41.6	47.4
With Risk Reducer:		
Demand	31	43
%	20.1	27.9

NOTE: Percentage values are calculated based on the total market size of 154.

According to the observed result, the demand for the firm that maintains the high-quality claim shows the predicted pattern. First, the demand is higher with lower information search cost in the market (47.4% > 41.6% and 27.9% > 20.1%) and higher perceived risk of the low-type seller's product (41.6% > 20.1% and 47.4% > 27.9%). The results of two-way ANOVA with the demand as the dependent variable has shown that the effect of perceived risk is significant ($F(1,1) = 441$, $p < 0.05$) while the effect of information search cost is weakly significant ($F(1,1) = 49$, $p < 0.1$). These results suggest that, when a low-type seller discloses the quality of its product, the demand of the product that maintains a high-quality claim is strongly affected by the perceived risk of the low-type seller and also affected by the information search cost of the market, providing support for Proposition 4.

2.3.2.3 Impact of Low-Type Seller's Information Disclosure

So far we have investigated two different markets (with and without information collusion) and examined whether the sizes of demand observed from the experiments show the predicted patterns from the analytic model. We have found that the effect of the perceived risk has been consistent with the predictions in all cases. Now we attempt to test the most important propositions of this essay and see how the low-type seller's information disclosure impacts the market. We focus on the change in demand between the market with information collusion and the market with no information collusion to understand what happens to market outcomes when a low-type seller deviates from the original information collusion situation and decides to voluntarily disclose its type.

2.3.2.3.1 Impact on Low-Type Seller's Demand

Proposition 5 has provided the most important prediction of this essay, as it has explained what happens to the demand for the low-type seller's product when he discloses quality information, examining the economic incentive for a low-type seller to reveal his type. The analytic model has proposed that the change in demand for the low-type seller's product will be higher with lower perceived risk of the product, and the absolute size of the change will be higher with lower information search cost in the market. By investigating the experiment results, we can observe whether the impact of low-type seller's information disclosure shows the predicted patterns. Table 2.8 presents the observed change in demand for the low-type seller's product.

Table 2.8: Observed Change in Demand for the Low-Type Seller with Information Disclosure

	Higher Info Search Cost	Lower Info Search Cost
Without Risk Reducer:		
Change in Demand	-3	-15
%*p*[11]	-1.9	-9.7
With Risk Reducer:		
Change in Demand	55.5	36
%*p*	36	23.4

NOTE: Percentage values are calculated based on the total market size of 154.

As is shown in the table, the change in demand for the firm that shares negative information only partially shows the predicted pattern of the analytic model. The change in demand is higher with lower perceived risk (36%*p* > -1.9%*p* and 23.4%*p* > -9.7%*p*), but the absolute size shows mixed patterns with the size of information search cost (-1.9%*p* > -9.7%*p* but 36%*p* > 23.4%*p*). The results of two-way ANOVA with the change in demand as the dependent variable has shown that the effect of perceived risk ($F(1,1) = 213.16$, $p < 0.05$) is significant, while the effect of information search cost ($F(1,1) = 17.64$, $p = 0.149$) is not significant. This suggests that the change in demand for the low-type seller's product when he discloses quality information is strongly affected by the level of perceived risk of the product, but we cannot say that the effect of information search cost has a significant effect on the change in demand, providing partial support for Proposition 5.

One important observation from these results is that when the perceived risk is appropriately reduced, the low-type seller actually enjoys positive change in demand by disclosing the quality of his product. Therefore, we can say that full disclosure can help low-type sellers as long as they can decrease perceived risk with information disclosure, and this result

[11] %*p* means percentage point, the unit for the arithmetic difference of two percentage values.

verifies that there exists the economic incentive for low-type sellers to fully disclose quality information. On the other hand, Table 2.8 also shows that this low-type seller actually loses customers by disclosing true quality if perceived risk is not sufficiently reduced, both in high and low information search cost cases. Therefore, we can say that the incentive for low-type sellers to disclose quality information depends on the effectiveness of risk intermediary in reducing perceived risk of customers. Essay 2 explains this more in detail with actual market data.

2.3.2.3.2 Impact on Market Demand

Proposition 6 has also proposed some predictions on how the market demand is impacted when a low-type seller discloses quality information. More specifically, the model has proposed that the change in market demand caused by the low-type seller's information disclosure will be higher with lower perceived risk of the low-type seller's product, and the absolute size of the change will be higher with lower information search cost in the market. Table 2.9 shows the change in market demand with low-type seller's information disclosure, observed from the experiment.

Table 2.9: Observed Change in Market Demand with the Low-Type Seller's Information Disclosure

	Higher Info Search Cost	Lower Info Search Cost
Without Risk Reducer:		
Change in Demand	33	24
%*p*	21.4	15.6
With Risk Reducer:		
Change in Demand	60	38
%*p*	39.0	24.7

NOTE: Percentage values are calculated based on the total market size of 154.

As is shown in the table, the change in market demand only partially shows the predicted patterns from the analytic model. The change in demand is higher with lower perceived risk

(39.0%p > 21.4%p and 24.7%p > 15.6%p), but the absolute size of the change is higher with higher information search cost (21.4%p > 15.6%p and 39.0%p > 24.7%p). However, the results of two-way ANOVA with change in demand as the dependent variable has shown that neither the effect of perceived risk ($F(1,1) = 9.947$, $p = 0.195$) nor the effect of information search cost ($F(1,1) = 5.686$, $p = 0.253$) is significant. This suggests that the impact of the low-type seller's information disclosure on market demand is not strongly affected by either the level of perceived risk of the product or information search cost of the market, although the experiment results show the predicted pattern for the effect of perceived risk. The results thus provide no support for Proposition 6.

However, there is one important observation from the results, as market demand increases in all four cases when a low-type seller discloses quality information, regardless of the variation in two factors. Therefore, although the result is not consistent with the predictions from the analytic model, it presents some important implications about consumer welfare as the low-type seller's voluntary disclosure is shown to help the entire market by attracting more customers, providing some interesting research questions regarding marketing and public policy. We investigate the relationship between information disclosure and social welfare more in detail in Essay 3.

2.3.2.3.3 Impact on High-Type Seller's Demand

We also have some predictions on the change in demand for the seller claiming high quality when a low-type seller discloses his type. Proposition 7 has predicted that the change in the demand for the firm which maintains a high-quality claim will be higher with higher perceived risk of the low-type seller's product, and the absolute size of the change will be higher with lower information search cost in the market. By analyzing the experiment results, we can

tell whether the low-type seller's information disclosure has impacted the demand for the seller claiming high quality as predicted. Table 2.10 shows the change in the demand for the seller claiming high quality when one low-type seller reveals its type, observed from the experiment.

Table 2.10: Observed Change in Demand for the High-Quality Claim Seller with the Low-Type Seller's Information Disclosure

	Higher Info Search Cost	Lower Info Search Cost
Without Risk Reducer:		
Change in Demand	36	39
%*p*	23.4	25.3
With Risk Reducer:		
Change in Demand	4.5	2
%*p*	2.9	1.3

NOTE: Percentage values are calculated based on the total market size of 154.

As is shown in the table, the change in demand for the product with high-quality claim only partially shows the predicted patterns of the analytic model. While the change in demand is higher with higher perceived risk (23.4%*p* > 2.9%*p* and 25.3%*p* > 1.3%*p*) as predicted by the model, the pattern shows mixed result for the effect of information search cost (25.3%*p* > 23.4%*p* and 1.3%*p* < 2.9%*p*). The results of two-way ANOVA with the change in demand as the dependent variable has shown that the effect of perceived risk ($F(1,1) = 155.12$, $p = 0.051$) is nearly strongly significant while the effect of information search cost ($F(1,1) = 0.008$, $p = 0.942$) is not. This suggests that the change in demand for the product claiming high quality is strongly affected by the level of perceived risk of the low-quality seller, while the effect of the information search cost is negligible.

One important observation from these results is that demand for the product claiming high quality always increases when a low-type seller fully discloses quality information. This supports the finding from the analytic model that the low-type seller's full disclosure even helps

the firm that maintains a high-quality claim. This is a very interesting result and the analytic model explains that low-type's information disclosure will drive less risk-sensitive customers away from the low-type seller, resulting in the increased demand for the seller claiming high quality.

2.3.3 Alternative Experiment Design

In addition to the experiment analyzed above, we have also run alternative experiments using 2-by-2 within-subjects design with 356 subjects under the same setting. Although repeated observation through manipulated factors of interest may provide some noise to the results, a within-subjects design has a benefit of maintaining the distribution of risk sensitivities among the subjects. Therefore, we will only examine the results from this alternative design to see whether the outcome is consistent, and to check the robustness of our main results.

Table 2.11: Observed Impact of the Low-Type Seller's Information Disclosure (Within-Subjects Experiments)

	Demand for Low-Type Seller's Product		Market Demand		Demand for High-Claim Seller's Product	
	Higher info search cost	Lower info search cost	Higher info search cost	Lower info search cost	Higher info search cost	Lower info search cost
Without Risk Reducer:						
Change in Demand	-17	-72.5	91	65	108	137.5
%*p*	-3	-12.9	16.1	11.5	19.1	24.4
With Risk Reducer:						
Change in Demand	273	185.5	240	202	-33	16.5
%*p*	48.4	32.9	42.6	35.8	-5.9	2.9

NOTE: Percentage values are calculated based on the total market size of 356.

While the patterns were not exactly same with the results from between-subjects experiments, the main results regarding the change in demands were overall consistent in these experiments too. When a low-type seller disclosed quality information, the effects of perceived risk on the change in demand for the low-type seller ($F(1,1) = 293.266$, $p < 0.05$), the change in

market demand ($F(1,1) = 568.028$, $p < 0.05$), and the change in demand for the seller claiming high quality ($F(1,1) = 171.61$, $p < 0.05$) are all in the predicted patterns and significant while the effects of information search cost were all insignificant. Therefore, we can conclude that the findings from the analytic model and experimental analysis that the level of perceived risk strongly affects the market outcome when a low-type fully discloses quality information are robust and consistent.

2.3.4 Conclusion

We have used experimental analysis to determine whether the findings from the analytic model are consistent with what we observe in reality and investigated whether two factors of interest actually affect the market outcomes as predicted by the analytic model. More specifically, we have looked at the impact of perceived risk and information search cost in three circumstances: i) the market equilibrium when everyone is claiming high quality, ii) the market equilibrium when one low-type seller is disclosing quality information, and iii) the impact of the low-quality seller's information disclosure on market outcomes (i.e., change between i) and ii)). The experiments have shown that when one low-type seller discloses quality information, the market outcome is significantly affected by the level perceived risk of the low-type seller while the effect of information search cost is a little unclear. The results of the experimental analysis are summarized in Table 2.12.

Table 2.12: Summary of the Results of Experimental Analysis

	Circumstance	Demand of Interest	Prediction on Perceived Risk	Prediction on Information Search Cost
Proposition 1	Market under information collusion	Market	N/A	Supported
Proposition 2	Market under no information collusion	Low-type product	Supported	Not supported
Proposition 3		Market	Supported	Not supported
Proposition 4		High-type product	Supported	Supported
Proposition 5	Impact of low-type seller's information disclosure	Low-type product	Supported	Not supported
Proposition 6		Market	Not Supported	Not supported
Proposition 7		High-type product	Supported	Not supported

One possible reason why the effect of information search cost does not seem to be consistent with the predictions of the analytic model is because the difference in information search cost the subjects of the experiments perceived between two settings (accident history vs. noise) could have been insufficient. In other words, as much as it is hard for customers to figure out past accident history of a used car without the help of third-party certification, they may also have felt that figuring out noise of the car before purchase is not easy without help from someone with sufficient knowledge about car mechanisms. Therefore, the information search cost could have been almost as high in the low-cost condition as in the high-cost condition. Replacing the noise with some other product attributes with much lower information search cost, such as car appearances or mileage, might more strongly differentiate the information search cost across two settings and provide better understanding about the effect of information search cost.

Overall, the experimental analysis has provided strong supports for the finding that low-type seller's disclosure can actually increase demand if perceived risk can be appropriately reduced, verifying the existence of the incentive for low-type sellers to fully disclose quality information. Therefore, we can say that disclosing low-quality can actually help low-type sellers even in the short run as long as they can reduce perceived risk, even without considering the long term relations with customers or the impact from seller reputation.

2.4 Discussion

This essay has attempted to provide a different theoretical understanding about the information asymmetry in markets by showing that a low-type seller's information disclosure can increase demand even in the short run and verifying the existence of economic incentives for low-type sellers to fully disclose their types. More specifically, this essay has explained the circumstances whereby a low-type seller's information disclosure can enhance sellers' profitability and customers' welfare and shown that a low-type seller's information disclosure can also increase the market demand and the demand for the seller claiming high quality. The fundamental rationale behind this result is that customers do not have to spend the information search cost when a low-type seller voluntarily shares quality information, and thus everyone in the market can benefit from the decreased search cost. Moreover, the fact that prices have been fixed throughout our analysis shows that a low-type seller does not have to reduce prices to make up for its full disclosure.

Therefore, this essay can provide an important theoretical basis to solve various market dilemmas under information asymmetry. As is explained in a previous chapter, information disclosure literature has long debated whether voluntary disclosure can solve adverse selection issues (Grossman and Hart 1980; Grossman 1981; Jovanovic 1982; Milgrom 1981; Viscusi 1978)

or mandatory disclosure is necessary (Bar-Isaac, Caruana, and Cuñat 2012; Board 2009; Cheong and Kim 2004; Fishman and Hagerty 2003; Gavazza and Lizzeri 2007; Grubb 2011; Guo and Zhao 2009; Harbaugh, Maxwell, and Roussillon 2011; Hirshleifer, Lim, and Teoh 2004; Hotz and Xiao 2013; Matthews and Postlewaite 1985; Schwartz 2008; Shavell 1994; Stivers 2004; Verrecchia 1983). However, most of the literature has focused on the information disclosure of the sellers with high-quality products, and the information disclosure of the sellers with low-quality products has been generally overlooked. By focusing on the economic incentive for low-type sellers' information disclosure, this essay provides an important implication regarding whether, when, and how low-type sellers fully disclose quality information, which can possibly support the literature on voluntary disclosure. In addition to its contribution to the information disclosure literature, this study can provide some useful knowledge to marketing managers regarding marketing communications strategy using risk intermediaries such as quality certifications. For example, marketing managers may learn that voluntarily sharing unfavorable information about their products or services can actually increase profit if such a disclosure is accompanied by an appropriate risk intermediary. Future research can develop the idea presented in this essay in various directions, such as expanding the analytic model or adopting a more realistic distribution of risk propensities.

The following essays develop the theoretical findings from this essay and explore more about the economic incentive for low-type sellers to disclose quality information and the effect of quality certifications on market outcomes, through observing actual market data and conducting controlled economic experiments.

3. ESSAY 2: "TO HIDE, OR NOT TO HIDE—THAT IS THE QUESTION": SELLERS' ECONOMIC INCENTIVES FOR FULL VS. FRAUDULENT DISCLOSURE

3.1 Introduction

3.1.1 Motivation

As Essay 1 has presented a theoretical model explaining the economic incentive of low-type sellers to fully disclose quality information along with some evidence from experimental analysis, this essay now attempts to check whether those findings are consistent with what we observe in a real market through analyzing actual sales data of several different products. By analyzing two different empirical models with sales data from three product categories, this essay checks the prediction from the analytic model that low-type sellers can increase demand by disclosing quality information. The first model employs the original assumption of uniform distribution of customers' risk sensitivity (basic specification), while the second model relaxes the original assumption and substitutes a more realistic distribution, with a larger number of risk-sensitive customers than risk-insensitive customers (alternative specification). Overall, the result from our analysis confirms that low-type sellers can increase demand by full information disclosure if proper risk-reducing methods are employed. We focus on the effect of third-party product certification because other signaling methods are not as easy to establish or as trustworthy as quality certifications, as is explained above, and our empirical results also show that third-party certification is the only risk intermediary that has significant effects across all three product categories observed in our analysis. Moreover, a lot of previous studies on information disclosure have also focused on the effect of certification and how it solves adverse selection issues in markets.

Our primary results show that the certification works as an effective signaling method and provides incentives to low-type sellers to disclose quality information in real markets, which is consistent with the findings from Essay 1. Moreover, we have also found that the sizes of the incentives differ across different product categories and therefore the certification does not encourage low-type sellers to voluntarily disclose quality information in certain product categories. We assume that the varying quality of certification is possibly one of the reasons of this heterogeneous impact, and thus analyze the effect of various certification qualities on market outcomes in Essay 3. We find another interesting aspect from out analysis as the result from the alternative model shows that the impact of disclosing unfavorable information differs according to the original quality level. More specifically, disclosing the same unfavorable information provides higher incentives when the actual quality level is higher. Therefore, although the empirical finding from the basic specification confirms the existence of the incentive for a low-quality seller to fully disclose quality information and provides supports for voluntary disclosure, the finding from the second specification shows that the size of the incentive differs according to the level of true quality, possibly providing support for both voluntary and mandatory disclosure.

3.1.2 Related Literature

This essay follows the stream of empirical studies on information disclosure and quality signaling in online auction environment. Lewis (2011), Li et al. (2009), and Jin and Kato (2006) have provided some important findings regarding information disclosure in an online auction setting, and therefore are closely related with this essay. Lewis (2011) and Li et al. (2009) have investigated the effect of various risk intermediaries and contributed to the literature as most other online auction literature has only focused on seller feedback mechanism. More specifically, Lewis (2011) has examined the effect of online information disclosure through observing nearly

50,000 car transactions on eBay Motors and found that text and photos posted online work as enforceable contract and alleviate information asymmetry through influencing prices. By observing eBay's paintings and silver plates market, Li et al. (2009) have also investigated how product quality indicators such as picture postings and money-back guarantees along with seller credibility indicators such as seller rating and third-party payment alleviate information asymmetry. They have found that those indicators encourage bidder participation, and the effect is even stronger when both types of indicators are used simultaneously. However, these studies have not considered the effect of claimed quality, as the data does not provide appropriate variables indicating the quality levels of the products. Therefore, these studies have not examined the relationship between the seller's claimed quality and information disclosure and how the quality of product affects the seller's information disclosure, which is the main question of the current essay. Jin and Kato (2006) is different in this perspective as their data includes the variable indicating the quality of the products. They have looked at the collectible baseball card market to examine the relationship between price, quality, seller claims, and seller reputation in Internet auctions and shown evidence that voluntary disclosure may not work in an online setting. More specifically, by investigating the sales data of collectible baseball cards and also purchasing and analyzing actual products, they have provided an interesting observation about online auction market: while cards with higher quality claims yield price premium, actual average quality from high-claim cards is indistinguishable from the cards with more modest claims. Therefore, they have shown that there is actually a considerable amount of fraud in the market as false claim seems to provide more profit, and the information disclosure mechanisms do not work properly to prevent adverse selection issues in this online market.

Among these studies, Jin and Kato (2006) share some similarities with the current essay, as both use the data from same product category and investigate the relationship between claimed quality and information disclosure. However, the focus and findings of this dissertation are very different from Jin and Kato (2006)'s, and the theoretical approach of Essay 1 and the empirical results of Essay 2 provide contradictory findings about seller's incentive for information disclosure. We explain the differences between two studies more in detail as follows. First, while Jin and Kato (2006) basically show how low-type sellers fraudulently claim higher quality (i.e., conceal their types) and achieve higher profit, this essay explains how low-type sellers fully disclose quality information and increase profit. Second, this paper also looks at additional product categories such as collectible coins and collectible stamps and attempt to understand how the effect of risk intermediaries on information disclosure differs across different product categories. This essay has actually found that the basic finding of Jin and Kato (2006) is not replicated in some other product categories: although Jin and Kato's (2006) key finding is also shown to be valid with this paper's analysis of baseball card data as the potential demand increases with bold claims without certification, the potential demand does not increase with bold claims in the coin market (i.e., "cheap talk"), showing that fraudulent claim does not always help sellers in some markets. Therefore, this essay has found that Jin and Kato's (2006) finding of the positive effect of dishonesty can only be applied to limited product categories. Third, many factors of the model, such as dependent variable, key independent variables, and estimation method, are different between the two papers and thus show distinct perspectives. Fourth, this essay is based on the analytic model predictions from Essay 1 and thus provides its own theoretical explanations on the empirical finding, while Jin and Kato (2006) is mainly empirically focused. The bottom line is that, although Jin and Kato (2006) and this essay observe

similar product categories and variables, the finding is almost the opposite as one shows that fraudulent claim helps low-type sellers and supports mandatory disclosure, while the other verifies economic incentives for low-type seller's full disclosure and supports voluntary disclosure.

Overall, the contribution of this paper to the related empirical literature on information disclosure in an online auction environment is to provide a different perspective by focusing on the relationship between claimed quality and information disclosure and showing evidences of the incentive for the low-type sellers to disclose quality information. Table 3.1 compares these related studies.

Table 3.1: Comparison of Information Disclosure Literature on Online Auction

	Lewis (2011)	Li et al. (2009)	Jin and Kato (2006)	This Essay
Risk Intermediary	Text and photos posted online	Picture postings, money-back guarantees, seller rating, and third-party payment	Third-party certification	Third-party certification
Product Category	Used cars	Paintings and silver plates	Collectible baseball cards	Collectible baseball cards, coins, and stamps
Consideration of Claimed Quality	No	No	Yes	Yes
Main Findings	▪ Text and photos posted online alleviate information asymmetry and influence prices. ▪ Disclosure cost affects how much information a seller decides to post.	Product quality indicators and seller credibility indicators alleviate dual information asymmetry.	There is a considerable amount of fraud in the market and false claims provide more profit to sellers.	▪ Revealing low quality increases demand with third-party certification. ▪ The effect of certification on information disclosure differs across product categories.
Supporting Disclosure Scheme	Voluntary disclosure	Voluntary disclosure	Mandatory disclosure	Voluntary disclosure

3.2 Data

This essay attempts to check the theoretical predictions from Essay 1 through analyzing whether market data actually corresponds with the prediction that disclosing low-type can increase demand. After investigating various product categories, we have chosen three product categories as our primary targets for empirical analysis: collectible baseball cards, collectible coins, and collectible stamps. First of all, the markets for collectible baseball cards, coins, and stamps have clear information asymmetry, since customers rarely have the capability to accurately evaluate the quality of products, in most cases even after purchase. Second, collectible

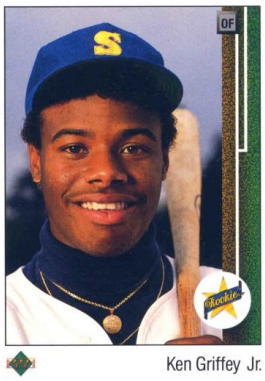
baseball cards, coins, and stamps have different levels of perceived risk since some sellers are more trusted than others, and some products' qualities are professionally verified while others are not. Third, the quality of the products can be easily compared, as all of the baseball cards, coins, and stamps in the market are measured by their respective universal grading standards. Finally, all baseball cards, coins, and stamps under the same product group are basically identical and only differ in quality, price, and risk level.

Unlike previous studies on quality signaling under the Internet auction setting listed above, we observe three different product categories to see whether the findings are consistent across different product categories. We are interested in understanding how the impact of third-party certification on market outcomes differs across different product categories, assuming that the characteristics and quality of third-party certifications all vary in these different product categories.

Among numerous kinds of collectible baseball cards and coins, we have picked Ken Griffey, Jr.'s 1989 Upper Deck card and the 1921 Morgan silver dollar (Figure 3.1) since they are some of the most actively traded products in their respective markets. As the stamp market has a lot more variety and each different product has only a limited number of trades, we have collected data from 15 different product types (1901 Pan-American Issue, 1904 Louisiana Purchase Issue, Washington-Franklin Era 1908-09 Regular Issue, Washington-Franklin Era 1909 Commemorative Issue, Washington-Franklin Era 1913-15 Panama-Pacific Issue, 1934 National Parks Issue, 1936-37 Army-Navy Issue, 1938 Presidential Issue, 1939 Presidential Coil Issue, 1940 Famous Americans Issue, Airmail 1941-44 Rotary Issue, 1944 Overrun Countries Issue, First Airmail Issue, Graf Zeppelin Issue, and Special Delivery Rotary Press Issue). We have collected sales data from eBay from February 2013 to May 2013 for baseball cards, from

December 2014 to February 2015 for collectible coins, and from September 2015 to December 2015 for stamps. We have only included baseball cards graded by Beckett Grading Services (BGS), coins graded by NGC Coin Grading System (NGC), and stamps graded by Professional Stamp Experts (PSE), for the professionally graded products since they are some of the most trusted professional grading services in their respective industries. In total, we have collected sales data of 456 collectible baseball cards (225 professionally graded and 231 not professionally graded), 438 collectible coins (224 professionally graded and 214 not professionally graded), and 349 collectible stamps (101 professionally graded and 248 not professionally graded).

Figure 3.1: Ken Griffey, Jr.'s 1989 Upper Deck Card and 1921 Morgan Silver Dollar



3.3 Model

3.3.1 Variables

Based on previous studies on Internet auctions and our own judgment, we have carefully selected the variables that fit the purpose of our essay. The following variables have been considered for all three product categories.

First, since this essay's main interest is to understand how demand shifts with respect to the changes in various factors, the number of unique bidders is chosen as a dependent variable. We use the number of bidders as a proxy to estimate the size of demand for each product since

each bid in an eBay auction is regarded as a legal contract to purchase the product.[12] As each bidder has actually agreed to purchase the product (i.e., had a buyer not had the intention to purchase the item, he or she would not have made a bid on the item in the first place), it is logical to think of the number of bidders a reasonable construct to capture the underlying size of potential demand for each product. Although the number of bidders has been treated as exogenous in traditional auction theory literature, it has been considered as endogenous in online auction studies (Bapna et al. 2004). Next, the variables that we believe to influence the number of bidders in this empirical application are selected as potential candidates for independent variables and classified into four groups: variables representing perceived risk, claimed quality, price of the product, and others.

The first variable measuring perceived risk is the dummy variable showing whether the product on sale is professionally graded or not. As the physical condition of the product is very important in deciding the quality level, high-resolution pictures of the product can be a good risk reducer, and thus how many sides of the product are shown with high-resolution pictures is also used as an independent variable. Variables measuring the trustworthiness of a seller are the feedback score, a dummy for 100 percent positive feedback ratings, and a dummy for whether the seller is "Top Rated." The feedback score is calculated and displayed by eBay through subtracting the number of negative feedback ratings from the number of positive feedback ratings, and "Top Rated Seller" is entitled by eBay to the sellers who meet several requirements, such as having an eBay account that has been active for at least 90 days, a positive feedback rating of at least 98 percent, and at least 100 transactions and $1,000 in sales with U.S. buyers over the most recent 12-month period. The claimed quality of the product is measured by the

[12] When you bid on a product at eBay, you see a message that says, "By clicking Confirm bid, you commit to buy this product from the seller if you are the winning bidder."

standard grade claimed by the seller, which ranges from one (Poor) to ten (Gem Mint) for baseball cards, from one (Poor) to seventy (Mint State, Uncirculated) for coins, and from five (Poor) to one hundred (Super Gem) for stamps. We measure price of the products through both starting price and shipping price, while final price of an auction is not used as an independent variable as a seller does not have a direct control over this variable. The auction literature also regards the final price as the outcome of auction competitiveness, not as the predictor (Bapna, Jank, and Shmueli 2008; Pinker, Seidmann, and Vakrat 2003; Reddy and Dass 2006). Finally, we include the length of an auction, delivery time, return period, and the dummies to measure whether the auction ends during the prime time or the weekend (Melnik and Alm 2002).

In addition to those common independent variables explained above, there are several other variables that are product category specific. For the estimation of collectible coins data, we have included two additional dummies for whether a coin is produced in Denver or San Francisco[13], thus where it was produced is a very important factor in deciding a coin's value. For stamp data, we have included dummies for product types, as we have observed sales data of several different product types, unlike baseball card and coin data. Moreover, the dummies for whether the product is encapsulated, cancelled, or hinged are also included, since these factors affect perceived value of the stamps. We have observed that some stamps have buy-it-now options and thus added a dummy for whether the product is sold with a buy-it-now option. On the other hand, no products have shown a buy-it-now option in baseball card and coin data. The summary statistics for these variables are represented in Table 3.2, Table 3.3, and Table 3.4.

[13] The coins in our data were produced in one of the Mint facilities in three cities: Denver, San Francisco, or Philadelphia.

Table 3.2: Summary Statistics: Collectible Baseball Cards

	Mean	Median	S.D.	Max	Min	OBS
Dependent Variable						
Number of bidders	5.26	6	3.94	27	0	456
Perceived Risk						
Dummy = 1 if professionally graded	0.49	0	0.50	1	0	456
Number of card sides clearly shown	1.21	1	0.57	2	0	456
Feedback score	13383	783	38935	197107	1	456
Dummy = 1 if only positive feedback	0.77	1	0.42	1	0	456
Dummy = 1 if the seller is “top rated”	0.21	0	0.41	1	0	456
Claimed Quality						
Claimed card grade	8.44	8.5	0.83	10	5	456
Price						
Auction starting price ($)	17.02	1.99	34.96	200	0.01	456
Shipping price ($)	2.72	2.95	1.46	13	0	456
Other						
Dummy = 1 if ends in weekend	0.39	0	0.49	1	0	456
Dummy = 1 if ends in prime time	0.39	0	0.49	1	0	456
Auction duration (days)	6.11	7	1.97	10	1	456
Estimated delivery time (days)	4.78	4	1.78	15.5	3	456
Return period (days)	8.49	14	6.92	30	0	456

Table 3.3: Summary Statistics: Collectible Coins

	Mean	Median	S.D.	Max	Min	OBS
Dependent Variable						
Number of bidders	4.96	5	4.14	16	0	438
Perceived Risk						
Dummy = 1 if professionally graded	0.51	1	0.5	1	0	438
Number of coin sides clearly shown	1.95	2	0.27	2	0	438
Feedback score	8845.51	3974	14778.27	126950	6	438
Dummy = 1 if only positive feedback	0.54	1	0.5	1	0	438
Dummy = 1 if the seller is “top rated”	0.44	0	0.5	1	0	438
Claimed Quality						
Claimed coin grade	61.07	63	5.29	67	50	438
Price						
Auction starting price ($)	28.67	0.995	62.72	1069	0.01	438
Shipping price ($)	1.59	1.95	1.47	7.99	0	438
Other						
Dummy = 1 if ends in weekend	0.3	0	0.46	1	0	438
Dummy = 1 if ends in prime time	0.38	0	0.49	1	0	438
Auction duration (days)	5.41	7	2.34	10	1	438
Estimated delivery time (days)	5.46	6	1.45	14	3	438
Return period (days)	12.51	14	7.09	60	0	438
Coin produced in Denver	0.15	0	0.36	1	0	438
Coin produced in San Francisco	0.11	0	0.32	1	0	438

Table 3.4: Summary Statistics: Collectible Stamps

	Mean	Median	S.D.	Max	Min	OBS
Dependent Variable						
Number of bidders	2.7	1	3.21	16	0	349
Perceived Risk						
Dummy = 1 if professionally graded	0.29	0	0.45	1	0	349
Number of stamp sides clearly shown	1.38	1	0.49	2	1	349
Feedback score	18438.74	7384	23917.19	79319	13	349
Dummy = 1 if only positive feedback	0.70	1	0.46	1	0	349
Dummy = 1 if the seller is “top rated”	0.05	0	0.22	1	0	349
Claimed Quality						
Claimed stamp grade	82.54	80	10.86	100	30	349
Price						
Auction starting price ($)	39.74	1.75	113.84	850	0.01	349
Shipping price ($)	1.14	1	1.30	15.99	0	343
Other						
Dummy = 1 if ends in weekend	0.52	1	0.50	1	0	349
Dummy = 1 if ends in prime time	0.43	0	0.50	1	0	349
Auction duration (days)	6.88	7	1.24	10	1	349
Estimated delivery time (days)	4.86	5	1.05	9	3	343
Return period (days)	17.72	14	8.14	30	0	349
Dummy = 1 if the stamp is encapsulated	0.09	0	0.28	1	0	349
Dummy = 1 if the stamp is cancelled	0.18	0	0.38	1	0	349
Dummy = 1 if the stamp is hinged	0.41	0	0.49	1	0	349
Dummy = 1 for buy-it-now option	0.04	0	0.19	1	0	349
Product Type						
Dummy = 1 for product type 1	0.15	0	0.35	1	0	349
Dummy = 1 for product type 2	0.05	0	0.22	1	0	349
Dummy = 1 for product type 3	0.06	0	0.23	1	0	349
Dummy = 1 for product type 4	0.05	0	0.22	1	0	349
Dummy = 1 for product type 5	0.04	0	0.19	1	0	349
Dummy = 1 for product type 6	0.03	0	0.18	1	0	349
Dummy = 1 for product type 7	0.03	0	0.16	1	0	349
Dummy = 1 for product type 8	0.10	0	0.30	1	0	349
Dummy = 1 for product type 9	0.05	0	0.22	1	0	349
Dummy = 1 for product type 10	0.07	0	0.25	1	0	349
Dummy = 1 for product type 11	0.04	0	0.20	1	0	349
Dummy = 1 for product type 12	0.07	0	0.25	1	0	349
Dummy = 1 for product type 13	0.16	0	0.36	1	0	349
Dummy = 1 for product type 14	0.06	0	0.24	1	0	349

3.3.2 Model Specification

3.3.2.1 Count Model Selection

Our dependent variable, the number of bidders, has actually been treated as exogenous in most previous auction literature. As most auction literature considers traditional auction settings, not online auctions as in this essay, the number of bidders has usually been considered as fixed and commonly known to every participant (Athey and Haile 2002; Bapna et al. 2004). However, the understanding of the number of bidders in online auction studies is different from those traditional auction studies. Online auction studies have considered the number of bidders as random and some have assumed the arrival of buyers or the number of bidders to follow a Poisson process (Ackerberg, Hirano, and Shahriar 2006; Bajari and Hortacsu 2003; Etzion, Pinker, and Seidmann 2006; Hong and Nekipelov 2012). Since this essay also considers an online auction setting, we adopt this approach from online auction studies and consider this estimation as the analysis of count data.

3.3.2.1.1 Over-dispersion

We first check over-dispersion in the data to find out whether Poisson distribution or negative binomial distribution is more appropriate. In the baseball card data, the likelihood ratio test of over-dispersion parameter alpha shows a very low chi-squared value (0.0000046 with one degree of freedom). Since over-dispersion alpha is not significantly different from zero (p = 0.499), the result suggests that negative binomial distribution is equivalent to a Poisson distribution and over-dispersion is not an issue. In the coin data, the likelihood ratio test of over-dispersion parameter alpha also shows an extremely low chi-squared value (0 with one degree of freedom). Since over-dispersion alpha is not significantly different from zero (p = 0.5), the result also suggests that negative binomial distribution is equivalent to a Poisson distribution and over-

dispersion is not an issue in this case either. However, in the stamp data, the likelihood ratio test of over-dispersion parameter alpha shows high chi-squared value (39.53 with one degree of freedom). Since over-dispersion alpha in this case is significantly different from zero (p = 0.000), the result suggests that negative binomial distribution is not equivalent to a Poisson distribution and over-dispersion is an issue. Therefore, a Poisson regression seems to be appropriate for baseball card and coin data while a negative binomial regression is more appropriate for stamp data.

3.3.2.1.2 Zero-Inflation

We also checked if we have to use zero-inflated model for the data through examining both theoretical and model fits. We have first tried to understand whether a separate process is at work for the products with zero number of bidders and if customers automatically avoid bidding on some items since they are considered as "not for sale." We also checked the model fit between normal count models and zero-inflated models using a Vuong test (Vuong 1989). Greene (1994) has suggested using the Vuong test for non-nested models as normal count models and zero-inflated models are not nested. The Vuong test compares two non-nested models and finds which model better fits the data through the following process (Long and Freese 2006). Let's assume that $\widehat{P_Z}(y_i|x_i)$ is the predicted probability of observing *y* in the zero-inflated model and $\widehat{P_S}(y_i|x_i)$ is the predicted probability of observing *y* in the standard count model. We can define the following.

$$m_i = ln\left\{\frac{\widehat{P_Z}(y_i|x_i)}{\widehat{P_S}(y_i|x_i)}\right\}$$

Let $\bar{m}$ be the mean and let s_m be the standard deviation of m_i. Then the Vuong statistic which tests the hypothesis that $E(m) = 0$ is

$$V = \frac{\sqrt{N}\bar{m}}{s_m}$$

If $V > 1.96$, the zero-inflated model is preferred, and if $V < -1.96$, the standard count model is preferred. However, the literature has also suggested corrections to the Vuong test statistic because the zero-inflated models involve several more parameters than normal count models (Desmarais and Harden 2013), and even Vuong (1989) has recommended adjusting his test for the number of parameters. Therefore, we have also tested zero-inflation using the corrected Vuong statistics based on the Akaike and Bayesian (Schwarz) information criteria (AIC and BIC).

In total, 80 of 456 total observations of baseball card data (17.54%), 123 of 438 total observations of coin data (28.08%), and 110 of 349 total observations of stamp data (31.52%) show zero unique bidders. First, in terms of the theoretical fit, there is no reason to believe that a separate process is at work for these products with zero bidders. We believe that all baseball cards, coins, and stamps listed on eBay have one same purpose of being sold, and there is no separate category of products which customers automatically avoid bidding since sellers post them for other purposes than selling them. Second, in terms of the model fit, we have checked the uncorrected Vuong statistic along with the Vuong statistics with the AIC and BIC corrections (using the *ZIPCV* and *ZINBCV* procedure provided in STATA 13.1), and the results are summarized in Table 3.5. While the uncorrected Vuong test favors zero-inflated models for baseball cards ($p = 0.03$), coins ($p = 0.02$), and stamps ($p = 0.01$) data, both the AIC-corrected Vuong test and the BIC-corrected Vuong test show support for neither the zero-inflated model nor the standard count model. In particular, BIC-corrected Vuong test shows support for standard count models for baseball cards and stamps with the test statistic being -0.84 and -0.75 respectively, although these are not significant ($p = 0.2$ and 0.226, respectively).

Therefore, there is no theoretical evidence for using the zero-inflated model, and various Vuong tests do not provide support for zero-inflated models for baseball card, coin, and stamp data.

Table 3.5: Vuong Tests of Zero-Inflated Models vs. Standard Count Models

	Baseball Cards		Coins		Stamps	
Vuong test without correction	z = 1.94	Pr>z = 0.0264 Pr<z = 0.9736	z = 2.06	Pr>z = 0.0198 Pr<z = 0.9802	z = 2.46	Pr>z = 0.0070 Pr<z = 0.9930
Vuong test with AIC correction	z = 1.03	Pr>z = 0.1521 Pr<z = 0.8479	z = 1.54	Pr>z = 0.0620 Pr<z = 0.9380	z = 1.36	Pr>z = 0.0875 Pr<z = 0.9125
Vuong test with BIC (Schwarz) correction	z = -0.84	Pr>z = 0.7996 Pr<z = 0.2004	z = 0.48	Pr>z = 0.3168 Pr<z = 0.6832	z = -0.75	Pr>z = 0.7743 Pr<z = 0.2257

3.3.2.1.3 Final Model Selection

In summary, we have found that over-dispersion cannot be ignored in the stamp data, while it is not a serious issue with baseball card and coin data. Moreover, we have checked that zero-inflation is not supported in all of the product categories. Based on these considerations, we run a Poisson regression for the baseball and coin data and a negative binomial regression for the stamp data.

3.3.2.2 Multicollinearity

When we have first estimated the suggested models with the variables defined above, our primary results show some possibilities of multicollinearity, as only 4 out of 13 independent variables for baseball card data, 4 out of 15 independent variables for coin data, and 6 out of 31 independent variables for stamp data have been found to be significant. Therefore, we have examined if there are any multicollinearity issues among the independent variables in our model.

For the baseball card data, none of the correlation coefficients between independent variables seems to be strong and worrisome. The highest correlation is 0.4144 between TOPRATED (whether a seller is "Top Rated") and RETURN (return period), and most other correlation coefficients are lower than 0.2. We also directly check for multicollinearity by observing VIF (variance inflation factor) values of the independent variables, and the result is shown in Table 3.6. As we can see, none of the VIF values is higher than 1.5, and thus there seems to be no need for further investigation of multicollinearity in our model for baseball card data.

Table 3.6: Variance Inflation Factors (Baseball Cards)

Variable	VIF	1/VIF
FEEDBACK	1.46	0.6858
TOPRATED	1.45	0.6891
RETURN	1.4	0.7157
DELIVERY	1.27	0.7863
PRO_GRADE	1.27	0.7904
FEEDBACK_100	1.25	0.7998
PRICE_START	1.21	0.8246
GRADE	1.19	0.8424
PRICE_SHIPPING	1.07	0.9311
SIDES_LEGIBLE	1.07	0.9331
DURATION	1.07	0.9336
PRIMETIME	1.07	0.9342
WEEKEND	1.05	0.9554
Mean VIF	1.22	

For the coin data, none of the correlation coefficients seems to be strong and worrisome either. The highest correlation is 0.416 between TOP_RATED (whether a seller is "Top Rated") and RETURN (return period), and most other correlation coefficients are lower than 0.2. We also observe VIF values of the independent variables, and the result is shown in Table 3.7. As we can

see, none of the VIF values is higher than 1.8, and thus there is no need for further investigation of multicollinearity in this case.

Table 3.7: Variance Inflation Factors (Coins)

Variable	VIF	1/VIF
TOP_RATED	1.75	0.573039
PRO_GRADE	1.61	0.621864
GRADE	1.47	0.681368
RETURN	1.41	0.707161
FEEDBACK	1.23	0.811432
DELIVERY	1.2	0.835809
FEEDBACK_100	1.19	0.838145
PRICE_SHIPPING	1.19	0.843298
DURATION	1.16	0.865051
PRICE_START	1.14	0.877785
MINT_S	1.13	0.882421
MINT_D	1.1	0.907904
SIDES_SHOWN	1.09	0.920004
PRIME_TIME	1.06	0.941922
WEEKEND	1.05	0.955748
Mean VIF	1.25	

Finally, for the stamp data, the investigation of the correlation coefficients does not caution any multicollinearity either. The highest correlation is 0.463 between PRO_GRADE (whether the product is graded by professional grading service) and FEEDBACK (seller's feedback score), and most other correlation coefficients are lower than 0.2. We also observe VIF values of the independent variables, and the result is shown in Table 3.8. As we can see, the highest VIF value is 5.45, and thus multicollinearity does not seem to be a serious issue for stamp data.

Table 3.8: Variance Inflation Factors (Stamps)

Variable	VIF	1/VIF
PRODUCT_13	5.45	0.183364
PRODUCT_01	3.94	0.253755
PRO_GRADE	3.54	0.282776
ENCAP	3.1	0.322636
PRODUCT_08	2.92	0.34302
PRODUCT_12	2.6	0.385352
FEEDBACK	2.56	0.390496
PRODUCT_03	2.47	0.404345
PRODUCT_14	2.47	0.405284
PRODUCT_05	2.42	0.413335
PRODUCT_10	2.42	0.413374
HINGED	2.21	0.45198
PRODUCT_02	2.21	0.453097
RETURN	2.19	0.457486
PRICE_START	2.18	0.459423
PRODUCT_11	2.1	0.475559
FEEDBACK_100	2.08	0.480774
PRODUCT_04	2.02	0.496231
GRADE	2.01	0.498291
PRODUCT_09	1.99	0.502131
PRODUCT_06	1.99	0.502464
CANCEL	1.98	0.504386
PRICE_SHIP~G	1.98	0.505165
SIDES_SHOWN	1.67	0.599679
PRODUCT_07	1.61	0.619761
WEEKEND	1.57	0.635846
PRIME_TIME	1.55	0.644857
DELIVERY	1.52	0.655845
BUY_IT_NOW	1.35	0.743029
DURATION	1.34	0.743865
TOP_RATED	1.18	0.847754
Mean VIF	1.25	

Judging by these results, we can conclude that multicollinearity is not an issue for any of the product categories observed in our analysis.

3.3.2.3 Model Comparison

As we have confirmed that multicollinearity is not an issue for all three product categories, we have decided to check whether the variables included in the primary analysis are all necessary. If some variables are added in the model without contributing toward better model fit, they may just increase the size of standard errors, reducing the precision of all our estimates. Among those 13 independent variables for baseball card data, 15 independent variables for coin data, and 31 independent variables for stamp data, the primary analysis shows that 8 variables (feedback score, the dummy for 100% positive feedback, shipping price, the duration of the auction, delivery time, return period, and the dummies to measure whether the auction ends during the prime time or the weekend) do not seem to be significant in any of the product categories observed. As their insignificance is universal among all product categories, it seems logical to remove those variables which do not contribute to the model fit and only increase standard errors. Among these variables, we still believe that there are theoretical grounds to include the feedback score, the dummy for 100 percent positive feedback, and shipping price as they are related with the factors considered in our analytic model explaining perceived risk and price of the product. Therefore, we have estimated new parsimonious models for baseball card, coin, and stamp data that exclude the following 5 variables: the duration of the auction, delivery time, return period, and the dummies to measure whether the auction ends during the prime time or the weekend.

Table 3.9: Model Fit Comparisons

		Primary Model	Parsimonious Model	Difference (Primary – Parsimonious)
Baseball Cards	AIC	1959.858	1956.252	3.606
	BIC	2021.53	1997.367	24.163
Coins	AIC	1875.43	1874.104	1.326
	BIC	1944.789	1923.091	21.698
Stamps	AIC	1171.964	1169.08	2.884
	BIC	1302.447	1280.374	22.073

Table 3.9 shows the model fit comparison between the primary model and the parsimonious model. Both AIC and BIC provide evidence that the parsimonious model has a much better fit. The differences in BIC statistics are bigger than 20 in all three product categories, suggesting that the parsimonious model is very strongly preferred over the primary model. In other words, we can see that those excluded 5 variables do not contribute toward better model fit and just increase the size of standard errors and reduce the precision of all our estimates. Therefore, we decide to run our analysis with parsimonious models for all three product categories. Table 3.10 shows the definitions of variables finally selected for the estimation.

Table 3.10: Definitions of Variables

Variables	Definition	Estimation		
		Baseball Cards	Coins	Stamps
Potential Demand				
NO_BIDDER	The number of buyers who have bid for the item before the auction ends	O	O	O
Perceived Risk				
PRO_GRADE	Dummy variable indicating whether the product was graded by a third-party professional grading service	O	O	O
SIDES_SHOWN	Number of product sides shown with high-resolution pictures so that customers can evaluate the appearances	O	O	O
FEEDBACK	Total feedback score calculated and displayed by eBay through subtracting the number of negative feedback ratings from the number of positive feedback ratings	O	O	O
FEEDBACK_100	Dummy variable indicating whether the seller has a 100% positive feedback score	O	O	O
TOP_RATED	Dummy variable indicating whether the seller satisfies certain requirements and is thus entitled as "Top Rated Seller" by eBay	O	O	O
Claimed Quality				
GRADE	The quality level of the product claimed by the seller by the grading standard commonly used in the product category	O	O	O
Price				
PRICE_START	The initial price for the auction item set by the seller	O	O	O
PRICE_SHIPPING	The shipping price for the auction item set by the seller	O	O	O
Other				
MINT_D	Dummy variable indicating whether the coin is originally produced in Denver		O	
MINT_S	Dummy variable indicating whether the coin is originally produced in San Francisco		O	
ENCAP	Dummy variable indicating whether the stamp is protected in a firm and clear holder made of inert styrene plastic			O
CANCEL	Dummy variable indicating whether the stamp has a postal marking or postal stationery applied on it to deface the stamp and prevent its re-use			O
HINGED	Dummy variable indicating whether the stamp had been affixed onto a stamp album and thus has folded, transparent, and rectangular pieces of paper coated with a mild gum			O
BUY_IT_NOW	Dummy variable indicating whether the seller offers a buy-it-now option			O

3.4 Results

3.4.1 Basic Specification

3.4.1.1 Estimation Procedure

Based on the considerations discussed above, we estimate our data from three product categories with the variables defined above.

3.4.1.1.1 Baseball Cards

Let's assume that the number of unique bidders for the auction item *j* sold by seller *i* is drawn from a Poisson distribution where the mean of the distribution is shown by the parameter λ_{ij}:

$$\text{Prob}\left(Q_{ij} = q\right) = \frac{e^{-\lambda_{ij}}\lambda_{ij}^{q}}{q!},$$

$$\text{where } q = 0, 1, 2, \ldots, \text{ and } \ln\left(\lambda_{ij}\right) = \beta X_{ij}.$$

We use the following specification for the independent variables:

$$\beta X_{ij} = \beta_0 + \beta_1 \text{Dummy for Professional Grading}_{ij}$$
$$+ \beta_2 \text{Number of Card Sides Shown with High-Resolution Pictures}_{ij}$$
$$+ \beta_3 \text{Feedback Score}_{ij} + \beta_4 \text{Dummy for Positive Feedback Only}_{ij}$$
$$+ \beta_5 \text{Dummy for "Top Rated" Seller}_{ij} + \beta_6 \text{Claimed Card Grade}_{ij}$$
$$+ \beta_7 \text{Auction Starting Price}_{ij} + \beta_8 \text{Shipping Price}_{ij}$$

Table 3.11 shows the result of the estimation.[14] We can do some primary analysis by examining whether this result corresponds with the main proposition, which has made predictions about the incentive for the low-type sellers to disclose quality information. First, we check whether the demand for the product increases with lower perceived risk. The result shows

[14] Total observation is 451 for this estimation since 5 observations without seller information have been excluded for panel data analysis.

that the coefficients for two variables representing perceived risk—whether the card is professionally graded and the number of sides clearly shown—are both significant and positive. Therefore, the estimation result regarding the effect of perceived risk follows the prediction of the main proposition. Second, we can check whether the demand for the product increases with higher claimed quality. The result shows that the coefficient for the variable representing claimed quality—claimed card grade—is significant and positive. Therefore, the effect of claimed quality also follows the prediction of the main proposition. Third, the variable representing auction starting price is negative and strongly significant as indicated by the analytic model. Overall, our analytic model seems to work well in predicting the real market situations in the baseball card market, according to the estimation results.

Table 3.11: Estimation Results for Baseball Cards (Basic Specification)

Perceived Risk		
Dummy = 1 if professionally graded	0.1279	***
	(0.0499)	
Number of card sides clearly shown	0.0845	**
	(0.0427)	
Feedback score	0.00000156	*
	(0.000000808)	
Dummy = 1 if only positive feedback	0.0404	
	(0.0576)	
Dummy = 1 if the seller is "top rated"	0.0619	
	(0.0622)	
Claimed Quality		
Claimed card grade	0.2377	***
	(0.0303)	
Price		
Auction starting price ($)	-0.0548	***
	(0.0031)	
Shipping price ($)	-0.0054	
	(0.0170)	
Observations	451	
Chi-squared	459.48	***
d.f.	8	

* p<0.1.
** p<0.05.
*** p<0.01.

3.4.1.1.2 Coins

For the coin data, we again run a Poisson regression with the variables defined above and assume that the number of unique bidders for the auction item *j* sold by seller *i* is drawn from a Poisson distribution where the mean of the distribution is shown by the parameter λ_{ij}:

$$\text{Prob}\left(Q_{ij} = q\right) = \frac{e^{-\lambda_{ij}}\lambda_{ij}^{q}}{q!},$$

$$\text{where } q = 0, 1, 2, \ldots, \text{ and } \ln\left(\lambda_{ij}\right) = \beta X_{ij}.$$

We use the following specification for the independent variables:

$$\beta X_{ij} = \beta_0 + \beta_1 \text{Dummy for Professional Grading}_{ij}$$

$$+ \beta_2 \text{Number of Coin Sides Shown with High-Resolution Pictures}_{ij}$$

$$+ \beta_3 \text{Feedback Score}_{ij} + \beta_4 \text{Dummy for Positive Feedback Only}_{ij}$$

$$+ \beta_5 \text{Dummy for "Top Rated" Seller}_{ij} + \beta_6 \text{Claimed Coin Grade}_{ij}$$

$$+ \beta_7 \text{Auction Starting Price}_{ij} + \beta_8 \text{Shipping Price}_{ij}$$

$$+ \beta_9 \text{Dummy for Coin Produced in Denver}_{ij}$$

$$+ \beta_{10} \text{Dummy for Coin Produced in San Francisco}_{ij}$$

Table 3.12 shows the result of the estimation for collectible coins data. Again, we can do some primary analysis by examining whether this result corresponds with the main proposition regarding the economic incentive for low-type sellers to disclose information. First, we check whether the demand for the product increases with lower perceived risk. The result shows that the coefficients for two variables representing perceived risk—whether the coin is professionally graded and number of sides clearly shown—are both significant and positive. Therefore, the estimation result regarding the effect of perceived risk follows the prediction of the main proposition. Second, we can check whether the demand for the product increases with higher claimed quality. The result shows that the coefficient for the variable representing claimed

quality—claimed coin grade—is positive. However, the effect of this variable is not significant, unlike the case of baseball card data. Therefore, the effect of claimed quality does not correspond with the prediction of the main proposition. This is also different from the findings from Jin and Kato (2006), who have shown that a higher claimed grade always helps sellers, even when the claim is not true. Third, the variable representing auction starting price is negative and strongly significant, as indicated by the analytic model. Overall, the coin data shows that our analytic model again seems to work fine in predicting the real market situations, although the effect of claimed quality is not significant. The effect of claimed quality will be analyzed again with an alternative specification, where it shows some significant effects through interaction.

Table 3.12: Estimation Results for Coins (Basic Specification)

Perceived Risk		
Dummy = 1 if professionally graded	0.3553	***
	(0.1127)	
Number of coin sides clearly shown	0.4098	**
	(0.1997)	
Feedback score	-0.000000698	
	(0.0000037)	
Dummy = 1 if only positive feedback	-0.1584	
	(0.1068)	
Dummy = 1 if the seller is "top rated"	0.1826	*
	(0.1027)	
Claimed Quality		
Claimed coin grade	0.0109	
	(0.0091)	
Price		
Auction starting price ($)	-0.0293	***
	(0.0037)	
Shipping price ($)	-0.0175	
	(0.0316)	
Other		
Dummy = 1 if produced in Denver	0.0857	
	(0.0814)	
Dummy = 1 if produced in San Francisco	0.0262	
	(0.0925)	
Observations	438	
Chi-squared	132.63	***
d.f.	10	

* p<0.1.
** p<0.05.
*** p<0.01.

3.4.1.1.3 Stamps

For the stamp data, we run a negative binomial regression with the variables defined above and assume that the number of unique bidders for the auction item *j* sold by seller *i* is drawn from a negative binomial distribution where the mean of the distribution is shown by the parameter $\tilde{\lambda}_{ij}$:

$$\text{Prob}\left(Q_{ij} = q\right) = \frac{e^{-\tilde{\lambda}_{ij}}\tilde{\lambda}_{ij}^{q}}{q!},$$

$$\text{where } q = 0, 1, 2, \ldots, \text{ and } \ln\left(\tilde{\lambda}_{ij}\right) = \beta X_{ij} + \varepsilon_{ij.}$$

We use the following specification for the independent variables:

$$\beta X_{ij} + \varepsilon_{ij} = \beta_0 + \beta_1 \text{Dummy for Professional Grading}_{ij}$$
$$+ \beta_2 \text{Number of Stamp Sides Shown with High-Resolution Pictures}_{ij}$$
$$+ \beta_3 \text{Feedback Score}_{ij} + \beta_4 \text{Dummy for Positive Feedback Only}_{ij}$$
$$+ \beta_5 \text{Dummy for "Top Rated" Seller}_{ij} + \beta_6 \text{Claimed Stamp Grade}_{ij}$$
$$+ \beta_7 \text{Auction Starting Price}_{ij} + \beta_8 \text{Shipping Price}_{ij}$$
$$+ \beta_9 \text{Dummy for Encepsulated Stamp}_{ij}$$
$$+ \beta_{10} \text{Dummy for Cancelled Stamp}_{ij}$$
$$+ \beta_{11} \text{Dummy for Hinged Stamp}_{ij}$$
$$+ \sum_{k=1}^{14} \beta_{k+11} \text{Stamp Type}^{k}_{ij} + \varepsilon_{ij}$$

Table 3.13 shows the result of the estimation for collectible stamp data. Again, we can do some primary analysis by examining whether this result corresponds with the main proposition regarding the economic incentive for low-type sellers to disclose information. First, we check whether the demand for the product increases with lower perceived risk. The result shows that the coefficient for the dummy variable for whether the coin is professionally graded is significant and positive. Therefore, the estimation result regarding the effect of perceived risk follows the prediction of the main proposition. Second, we can check whether the demand for the product increases with higher claimed quality. The result shows that the coefficient for the variable representing claimed quality—claimed stamp grade—is significant and positive. Therefore, the effect of claimed quality also follows the prediction of the main proposition. Third, the coefficient for the variable representing auction starting price is negative and strongly significant as predicted by the analytic model. Overall, the stamp data shows that our analytic model again seems to work fine in predicting the real market situations.

Table 3.13: Estimation Results for Stamps (Basic Specification)

Perceived Risk		
Dummy = 1 if professionally graded	0.5979	**
	(0.2521)	
Number of stamp sides clearly shown	0.0254	
	(0.1720)	
Feedback score	0.0000108	
	(0.00000734)	
Dummy = 1 if only positive feedback	-0.1982	
	(0.3132)	
Dummy = 1 if the seller is "top rated"	-0.0442	
	(0.3718)	
Claimed Quality		
Claimed stamp grade	0.0144	**
	(0.0061)	
Price		
Auction starting price ($)	-0.0059	***
	(0.0012)	
Shipping price ($)	0.0890	
	(0.0814)	
Other		
Dummy = 1 for encapsulated stamp	-0.5779	
	(0.6642)	
Dummy = 1 for cancelled stamp	-0.4843	**
	(0.1896)	
Dummy = 1 for hinged stamp	0.0922	
	(0.1138)	
Dummy = 1 for buy-it-now option	-30.0338	
	932279.1000	
Stamp Type		
Dummy = 1 for stamp type 1	0.4365	*
	(0.2581)	
Dummy = 1 for stamp type 2	-0.0655	
	(0.3648)	
Dummy = 1 for stamp type 3	0.1601	
	(0.3505)	
Dummy = 1 for stamp type 4	-0.3370	
	(0.3667)	
Dummy = 1 for stamp type 5	0.5613	
	(0.3730)	
Dummy = 1 for stamp type 6	-0.4910	
	(0.4633)	
Dummy = 1 for stamp type 7	0.1168	
	(0.2784)	
Dummy = 1 for stamp type 8	0.5455	**
	(0.2343)	
Dummy = 1 for stamp type 9	0.0224	
	(0.2589)	
Dummy = 1 for stamp type 10	-0.0055	
	(0.2513)	
Dummy = 1 for stamp type 11	0.0845	
	(0.2565)	
Dummy = 1 for stamp type 12	0.3947	
	(0.2859)	

Dummy = 1 for stamp type 13	1.2549 (0.3037)	***
Dummy = 1 for stamp type 14	-0.0495 (0.2673)	
Observations	343	
Chi-squared	89.33	***
d.f.	26	

* p<0.1.
** p<0.05.
*** p<0.01.

3.4.1.2 Check for Endogeneity

The primary estimation results of three different product category all show that the effect of third-party certification is always positive and significant, suggesting that an economic incentive for the low-type seller to disclose information may be present in real markets. However, before we do more analysis on this, we should first investigate potential endogeneity in this model. In particular, it is possible that the seller's decision to use a professional grading service is not exogenous, but is actually affected by some omitted factors. More specifically, it is possible that a seller with a high-quality product may be motivated to seek third-party certification as it is more likely to get a good grade. On the other hand, it is also possible that a seller with a high-quality product may be less motivated to seek third-party certification as other factors are already communicating its quality information with bidders. Either way, some omitted factors may affect the potential demand of the product. We have therefore explicitly checked the endogeneity in our model using instrument variables.

To find appropriate instruments, we have exploited the panel structure of the data with the focus on seller-specific behaviors to find appropriate instruments, applying the approach of Hausman, Leonard, and Zona (1994), Hausman (1997), and Nevo (2001). As these previous studies have assumed that the errors in demand are independent across markets and then used prices of the product in other markets as an instrumental variable for prices of the product in current markets, we have assumed that the errors in auction results are independent across

auctions in different periods and defined instrument variables from the auctions of the same seller (for sellers with multiple auctions) or the same type of sellers (for sellers with a single auction)[15] in a different period. We thus have divided auctions into two periods based on the time and date the seller has listed each item, and measured two instruments from the auctions in each different period: the probability of being graded by professional grading service and the average number of high-resolution pictures posted. We have picked up these instruments since we believe that the probability of being graded by a professional grading service and the average number of high-resolution pictures shown for auctions by one seller or one type of sellers in one period are associated with the same seller or the same type of seller's decision to use a professional grading service for the auctions in the other period. Therefore, we can say that these instruments satisfy instrument relevance condition. Moreover, since these variables observed from auctions in one period cannot affect the number of bidders for the auctions in a different period and thus are not related to the error term of the main estimation, these instruments also satisfy the instrument exogeneity condition. These conditions of valid instruments are again checked through some statistics in a following analysis.

Although we now have valid instruments for endogeneity test, we cannot directly apply Wu-Hausman test or Durbin test for endogeneity since our main estimation assumes Poisson or negative binomial distribution and the potentially endogenous variable is not linear. Therefore, we have instead applied the endogeneity test for binary regressor in a count data regression suggested by Staub (2009) and Wooldridge (1997). We have first regressed the potentially endogenous variable, a dummy for whether the product is professionally graded or not, as a function of other independent variables used in the original estimation and two excluded

[15] We have classified these sellers with a single auction item into 16 groups according to their experiences on eBay, assuming that sellers with similar experiences show similar behaviors. According to the post analysis explained below, this has provided valid instruments that meet both instrument relevance and exogeneity conditions.

instruments (the probability of being graded by a professional grading service and the average number of high-resolution pictures posted, both measured in a different period), and predicted residuals from this estimation. We have then tested whether this residual is significant in the second-stage Poisson or negative binomial model.

The results of these endogeneity tests have not rejected the null hypothesis that the variable in question is exogenous in baseball card, coin, and stamp data (p = 0.386, 0.950, and 0.137, respectively). We have also observed some statistics to reconfirm relevance and exogeneity conditions of these instruments. First, the regression of the dummy for whether the product is professionally graded or not on all other explanatory variables including instruments has shown that the effect from these instrument are significant in explaining this dummy, satisfying instrument relevance condition in baseball card, coin, and stamp data (p = 0.00, 0.02, and 0.00, respectively). We have also run Poisson and negative binomial estimations with the main dependent variable (number of bidders) and all explanatory variables including these instruments, and found that these two instruments are not significant in explaining the main dependent variable (p = 0.162 and 0.988 for baseball card data, 0.158 and 0.323 for coin data, and 0.554 and 0.909 for stamp data), also satisfying the instrument exogeneity condition.

Therefore, we can say that the potentially endogenous explanatory variable in question (a dummy for whether the product is professionally graded) is exogenous in all of the product categories we examine, and conclude that our results do not suffer from endogeneity bias.

3.4.1.3 Analysis of the Results

With the estimation results, we can explicitly investigate the most important but counterintuitive finding from the analytic model that there is an economic incentive to disclose

information about low-quality products. We have focused on the effect of third-party certification in providing this economic incentive.

3.4.1.3.1 Baseball Cards

In the baseball card case, the coefficient for whether the card is professionally graded is estimated to be 0.1279. The result suggests that the number of bidders increases by a factor of $e^{(0.1279)} \approx 1.1364$ if the card is professionally graded. Moreover, as the coefficient for claimed card grade is 0.2377, the data predicts the number of bidders to increase by a factor of $e^{(0.2377)} \approx 1.2683$ if claimed card grade increases by one.

Using these results, we can estimate the comprehensive effects from the changes in these variables and present whether disclosing information about low quality can benefit sellers or not. We have observed the estimated demand of sellers' three different strategies: i) fraudulently claiming higher quality, ii) disclosing lower quality without certification, and iii) disclosing lower quality with certification. First, for the strategy of claiming higher quality, we assume that sellers bluff buyers and fraudulently increase the grade of their cards by one half. For example, when the actual grade of a card is seven, a seller may claim that the grade is seven and a half. Second, for the strategy of disclosing lower quality without certification, we assume that sellers reveal the true grade of their cards but do not use certification to support their claims. For example, when the actual grade of a card is seven, some sellers may claim that the grade is actually seven but do not use a professional grading service. Third, for the strategy of disclosing lower quality with certification, we assume that these sellers reveal the true grade of their cards and support their claims using certification. For example, when the actual grade of a card is seven, these sellers claim that the grade is actually seven and use a professional grading service.

For this analysis, all other continuous variables are fixed at mean values and all other dummy variables are fixed at zero.

Figure 3.2: Plotted Demand of Baseball Cards (Basic Specification)

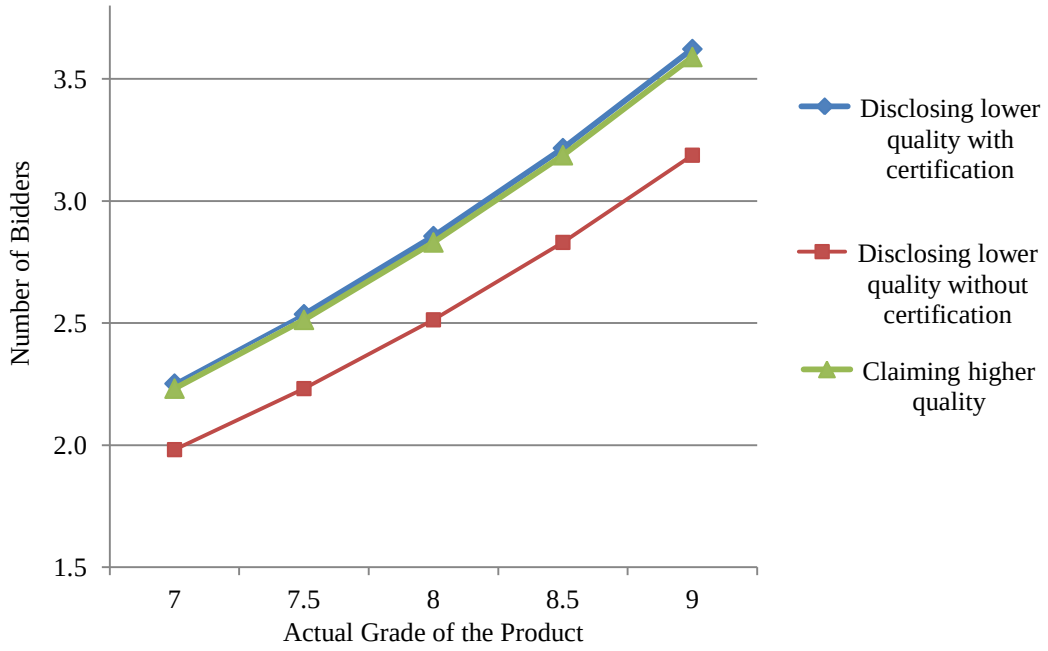


Figure 3.2 shows this estimated demand of each different strategy. From these results, we can examine whether there exists an incentive to disclose information about low quality. For example, suppose there is a baseball card with an actual grade of seven. A seller can choose one of the three strategies as explained: he either fraudulently claims that the grade is seven and a half, shares the actual (low) grade of seven without certification, or shares the actual grade of seven and uses certification. According to the estimation results, if a seller fraudulently claims the actual value of this card to be seven and a half, without using a professional grading service, the number of bidders is estimated to be 2.23. If this seller shares the actual grade as seven but does not use certification, the demand is estimated to be 1.98, which is lower than the demand from higher-claim strategy. However, if the same seller chooses to get the professional grading service, the demand is expected to rise to 2.25, which is more than the expected demand when

claiming higher quality. Therefore, the predicted demand from empirical analysis shows that the demand for the product which discloses low quality and reduces risk can be higher than the demand for the product which fraudulently claims high quality. Although revealing low quality is not usually believed to be the best strategy to get an instant increase in sales under information asymmetry, our analysis of market data shows that it is possible to immediately generate higher demand by disclosing information about low quality, suggesting an economic incentive for low-type sellers to disclose quality information. However, in the baseball card case, this economic incentive is relatively small, as the incentive from disclosing low quality with certification is not as strong as the incentive from fraudulently increasing the grade by, for example, one. For example, when the true quality is eight, fraudulently claiming the quality to be nine gives a bigger incentive (estimated demand of 3.19) to the seller than disclosing low quality with certification (estimated demand of 2.86). These economic incentives are summarized in Table 3.14. The fact that the incentive for disclosing information about low quality is relatively small in the baseball card data may support the result from Jin and Kato (2006) that sellers overstate the value of their products and achieve higher profit in the baseball card market.

Table 3.14: Estimated Demand of Baseball Cards (Basic Specification)

	Actual Quality of Card				
	7	7.5	8	8.5	9
Fraudulently increasing the grade by one half	2.23	2.51	2.83	3.19	3.59
Disclosing true quality					
Without certification	1.98	2.23	2.51	2.83	3.19
With certification	2.25	2.54	2.86	3.22	3.62

Notes: All other continuous variables are fixed at mean values and all other dummy variables are fixed at zero.

3.4.1.3.2 Coins

In the coin data estimation, the coefficient for whether the coin is professionally graded is estimated to be 0.3553. The result suggests that the number of bidders increases by a factor of $e^{(0.3553)} \approx 1.4266$ if the coin is professionally graded. However, the effect of the claimed coin grade is found to be insignificant in the coin data. This is not consistent with the finding from Jin and Kato (2006) that a higher claim will help sellers even when the claim is fraudulent. In other words, Jin and Kato (2006) have demonstrated that dishonesty generally helps sellers through observing market data and examining actual products, which our analysis of baseball card data has also shown to be true. However, our analysis of coin data seems to contradict the finding, as the seller simply claiming a higher grade does not affect the buyer's behavior. In short, there seems to be no economic incentive for sellers of coins to overstate quality information.

We can look at this argument more in detail by the following analysis. Just as we have done with the baseball card data, we have observed the estimated demand of sellers' three different strategies: i) fraudulently claiming higher quality, ii) disclosing lower quality without certification, and iii) disclosing lower quality with certification. For this analysis, all other continuous variables are fixed at mean values and all other dummy variables are fixed at zero.

Figure 3.3: Plotted Demand of Coins (Basic Specification)

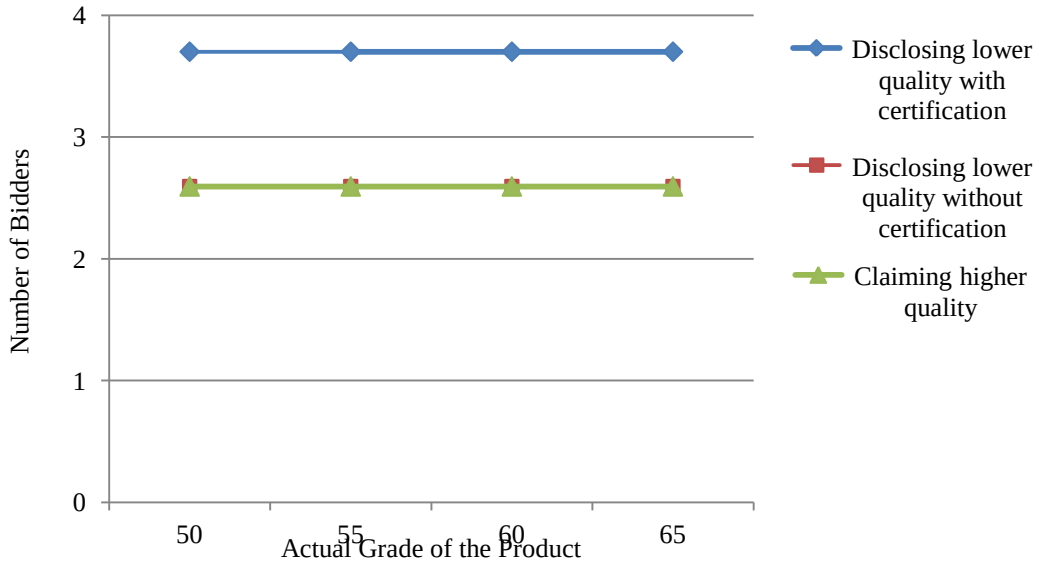


Figure 3.3 shows this estimated demand of each different strategy. From these results, we can examine whether there exists an incentive to disclose information about low quality. For example, suppose there is a coin with an actual grade of 55. A seller can choose one of the three strategies as explained: he either fraudulently claims that the grade is 60, shares the actual (low) grade of 55 without certification, or shares the actual grade of 55 and uses certification. According to the estimation results, if a seller fraudulently claims the actual value of this coin to be 60, without using a professional grading service, the number of bidders is estimated to be 2.59. However, when this seller shares the actual grade of 55 but does not use certification, the demand is also estimated to be 2.59, as grade variable is not significant in the coin data. Therefore, there is no incentive for sellers of coins to inflate quality information, contrary to Jin and Kato (2006)'s finding and our analysis of baseball card data. On the other hand, if the seller shares the actual grade as 55 and chooses to get the professional grading service, the demand is expected to rise to 3.70, which is bigger than the expected demand when claiming higher quality. Therefore, the predicted demand from empirical analysis shows that the demand for the product

which discloses low quality and reduces risk can be higher than the demand for the product which fraudulently claims high quality. This analysis shows that it is possible to immediately generate higher demand by disclosing information about low quality, suggesting economic incentives for sellers to disclose information about low-quality products. We have also found that there is no incentive for the seller to claim higher quality in the case of coin data, indicating even stronger incentives for full disclosure of low-quality product. These economic incentives are summarized in Table 3.15.

Table 3.15: Estimated Demand of Coins (Basic Specification)

	Actual Quality of Coin			
	50	55	60	65
Fraudulently increasing the grade by five	2.59	2.59	2.59	2.59
Disclosing true quality				
Without certification	2.59	2.59	2.59	2.59
With certification	3.70	3.70	3.70	3.70

Notes: All other continuous variables are fixed at mean values and all other dummy variables are fixed at zero.

3.4.1.3.3 Stamps

In the stamp case, the coefficient for whether the stamp is professionally graded is estimated to be 0.5979. The result suggests that the number of bidders increases by a factor of $e^{(0.5979)} \approx 1.8183$ if the stamp is professionally graded. Moreover, as the coefficient for claimed stamp grade is 0.0144, the data predicts the number of bidders to increase by a factor of $e^{(0.0144)} \approx 1.0145$ if the claimed stamp grade increases by one.

Using these results, we can estimate the comprehensive effects from the changes in these variables and present whether disclosing low quality can benefit sellers or not. We have again observed the estimated demand of sellers' three different strategies: i) fraudulently claiming higher quality, ii) disclosing lower quality without certification, and iii) disclosing lower quality

with certification. For this analysis, all other continuous variables are fixed at mean values and all other dummy variables are fixed at zero.

Figure 3.4: Plotted Demand of Stamps (Basic Specification)

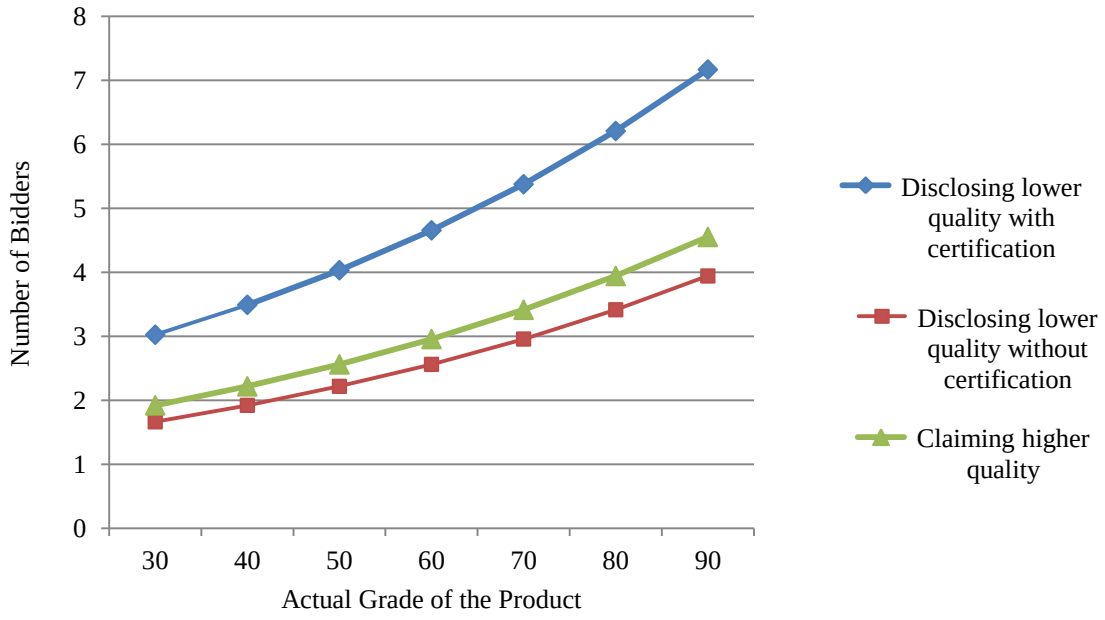


Figure 3.4 shows this estimated demand of each different strategy. From these results, we can examine whether there exists an incentive to disclose low quality. For example, suppose there is a stamp with an actual grade of 50. A seller can choose one of the three strategies as explained: he either fraudulently claims that the grade is 60, shares the actual (low) grade of 50 without certification, or shares the actual grade of 50 and uses certification. According to the estimation results, if a seller fraudulently claims the actual value of this stamp to be 60, without using a professional grading service, the number of bidders is estimated to be 2.56. If this seller shares the actual grade of 50 but does not use certification, the demand is estimated to be 2.22, which is lower than the demand from the higher-claim strategy. However, if the same seller chooses to get the professional grading service, the demand is expected to rise to 4.03, which is higher than the expected demand from claiming higher quality. Therefore, the predicted demand from empirical analysis shows that the demand for the product which discloses low quality and

reduces risk can be higher than the demand for the product which fraudulently claims high quality. This shows that it is possible to immediately generate higher demand by disclosing low-quality information, suggesting economic incentives to disclose information about low quality. In particular, in the stamp case, the economic incentive for making a low-quality claim is very big—disclosing true quality with certification has a bigger impact than fraudulently increasing the grade by 40. These economic incentives are summarized in Table 3.16.

Table 3.16: Estimated Demand of Stamps (Basic Specification)

	Actual Quality of Stamp						
	30	40	50	60	70	80	90
Fraudulently increasing the grade by ten	1.92	2.22	2.56	2.96	3.41	3.94	4.55
Disclosing true quality							
Without certification	1.66	1.92	2.22	2.56	2.96	3.41	3.94
With certification	3.02	3.49	4.03	4.66	5.38	6.21	7.17

Notes: All other continuous variables are fixed at mean values and all other dummy variables are fixed at zero.

3.4.1.4 Summary

We have investigated the economic incentives for sellers to disclose information about lower quality compared with the economic incentive for sellers to fraudulently claim higher quality. Although we have found that some economic incentives exist for disclosing low quality throughout all three product categories, the sizes of these incentives differ. In the baseball card case, the incentive for low-quality disclosure is relatively small and the incentive to fraudulently claim high quality is relatively high, which may encourage sellers to overstate their quality in the baseball card market, just like the findings from Jin and Kato (2006). However, in the coin case, there is almost no incentive for fraudulently claiming high quality and therefore the incentive for low-quality disclosure is apparent. In the stamp case, although the incentive to fraudulently claim high quality is strong enough, the incentive for low-quality disclosure is even stronger,

suggesting that it is definitely better for sellers to claim low quality with certification than to inflate quality claims. From these results, we can see that although a third-party certification always provides certain incentives to low-quality sellers to disclose quality information, the effectiveness of the incentive differs depending on the market circumstances, and this incentive for full disclosure is sometimes smaller than the incentive for fraudulent disclosure.

3.4.2 Alternative Specification

3.4.2.1 Motivation

While the basic specification shows various aspects of the economic incentives for information disclosure by observing several different markets, this essay also attempts to attain a more precise understanding of the incentive structure by replacing the original assumption of the analytic model that customers are uniformly distributed according to their risk sensitivities with a more realistic assumption that the number of risk-sensitive customers is bigger than the number of risk-insensitive customers, based on the following logic. First, most empirical studies that have estimated the risk propensities of customers generally show that there are more risk-averse customers than risk-taking customers in markets. For example, when Binswanger (1980) has observed the risk attitudes of Indian households using an experimental gambling approach, the number of customers has generally increased as the level of risk propensity goes from risk-taking to risk-averse. In this observation, the subjects' general tendency of risk aversion has even increased as the payoff size used in their gambling approach gets larger. To replicate the findings and confirm the new assumption, we have also observed the risk propensities of 718 undergraduate students at a major public university in the southern United States through using a set of monetary gambles, which is the most commonly used method in economics literature to measure an individual's risk propensity (Binswanger 1980; Holt and Laury 2002). When we

have measured the subjects' risk propensities from 1 (extremely risk-averse) to 6 (extremely risk-taking), the number of risk-averse subjects has been shown to be generally higher than the number of risk-taking subjects, as shown in Table 3.17. Therefore, we have found supports for the alternative assumption of the model that the number of risk-sensitive customers is generally higher than the number of risk-insensitive customers, from both previous literature and our own observations.

Table 3.17: Observed Distribution of Risk Propensities of Customers

	Extremely Risk-Averse	Fairly Risk-Averse	Moderately Risk-Averse	Moderately Risk-Taking	Fairly Risk-Taking	Extremely Risk-Taking
Observed Size	512	105	45	18	12	26
%	71.31	14.62	6.27	2.51	1.67	3.62

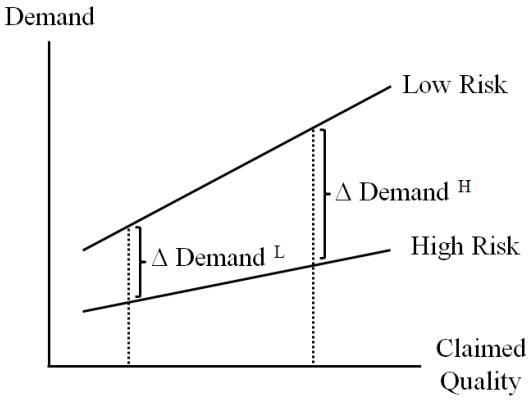
NOTE: Percentage values are calculated based on the total number of subjects.

To apply this alternative assumption to the original model, we have now added a factor of interaction between claimed product quality and the level of perceived risk. The rationale behind this interaction is as follows: since more customers are risk-sensitive, more people are interested in purchasing lower-risk products than higher-risk products. Therefore, the change in demand caused by the change in claimed product quality will be relatively lower for high-risk products than for low-risk products, as more customers are interested in low-risk products. For this reason, we hypothesize that there is an interaction between the claimed product quality and perceived risk of the products, since the impact on demand caused by same change in product quality differs depending on the level of the perceived risk of the product.

The existence of an interaction effect between perceived risk and claimed card grade suggests some important implications regarding the incentive to disclose information about low quality. The theoretical analysis about this alternative specification can be summarized in Figure 3.5. Figure 3.5 shows that the change in demand caused by the same amount of change in

claimed quality is higher for the product with low risk than for the product with high risk because of the interaction. Therefore, we can also see from this result that the increase in demand caused by the same reduction of risk is higher for the product with high claimed quality than for the product with low claimed quality. More specifically, in Figure 3.5, the increase in demand caused by same reduced risk is higher with high claimed product quality ($\Delta Demand^{H}$) than with low claimed product quality ($\Delta Demand^{L}$), because of the interaction effect.

Figure 3.5: Interaction Between Perceived Risk and Claimed Quality



Therefore, we can conclude that the effect of the same reduced perceived risk on demand is higher for high-quality products than for low-quality products. We have also learned from Essay 1 and the earlier sections of this essay that a certification provides economic incentives for the disclosure of low quality by reducing perceived risk. Judging from these, we can conclude that the seller's incentive for disclosure of low quality is affected by the level of original quality. We will also examine this argument more in detail with the following analysis.

3.4.2.2 Estimation Procedure

We now explicitly check the interaction effect in our data and examine what impacts it has on the economic incentives for a seller's information disclosure.

3.4.2.2.1 Baseball Cards

For the alternative specification, most of the specification of the original model is applied, but we have added the interaction between the dummy variable showing whether the card on sale is professionally graded or not and the standard card grade claimed by the seller. With this new specification, it is assumed that the number of unique bidders for auction item *j* sold by seller *i* is drawn from a Poisson distribution where the mean of the distribution is shown by the parameter λ_{ij}:

$$\text{Prob}\left(Q_{ij} = q\right) = \frac{e^{-\lambda_{ij}}\lambda_{ij}^{q}}{q!},$$

$$\text{where } q = 0, 1, 2, \ldots, \text{ and } \ln\left(\lambda_{ij}\right) = \beta X_{ij}.$$

In this case, we use the following specification for the independent variables:

$$\beta X_{ij} = \beta_0 + \beta_1 \text{Dummy for Professional Grading}_{ij}$$
$$+ \beta_2 \text{Number of Card Sides Shown with High Resolution Pictures}_{ij}$$
$$+ \beta_3 \text{Feedback Score}_{ij} + \beta_4 \text{Dummy for Positive Feedback Only}_{ij}$$
$$+ \beta_5 \text{Dummy for "Top Rated" Seller}_{ij} + \beta_6 \text{Claimed Card Grade}_{ij}$$
$$+ \beta_7 \text{Auction Starting Price}_{ij} + \beta_8 \text{Shipping Price}_{ij}$$
$$+ \beta_9 \text{Dummy for Professional Grading}_{ij} \text{ x Claimed Card Grade}_{ij}$$

Table 3.18 shows the result of the estimation. Most of the variables that have shown significant effects in the original model (whether the card is professionally graded, claimed card grade, and auction starting price) are again significant under the alternative specification. Moreover, we can analyze the key consideration of the alternative specification by observing the changes caused by the newly added interaction effect. Table 3.18 shows that the interaction effect seems strongly significant (with $p < 0.01$) in this estimation. In other words, the effect on demand caused by the same change in the value of the product seems to be much bigger when

the certification is used. Therefore, the modified assumption applied in this alternative specification has shown to be much more realistic and true to the actual market situation.

Table 3.18: Estimation Results for Baseball Cards (Alternative Specification)

Perceived Risk		
Dummy = 1 if professionally graded	-1.8781	***
	(0.5173)	
Number of card sides clearly shown	0.0812	*
	(0.0422)	
Feedback score	0.00000161	**
	(0.000000741)	
Dummy = 1 if only positive feedback	0.0404	
	(0.0576)	
Dummy = 1 if the seller is "top rated"	0.0324	
	(0.0605)	
Claimed Quality		
Claimed card grade	0.1304	***
	(0.0403)	
Price		
Auction starting price ($)	-0.0542	***
	(0.0030)	
Shipping price ($)	-0.0072	
	(0.0167)	
Interaction		
Dummy = 1 if professionally graded * Claimed card grade	0.2341	***
	(0.0601)	
Observations	451	
Chi-squared	497.16	***
d.f.	9	

* p<0.1.
** p<0.05.
*** p<0.01.

3.4.2.2.2 Coins

As we have done with the baseball card case, most of the specification of the original model is applied here, but the alternative specification has added the interaction between the dummy variable showing whether the coin on sale is professionally graded or not and the standard coin grade claimed by the seller, as explained above. With this new specification, it is assumed that the number of unique bidders for auction item *j* sold by seller *i* is drawn from a Poisson distribution where the mean of the distribution is shown by the parameter λ_{ij}:

$$\text{Prob}\left(Q_{ij} = q\right) = \frac{e^{-\lambda_{ij}}\lambda_{ij}^{q}}{q!},$$

where q = 0, 1, 2, …, and $\ln\left(\lambda_{ij}\right) = \beta X_{ij}$.

In this case, we use the following specification for the independent variables:

$$\beta X_{ij} = \beta_0 + \beta_1 \text{Dummy for Professional Grading}_{ij}$$
$$+ \beta_2 \text{Number of Coin Sides Shown with High-Resolution Pictures}_{ij}$$
$$+ \beta_3 \text{Feedback Score}_{ij} + \beta_4 \text{Dummy for Positive Feedback Only}_{ij}$$
$$+ \beta_5 \text{Dummy for "Top Rated" Seller}_{ij} + \beta_6 \text{Claimed Coin Grade}_{ij}$$
$$+ \beta_7 \text{Auction Starting Price}_{ij} + \beta_8 \text{Shipping Price}_{ij}$$
$$+ \beta_9 \text{Dummy for Coin Produced in Denver}_{ij}$$
$$+ \beta_{10} \text{Dummy for Coin Produced in San Francisco}_{ij}$$
$$+ \beta_{11} \text{Dummy for Professional Grading}_{ij} \text{ x Claimed Coin Grade}_{ij}$$

Table 3.19 shows the result of the estimation. The dummy for whether the coin is professionally graded and auction starting price are again significant under the alternative specification and the claimed coin grade is not significant in this case either. Instead, the interaction between claimed coin grade and whether the coin is professionally graded is strongly significant ($p < 0.01$), and we can analyze the main consideration of the alternative specification by observing the changes caused by this newly added interaction effect. Since the interaction effect seems significant, we can say that the effect on demand caused by the same change in the value of the coin seems to be much bigger with lower perceived risk.

Table 3.19: Estimation Results for Coins (Alternative Specification)

Perceived Risk		
Dummy = 1 if professionally graded	-4.7811	***
	(1.5752)	
Number of coin sides clearly shown	0.3711	*
	(0.1911)	
Feedback score	-0.00000103	
	(0.00000319)	
Dummy = 1 if only positive feedback	-0.1603	*
	(0.0943)	
Dummy = 1 if the seller is "top rated"	0.1628	*
	(0.0918)	
Claimed Quality		
Claimed coin grade	0.0009	
	(0.009)	
Price		
Auction starting price ($)	-0.0317	***
	(0.0032)	
Shipping price ($)	-0.0125	
	(0.0283)	
Interaction		
Dummy = 1 if professionally graded * Claimed coin grade	0.0823	***
	(0.0253)	
Other		
Dummy = 1 if produced in Denver	0.1247	
	(0.0795)	
Dummy = 1 if produced in San Francisco	0.0343	
	(0.0892)	
Observations	438	
Chi-squared	202.39	***
d.f.	11	

* p<0.1.
** p<0.05.
*** p<0.01.

3.4.2.2.3 Stamps

Again for the stamp data, most of the specification of original model is applied, but we have added the interaction between the dummy variable showing whether the stamp is professionally graded or not and the standard stamp grade claimed by the seller. With this new specification, it is assumed that the number of unique bidders for the auction item *j* sold by seller

i is drawn from a negative binomial distribution where the mean of the distribution is shown by the parameter $\tilde{\lambda}_{ij}$:

$$\text{Prob}\left(Q_{ij} = q\right) = \frac{e^{-\tilde{\lambda}_{ij}}\tilde{\lambda}_{ij}^{q}}{q!},$$

$$\text{where } q = 0, 1, 2, \ldots, \text{ and } \ln\left(\tilde{\lambda}_{ij}\right) = \beta X_{ij} + \varepsilon_{ij.}$$

We use the following specification for the independent variables:

$$\beta X_{ij} + \varepsilon_{ij} = \beta_0 + \beta_1 \text{Dummy for Professional Grading}_{ij}$$

$$+ \beta_2 \text{Number of Stamp Sides Shown with High-Resolution Pictures}_{ij}$$

$$+ \beta_3 \text{Feedback Score}_{ij} + \beta_4 \text{Dummy for Positive Feedback Only}_{ij}$$

$$+ \beta_5 \text{Dummy for "Top Rated" Seller}_{ij} + \beta_6 \text{Claimed Stamp Grade}_{ij}$$

$$+ \beta_7 \text{Auction Starting Price}_{ij} + \beta_8 \text{Shipping Price}_{ij} + \beta_9 \text{Dummy for Encapsulated Stamp}_{ij}$$

$$+ \beta_{10} \text{Dummy for Cancelled Stamp}_{ij} + \beta_{11} \text{Dummy for Hinged Stamp}_{ij}$$

$$+ \sum_{k=1}^{14} \beta_{k+11} \text{Stamp Type}^{k}_{ij}$$

$$+ \beta_{26} \text{Dummy for Professional Grading}_{ij} \times \text{Claimed Stamp Grade}_{ij} + \varepsilon_{ij}$$

Table 3.20 shows the result of the estimation. With this alternative specification, now the dummy for whether the coin is professionally graded and the grade of the stamp are both insignificant, while auction starting price is still significant. Moreover, the interaction between claimed stamp grade and whether the stamp is professionally graded is not strongly significant either ($p = 0.07$). We can conclude that this newly added interaction effect does not seem to significantly affect the potential demand level of stamp market, not as in the baseball card and coin markets.

Table 3.20: Estimation Results for Stamps (Alternative Specification)

Perceived Risk		
Dummy = 1 if professionally graded	-1.3542	
	(1.0924)	
Number of stamp sides clearly shown	0.0593	
	(0.1737)	
Feedback score	0.0000102	
	(0.00000743)	
Dummy = 1 if only positive feedback	-0.2024	
	(0.3184)	
Dummy = 1 if the seller is "top rated"	-0.0369	
	(0.3762)	
Claimed Quality		
Claimed stamp grade	0.0057	
	(0.0078)	
Price		
Auction starting price ($)	-0.0059	***
	(0.0012)	
Shipping price ($)	0.0804	
	(0.0824)	
Interaction		
Dummy = 1 if professionally graded * Claimed stamp grade	0.0232	*
	(0.0126)	
Other		
Dummy = 1 for encapsulated stamp	-0.5978	
	(0.6632)	
Dummy = 1 for cancelled stamp	-0.4445	**
	(0.1919)	
Dummy = 1 for hinged stamp	0.0693	
	(0.1149)	
Dummy = 1 for buy-it-now option	-29.7368	
	785758.8000	
Stamp Type		
Dummy = 1 for stamp type 1	0.4337	*
	(0.2589)	
Dummy = 1 for stamp type 2	-0.0654	
	(0.3657)	
Dummy = 1 for stamp type 3	0.1555	
	(0.3521)	
Dummy = 1 for stamp type 4	-0.3186	
	(0.3667)	
Dummy = 1 for stamp type 5	0.5516	
	(0.3739)	
Dummy = 1 for stamp type 6	-0.5149	
	(0.4624)	
Dummy = 1 for stamp type 7	0.1585	
	(0.2794)	
Dummy = 1 for stamp type 8	0.5436	**
	(0.2350)	
Dummy = 1 for stamp type 9	0.0321	
	(0.2593)	
Dummy = 1 for stamp type 10	-0.0073	
	(0.2516)	

Dummy = 1 for stamp type 11	0.0713 (0.2570)	
Dummy = 1 for stamp type 12	0.3585 (0.2872)	
Dummy = 1 for stamp type 13	1.2469 (0.3048)	***
Dummy = 1 for stamp type 14	-0.0468 (0.2678)	
Observations	343	
Chi-squared	92.95	***
d.f.	27	

* p<0.1.
** p<0.05.
*** p<0.01.

3.4.2.3 Analysis of the Results

3.4.2.3.1 Baseball Cards

We now explore more about the findings from the alternative specification that the incentive for information disclosure differs according to the absolute quality levels. In this analysis, all other considerations are the same as the basic specification, but now we have to investigate the effect of interaction. More specifically, as the coefficient for the interaction is 0.2341, the factor of $e^{(0.2341)} \approx 1.2638$ should also be considered when the card is professionally graded (and thus has lower risk).

Using these results, we can estimate the comprehensive effects from the changes in these variables and figure out whether the incentive for either overstating quality or disclosing low quality is bigger than the other. Just as we have done with the basic specification, we have observed the estimated demand from sellers' three different strategies: i) fraudulently claiming high quality, ii) disclosing low quality without certification, and iii) disclosing low quality with certification. First, for the strategy of fraudulently claiming high quality, we assume that sellers fraudulently increase the grade of their cards by one half. Second, for the strategy of disclosing low quality without certification, we assume that sellers disclose the true quality of their cards but do not use certification to support their claims. Third, for the strategy of disclosing low quality with certification, we assume that these sellers disclose the true, low quality of their cards

and support their claims using certification. We attempt to observe whether the incentive structure for information disclosure differs with respect to the absolute quality levels under this alternative specification. For this analysis, all other continuous variables are fixed at mean values and all other dummy variables are fixed at zero.

Figure 3.6: Plotted Demand of Baseball Cards (Alternative Specification)

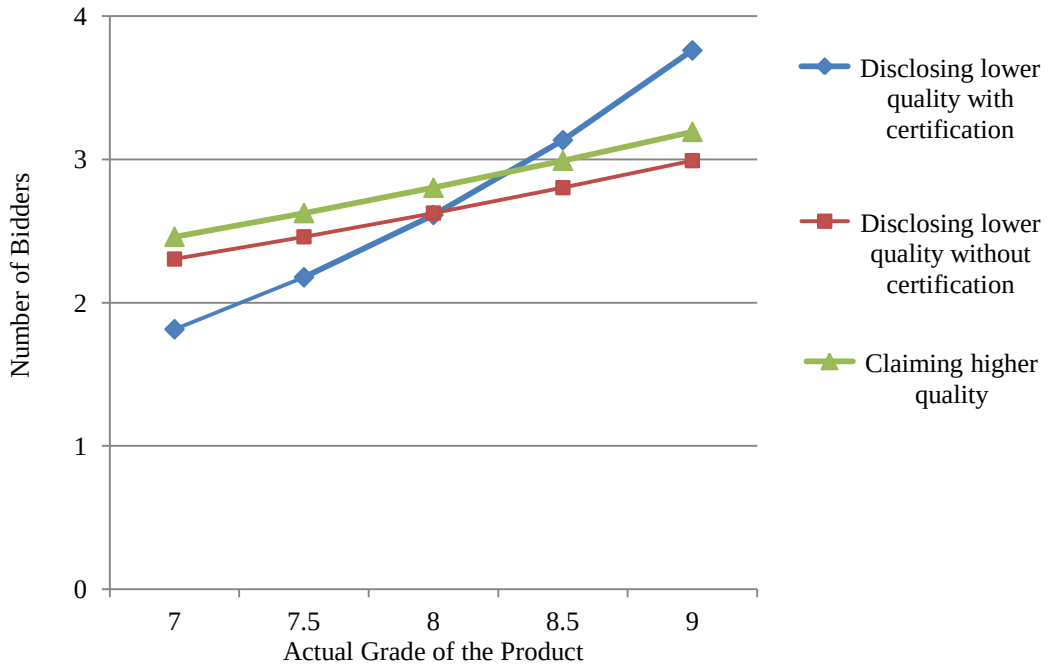


Figure 3.6 shows the estimated demand of each different strategy. From these results, we can examine the incentives to disclose true quality. First, we can think of a case where the seller has a product with lower than average quality. For example, suppose there is a baseball card with an actual grade of seven.[16] A seller can choose one of the three strategies as explained: he either fraudulently claims that the grade is seven and a half, discloses the actual grade of seven without any risk reducers, or discloses the actual grade of seven and uses certification. According to Figure 3.6, if a seller fraudulently claims the actual value of this card to be seven and a half,

[16] Although the grading system for collectible baseball cards ranges from 1 to 10, the value of most cards in the market stand between 7 and 10. Moreover, according to the summary statistics in Table 3-2, the average grade of the baseball cards in our data is 8.44, and the median value is 8.5. Therefore, a card with a value of 7 can be regarded as a lower than average quality product, while a card with a value 9 can be regarded as a higher than average quality product.

without offering professional grading, the number of bidders is estimated to be 2.46. If this seller discloses the actual quality as seven but does not use certification, the demand is estimated to be 2.3, which is lower than the demand from the high-quality-claim strategy. Moreover, if this seller discloses the true quality and chooses to get certification, the demand is expected to decrease to 1.81, which is even lower than the expected demand from disclosing quality information without certification. Therefore, the demand for the product which discloses true quality information cannot be higher than the demand for the product which fraudulently claims higher quality, even with certification, in this case of lower than average quality. Second, we can think of a case where the seller has a product of higher than average quality. For example, suppose there is a baseball card with an actual grade of nine. A seller can choose one of the three strategies as explained: he either fraudulently claims that the grade is nine and a half, discloses the true grade of nine without certification, or discloses the actual grade of nine and uses certification. As shown in Figure 3.6, if a seller fraudulently claims the value of this card to be nine and a half, without offering professional grading, the number of bidders is estimated to be 3.19. If this seller discloses the true grade as nine but does not use certification, the demand is estimated to be 2.99, which is lower than the demand from the high-claim strategy. However, if the seller discloses the true quality and chooses to get the professional grading service, the demand is expected to rise to 3.76, which is a lot higher than the expected demand from the high-quality-claim strategy. Therefore, the demand for the product which discloses true quality and reduces risk can be higher than the demand for the product which fraudulently claims high quality, when the product has a higher-than-average quality. These estimation results of both the lower-than-average-quality and higher-than-average-quality cases show that the economic incentive for disclosing

true quality gets higher than the incentive for fraudulently claiming high quality, as the original quality level is higher. These economic incentives are summarized in Table 3.21.

Table 3.21: Estimated Demand of Baseball Cards (Alternative Specification)

	Actual Quality of Card				
	7	7.5	8	8.5	9
Fraudulently increasing the grade by one half	2.46	2.63	2.80	2.99	3.19
Disclosing true quality					
Without certification	2.30	2.46	2.63	2.80	2.99
With certification	1.81	2.18	2.61	3.13	3.76

Notes: All other continuous variables are fixed at mean values and all other dummy variables are fixed at zero.

This asymmetric incentive for information disclosure is more noticeable if we compare Figure 3.2 and Figure 3.6. Figure 3.2 shows the estimated demand using the basic specification while Figure 3.6 shows the estimated demand using the alternative specification. As we can see from these graphs, when we assume uniform distribution of customers in terms of their risk sensitivities, the incentive for disclosing true quality is always bigger than the incentive for fraudulently claiming high quality, although it is not very strong, regardless of the true product quality level. However, when we assume that there are more risk-sensitive customers in the market, the incentive for disclosing true quality is bigger than the incentive for fraudulent claim when the product quality is higher than average, while fraudulently claiming high quality seems to be a better strategy when the product quality is lower than average. Overall, these results show that while there is an incentive for disclosing true quality, the incentive is more evident when the quality is higher than average.

3.4.2.3.2 Coins

Again, we explore the finding from the alternative specification that incentives for disclosing true quality differ according to the quality levels by analyzing the coin data. As the

coefficient for the interaction is .0823, the factor of $e^{(.0823)} \approx 1.0858$ should also be considered when the coin is professionally graded and thus has lower risk.

Using these results, we can estimate the comprehensive effects from the changes in these variables and present whether the incentive for full disclosure differs according to the quality level. Just as we have done with basic specification, we observe the estimated demand from sellers' three different strategies: i) fraudulently claiming high quality, ii) disclosing true quality without certification, and iii) disclosing true quality with certification. First, for the strategy of fraudulently claiming high quality, we assume that sellers inflate the grade of their coins by five. Second, for the strategy of disclosing true quality without certification, we assume that sellers disclose true quality but do not use any risk-reducing mechanism to support their claims. Third, for the strategy of disclosing true quality with certification, we assume that these sellers disclose the true quality of their coins and support their claims using certification. Most importantly, we attempt to observe whether the incentive for information disclosure is different according to the absolute quality levels of the coins under this alternative specification. For this analysis, all other continuous variables are fixed at mean values and all other dummy variables are fixed at zero.

Figure 3.7: Plotted Demand of Coins (Alternative Specification)

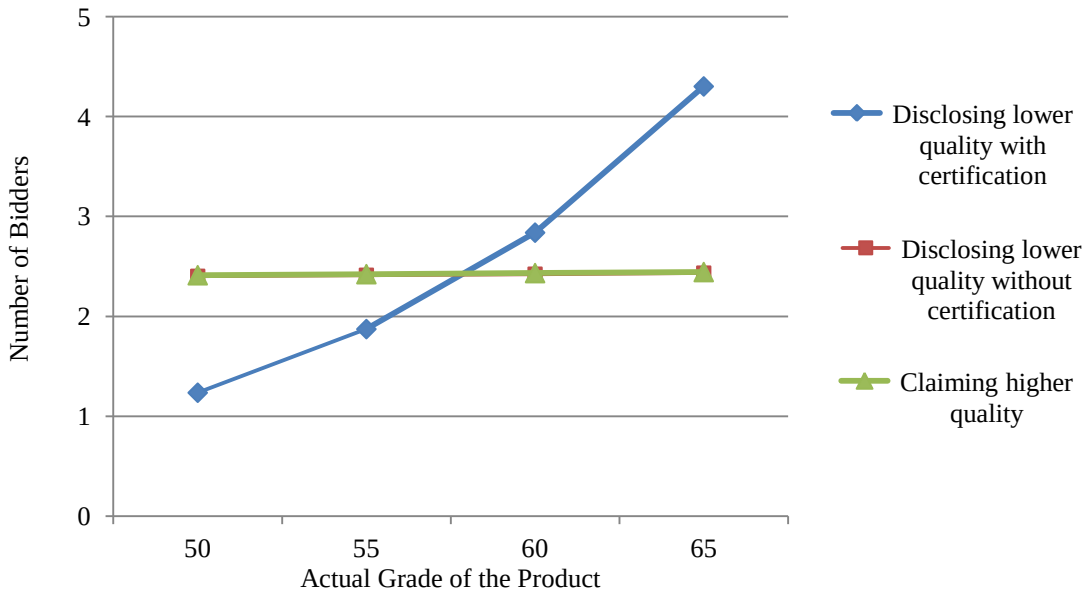


Figure 3.7 shows the estimated demand of each different strategy observed from the estimation. From these results, we can examine whether the incentive to disclose true quality differs according to quality levels. First, we can think of a case where the seller has a product of lower than average quality. For example, suppose there is a coin with an actual grade of 50.[17] A seller can choose one of the three strategies as explained: he either fraudulently claims that the grade is 55, discloses the true quality of 50 without any risk reducers, or discloses the true quality of 50 and uses certification. According to Figure 3.7, if a seller fraudulently claims the actual value of this coin to be 55, the number of bidders is estimated to be 2.41. If the seller discloses true quality of 50 but does not use any risk-reducing mechanism, the demand is estimated to be 2.40, which is almost the same as the demand from the high-claim strategy. Moreover, if the seller discloses true quality and chooses to get the professional grading service, the demand is expected to be 1.23, which is smaller than the high-claim strategy or the low-claim

[17] As shown in Table 3-3, the average grade of coins in our data is 61.07 and the median value is 63. Therefore, the coin with a value of 50 can be regarded as a lower than average quality product while the coin with a value 65 can be regarded as a higher than average quality product.

strategy without certification. Therefore, the demand for the product which discloses true quality does not seem to be higher than the demand for the product which fraudulently claims high quality even with reduced risk, in this case of lower than average quality. Second, we can think of a case where the seller has a product of higher than average quality. For example, suppose that there is a coin with an actual grade of 65. A seller can choose one of the three strategies as explained: he either fraudulently claims that the grade is 70, discloses the actual grade of 65 without any risk reducers, or discloses the actual grade of 65 and uses certification. As shown in Figure 3.7, if a seller fraudulently claims the actual value of this coin to be 70, the number of bidders is estimated to be 2.44. If this seller discloses the true grade as 65 but does not use any risk-reducing mechanism, the demand is estimated to be 2.43, which is almost the same as the demand from high-quality claim strategy. However, if the seller discloses the true quality and gets the professional grading service, the demand is expected to rise to 4.3, which is a lot higher than the expected demand from the high-quality claim strategy or low-quality claim without certification. Therefore, the demand for the product which discloses true quality and reduces risk can be higher than the demand for the product which does not, in the case of higher than average quality. These results show that the incentive for full disclosure is higher than the incentive for fraudulent disclosure when the product has higher than average quality. These results are summarized in Table 3.22.

Table 3.22: Estimated Demand of Coins (Alternative Specification)

	Actual Quality of Coin			
	50	55	60	65
Fraudulently increasing the grade by five	2.41	2.42	2.43	2.44
Disclosing true quality				
Without certification	2.40	2.41	2.42	2.43
With certification	1.23	1.87	2.84	4.30

Notes: All other continuous variables are fixed at mean values and all other dummy variables are fixed at zero.

Again, this asymmetric incentive for information disclosure is more noticeable by comparing Figure 3.3 and Figure 3.7. Figure 3.3 shows the estimated demand using the basic specification while Figure 3.7 shows the estimated demand using the alternative specification. As we can see from the graphs, when we assume uniform distribution of customers in terms of their risk sensitivities, the incentive for true quality disclosure is always higher than the incentive for fraudulent disclosure, regardless of the level of true quality. However, when we assume that there are more risk-sensitive customers in the market, the incentive for true quality claim is higher than the incentive for fraudulent quality claim when the quality is higher than average. Overall, these results show that voluntarily disclosing low quality is more effective when sellers are selling products with better than average quality than when they are selling products with lower than average quality.

3.4.2.4 Summary of Results

The alternative specification with the interaction between whether the product is professionally graded and claimed grade has provided us with a more realistic picture of the incentive for full disclosure. More specifically, the baseball card and coin data have shown us that there exists a significant interaction effect between certification and grade on the size of demand, and this result is consistent with the findings of Dewally and Ederington (2006) as they

have empirically shown the existence of the similar interaction effect on the final price of the online auction for comic books. We can conclude from this result that the incentive for true quality disclosure is much higher than the incentive for fraudulent disclosure as the quality gets higher. We believe this is due to the fact that there are more risk-sensitive customers than risk-insensitive customers in most markets, and therefore fraudulently claiming higher quality is worse than full disclosure when the true quality is higher than average, while fraudulent claim seems to be an effective strategy when the product quality is lower than average.

We can also say that, while the result from the basic specification supports the literature on voluntary disclosure as it shows that the incentive for full disclosure is generally higher than the incentive for fraudulent disclosure, the result from the alternative specification might provide support for both voluntary disclosure and mandatory disclosure arguments. More specifically, it has demonstrated that full disclosure is better than bluffing when the quality is higher than average, which verifies the incentive for voluntary disclosure, while the effect is the opposite when the quality is lower than average, suggesting the need for mandatory disclosure. As this interaction effect has not been shown to be significant in the stamp data, more studies are needed to understand this asymmetric incentive for full disclosure in other market environments.

3.4.3 Other Specifications

As is shown above, we have confirmed the interaction effect between the dummy variable showing whether the product is professionally graded and the standard product grade claimed by the seller. However, we can also think of some other interaction effects based on the same theoretical inference used to derive the primary moderator. For example, as the theory predicts that the level of perceived risk might work as a moderator between claimed product quality and number of bidders, we can also check interaction effects of some other variables that

are related to the level of perceived risk in our data. This empirical observation is also expected to work as a foundation for additional theoretical analysis and provide deeper understandings about the incentive for full disclosure.

3.4.3.1 Preliminary Moderators

Based on the theoretical analysis, we can consider the following possible moderators. First, number of high-resolution pictures shown might work as a moderator as this variable can work as a risk reducer and more customers might be affected by claimed product quality when the product has more high-resolution pictures. Second, a seller's feedback score might work as a moderator since it might work as a risk reducer and thus more people will be affected by claimed quality when a seller's feedback score is higher. Third, whether a seller is "Top Rated" or not might also work as a moderator in the same logic applied to the feedback score case. After establishing these hypotheses, we have investigated baseball card, coin, and stamp data to explicitly check the significance of these moderator variables.

3.4.3.2 Estimation Results

As we can see from Table 3.23, none of the additional moderator variables seem to be significant. Although the interaction between claimed product quality and professional grading, the primary moderating effect we have checked in the previous section, is again shown to be significant in this estimation, none of three other interaction effects we have hypothesized seem to have significant effects. The only exception is the interaction between feedback score and claimed quality in the stamp data, which shows a weakly significant effect. We can conclude that the effect of professional grading service is the only feasible moderator in our data, and future studies can investigate more about the moderating effect of a seller's feedback score on claimed quality, especially in the stamp data.

Table 3.23: Effect of Moderator Variables

Interactions	Baseball Cards		Coins		Stamps	
Dummy = 1 if professionally graded	0.2207	***	0.0810	***	0.0197	
* Claimed product grade	(0.0614)		(0.0262)		(.0138)	
Number of card sides clearly shown	-0.0062		-0.2326		-0.0001	
* Claimed product grade	(0.0532)		(0.1662)		(0.0145)	
Feedback score	-0.0000001		0.0000008		0.000000607	*
* Claimed product grade	(0.0000012)		(0.0000010)		(0.000000327)	
Dummy = 1 if the seller is "top rated"	0.1088		-0.0166		0.0254	
* Claimed product grade	(0.0764)		(0.0178)		(0.0318)	

* p<0.1.
** p<0.05.
*** p<0.01.

3.5 Discussion

This essay has first confirmed the predictions from Essay 1 using real market data, and then applied a more realistic distribution of customers' risk propensities to find more feasible implications for managers in terms of how to disclose true quality information. We have measured the effects of certification on demand through analyzing the sales data of collectible baseball cards, coins, and stamps from one of the major online sellers in the U.S. and verified the most important but counterintuitive finding from Essay 1 that there exist economic incentives for sellers to voluntarily disclose information about low quality. Moreover, relaxing the original assumption of uniform distribution of customers' risk sensitivity and replacing it with a more realistic assumption that the number of risk-sensitive customers is higher than the number of risk-insensitive customers has provided us with more feasible implications about marketing communications strategy under information asymmetry. It has been shown that the incentive to disclose true quality information is higher than the incentive to fraudulently claim high quality when the product quality is higher than average, because of the interaction between product quality and perceived risk. For this reason, marketing managers might be more likely to hide unfavorable information when selling lower-quality products while they might voluntarily share

the same unfavorable information when it is related with higher-quality products. On the other hand, we can also say that customers must be more careful in terms of frauds or false claims when making purchase in a market with low-quality products. These results can also explain why frauds in product claims or exaggerations in advertising can be more frequently observed in the market for low-quality products than in the market for high-quality products.

The observation from this essay provides various interesting perspectives to information disclosure literature. First of all, it has shown that the certification provides effective incentives for disclosing low quality and encourages full disclosure. As the incentive to disclose unfavorable information has rarely been considered in the literature, this finding contributes to the literature by providing a different perspective to the knowledge on information asymmetry in markets, generally supporting voluntary disclosure. However, the incentive might only be meaningful when the quality of the product is at least higher than average, and it might work better to fraudulently claim high quality when the product quality is less than average. Therefore, we can say that this essay actually supports the argument of both voluntary and mandatory disclosure, depending on the context of the situation. The dimensions covered in this essay may provide some public policy suggestions to solve fraud issues happening in many different markets.

One more interesting finding from this essay is that the incentive for full disclosure differs across the market as using the certification sometimes provides a very strong incentive to disclose information about true quality (coin and stamp markets), while in some other markets the incentive is somewhat limited and may not seem to effectively promote full disclosure (baseball card market). We presume that one of the reasons of this heterogeneity is the variation in the quality and attributes of the certification across different product markets, and attempt to

explicitly examine the effect of the certification quality on market outcomes more in detail using an analytic model and economic experiments in the following essay.

4. ESSAY 3: THE EFFECT OF NOISY CERTIFICATION ON INFORMATION DISCLOSURE

4.1 Introduction

The previous two essays have verified that there exist economic incentives for low-type sellers to fully disclose their types through analytic model and empirical observations. We have found that sellers may disclose low quality of their products and still expect increased profit by reducing perceived risk through available risk intermediaries such as third-party certifications. In Essay 2, we have also shown that the impact of this economic incentive may differ across different markets, and assumed that one of the possible reasons of this heterogeneity is the different characteristics of third-party certifications available in different markets. Therefore, in this essay, we attempt to understand the effect of different certification mechanisms on information disclosure by investigating how the certifications of different qualities affect the market outcome, such as seller's profit, buyer's profit, and the level of voluntary information disclosure. As is explained above, we focus on the effect of third-party certification among other risk intermediaries because reputation is not easy to establish in the short run, a seller's own signaling is generally not trustworthy, and warranty is usually not appropriate for credence attributes that customers cannot evaluate. Moreover, the empirical observation in Essay 2 has also shown that third-party certification is the only risk intermediary that has significant effects across all three product categories analyzed.

The literature on certification has explained that various factors related with the certifier, customer, and market structure can harm the effectiveness of the certification mechanism and provides noise to the certification (Anderson, Daly, and Johnson 1999; Edelman 2009; Feinstein

1989; Harbaugh, Maxwell, and Roussillon 2011; Hong and Kubik 2003; Lim 2001; Lizzeri 1999; Michaely and Womack 1999; Prendergast 2007; Waguespack and Sorenson 2011; Xiao 2010). However, although the sources of the certification errors have been studied by many of these studies, how these ineffective certification mechanisms impact market outcomes has not been the focus of the academic research so far. This essay tries to provide better understanding of the certification mechanism and its impact on information asymmetry in markets through analyzing the effect of certification errors or inaccurate certification on market outcomes. To the best of our knowledge, this is the first study that provides both theoretical and empirical analysis on specific consequences of inaccurate certification, and we expect that understanding how an inaccurate certification mechanism influences various market outcomes would provide important implications on how to use a certification system to solve adverse selection issues under information asymmetry.

The inaccuracy of the certification can be either created by chance or affected by certain intentions of sellers or certifiers. In this study, we only consider the cases when the certification is "noisy", in opposition to "biased", as we are interested in the case where the inaccuracy is caused by random process. We have thus investigated the effect of noisy certification on various market outcomes using analytic models assuming three different market situations: i) when there is no certification, ii) when the accuracy of the certification is 50 percent, and iii) when the accuracy of the certification is 100 percent. In particular, we have assumed that when the certification is 50 percent accurate, it shows the true value of the product only 50 percent of the time while 100 percent accurate certification always discloses the true value. Although the level of inaccuracy is set at 50 percent for the inaccurate certification in this study, it can also be generalized as an alpha between 0 and 1. Future studies can address the sensitivity of the results

to various levels of alpha. For this analysis, we have also relaxed several assumptions of the previous analysis to consider more realistic settings. We have assumed that a seller can flexibly decide any price he wants to charge and that there is a certain cost for using the certification. On the other hand, we have assumed that the buyers in this market are all homogenous in terms of their risk sensitivities and are all risk-neutral, to focus on the effect of noisy certification on market outcomes.

The results of the analytic model predict that, contrary to our expectations, the payoff for sellers will be the highest without certification and the lowest with 50 percent certification. The finding that a seller receives smaller profit with certification than without certification is quite surprising and somewhat different from the findings from previous essays, and we believe the discrepancy might originate from the assumption that all customers are risk-neutral and that there is a certain cost of using the certification. In fact, our experimental observation shows slightly different results from the analytic model, and we analyze these results more in detail in a following section. Another interesting finding from the analytic model is that sellers earn less profit with inaccurate certification than accurate certification, and we believe that this is due to the fact that the noise of certification causes some confusion and uncertainty in both sellers and buyers' decision to maximize profit, making it hard for sellers to predict buyers' behavior. In terms of buyers' payoff, the model basically predicts that buyers' profit is always zero, as sellers charge the maximum price the buyers are willing to pay. Again, the empirical observation shows different results about buyers' profit, and we explain them in a following section.

We have then tested these predictions with incentive-based lab experiments. To do so, we have run several sessions of lab experiments in which we have randomly assigned subjects into the roles of buyers and sellers and matched them in pairs, to observe their decisions to maximize

their profits under various certification types. There are several advantages using this economic laboratory experiment. First, we can accurately observe whether sellers are disclosing information fully or not, which is rarely possible in other empirical studies on information disclosure. Second, the participants of the experiment were paid cash rewards according to how they performed in the business deals during the session. The subjects played the role of either a buyer or a seller, and their total payoff from the deals was summed up and converted into cash rewards. Therefore, we believe that this payoff structure can reproduce the actual decisions of buyers and sellers and the results thus have some feasible predictions about real market outcomes.

Overall, the result of this experiment is not totally consistent with the prediction of the analytic model. Although seller's profit is the smallest with 50 percent accurate certification as predicted, the profit is actually shown to be higher with 100 percent certification than with no certification, unlike the prediction of the analytic model. Moreover, the buyer's profit is positive in all cases, showing the highest level with 100 percent certification and the lowest level with no certification. We believe this discrepancy between the prediction from the analytic model and the experimental results happens because we have assumed that buyers are homogenous in their risk sensitivities and all risk-neutral for the analytic model. In other words, the existence of risk-sensitive buyers would make both sellers and buyers get more profit under 100 percent certification than under 50 percent certification or no certification. Moreover, unlike the assumption in the analytic model that buyers and sellers are smart and strategically predict each other's behaviors, they have not been very strategic in actual experiments. We discuss this in more depth in a later section. Other than these main findings, we have also found various empirical regularities which provide interesting implications about market outcomes under information asymmetry, such as the effect of certification on social welfare and irrational

behaviors of sellers and buyers. Lastly, we have also checked whether the findings of Essay 2 are replicated with our experimental data.

The essay proceeds as follows. Section 4.2 introduces the analytic model and subgame perfect Nash equilibria predicted by the model. Section 4.3 explains the procedure of our economic experiments. Section 4.4 shows the experimental results and analyzes them in comparison with the results from the analytic model. The essay concludes with some discussion about the findings in Section 4.5.

4.2 Model

Our model consists of buyers and sellers, where there is information asymmetry; only sellers know the true quality of the products, and buyers assume the quality depending on the sellers' claims and whether the certification is used. We attempt to investigate the effect of certification on various market outcomes in three different conditions: i) when there is no certification, ii) when the accuracy of the certification is 50 percent, and iii) when the accuracy of the certification is 100 percent. We have assumed that when the certification is 50 percent accurate, it shows the true value of the product 50 percent of the times, and random value in the other 50 percent of the times. On the other hand, 100 percent accurate certification always discloses the true value. As is explained above, the price is flexible and sellers can determine the price level that maximizes profit. There is also a certain cost for using the certification and the buyers in this market are all homogenous in terms of risk sensitivity, and thus are all risk-neutral. The payoff structures of sellers and buyers are as follows.

4.2.1 Payoff Structure

4.2.1.1 Buyer's Payoff

There are two types of buyer's payoff as there is information asymmetry in the market. More specifically, buyer's expected payoff before purchase will not always be the same as the actual payoff from purchase.

4.2.1.1.1 Expected Payoff

Expected payoff for a buyer: $\pi_B = E(v) - p$

The expected payoff for a buyer is decided by both the expected value of the quality ($E(v)$) and the price of the product suggested by the seller (p). In particular, the expected value of the product ($E(v)$) can vary according to the characteristics of the available certifications. As buyers are all risk-neutral, there is no additional cost from perceived risk in this analysis. Let's assume that the quality of the product v is uniformly distributed between 0 to V (i.e., $U\ [0, V]$).

4.2.1.1.1.1 The Market with 100 Percent Accurate Certification

When the seller shows the certification. As the certification discloses the true quality with 100 percent certification, the claimed value (v_c) is the same as true value (v_T), and it is what buyers expect from the product.

$$\therefore E(v) = v_c = v_T$$

When the seller does NOT show the certification. When the seller does not show the certification, then the buyer assumes that actual quality is the average of certain possible value range, regardless of the level of claimed value. Let's assume that the range of the buyer's perceived value follows $U\ [0, X]$, where the maximum value is expected to be X. In this case, the expected value has the following value:

$$E(v) = \frac{X}{2}$$

4.2.1.1.1.2 The Market with 50 Percent Accurate Certification

When the seller shows the certification. The buyer knows that the certification is true 50 percent of the time, and wrong the other 50 percent of the time. If the certification is correct, then the actual quality (v_T) is the same as the certified quality (v_R), which is also the same as the claimed quality (v_C) (i.e., $v_T = v_R = v_C$). If the certification is incorrect, then the buyer assumes that actual quality is the average of entire possible value range, regardless of the level of claimed value.

$$\therefore E(v) = 0.5 \cdot v_T + 0.5 \cdot E\,(v_T)$$

$$= \ 0.5 \cdot v_T + 0.5 \cdot 0.5 \cdot V$$

$$= \ 0.5 \cdot v_T + 0.25 \cdot V$$

When the seller does NOT show the certification. When the seller does not show the certification, then the buyer assumes that actual quality is the average of a certain possible value range, regardless of the level of claimed value. Let's assume that their perceived value has the range of $U\ [0, X]$, where the maximum value is expected to be X. In this case, a buyer's expected value has the following value:

$$E(v) = \frac{X}{2}$$

4.2.1.1.1.3 The Market Without Certification

When there is no certification available and the seller thus does not show the certification, then the buyer assumes that actual quality is the average of entire possible value range, regardless of the level of claimed value.

$$\therefore E(v) = \frac{V}{2}$$

4.2.1.1.2 Actual Payoff

For buyers, as explained above, expected payoff differs from actual payoff as there is information asymmetry in this market and a buyer cannot accurately evaluate the quality of the product. Therefore, the actual payoff will be decided by true quality (v_T) and the price the buyer pays.

$$\text{Actual payoff for buyer: } \pi_B = v_T - p$$

On the other hand, if a buyer does not make purchase, then the actual payoff will be zero.

4.2.1.2 Seller's Payoff

The seller's payoff structure is as follows:

$$\text{Payoff for seller: } \pi_S = p \cdot n - c_F - c_R$$

In the case of the seller, $n\ (E(v), p) = 1, 0$ as a buyer either purchases the product or not depending on the expected value and price. Although c_F is fixed cost and will always occur, we will assume that c_F is zero for simplicity as this assumption does not change our results. c_R is the cost of using the certification and will be zero if a seller does not use the certification. As we assume that sellers can use flexible pricing and charge the price that maximizes the payoff, a seller will charge $E(v) - \delta$, where δ is a very small value which is negligible and only makes the price slightly lower than $E(v)$ so that buyers decide to make a purchase.

4.2.2 Market Equilibrium

Based on the setup, we can find the subgame perfect Nash equilibria of this model and predict market outcomes depending on whether there is 100 percent certification, 50 percent certification, or no certification. We will first analyze the case of 100 percent certification, followed by the analysis of 50 percent certification case and no certification case.

4.2.2.1 The Market with 100 Percent Accurate Certification

4.2.2.1.1 Subgame Perfect Nash Equilibrium

When the certification is 100 percent accurate, the subgame perfect Nash equilibrium differs depending on the expected value of the product perceived by customers. In particular, we have to consider strategic considerations of the buyers and sellers as follows.

At first, when the seller does not show the certification, the buyer assumes that actual quality can be any value and thus follows $U\ [0,\ V]$. In this case, $E(v) = \frac{V}{2}$ when the seller does not show the certification. Now the expected payoff for a seller when a buyer purchases the product is $v_T - c_R$ when he shows the certification, and $\frac{V}{2}$ when he does not show the certification. Therefore, the seller will prefer to show the certification if $v_T - c_R > \frac{V}{2}$. In this case, the maximum amount of v_T when the seller does not show the certification now becomes $\frac{V}{2} + \ c_R$. Considering this, the buyer now assumes that the range of true quality when the seller doesn't show the certification actually follows $U\ \left[0,\ \frac{V}{2} + c_R\right]$. In this case, $E(v) = \frac{1}{2} \cdot \left(\frac{V}{2} + \ c_R\right)$. Now, the seller shows the certification when $v_T - c_R > \frac{1}{2} \cdot \left(\frac{V}{2} + \ c_R\right)$. Therefore, the maximum amount of v_T when a seller does not show the certification now becomes $\frac{1}{2} \cdot \left(\frac{V}{2} + \ c_R\right) + \ c_R$. This strategic consideration can repeat many times until it converges. If this continues for *k* times, then v_{MAX}, the maximum amount of v_T when the seller does not show the certification, follows the subsequent process.

$$v_{MAX}^{k} = \left(\frac{1}{2}\right)^{k} \cdot V + \left\{\left(\frac{1}{2}\right) + \left(\frac{1}{2}\right)^{2} + \left(\frac{1}{2}\right)^{3} + \cdots + \left(\frac{1}{2}\right)^{k-1}\right\} \cdot c_R \ + \ c_R$$

$$= \left(\frac{1}{2}\right)^{k} \cdot V + \left\{1 - \left(\frac{1}{2}\right)^{k-1}\right\} \cdot c_R \ + \ c_R$$

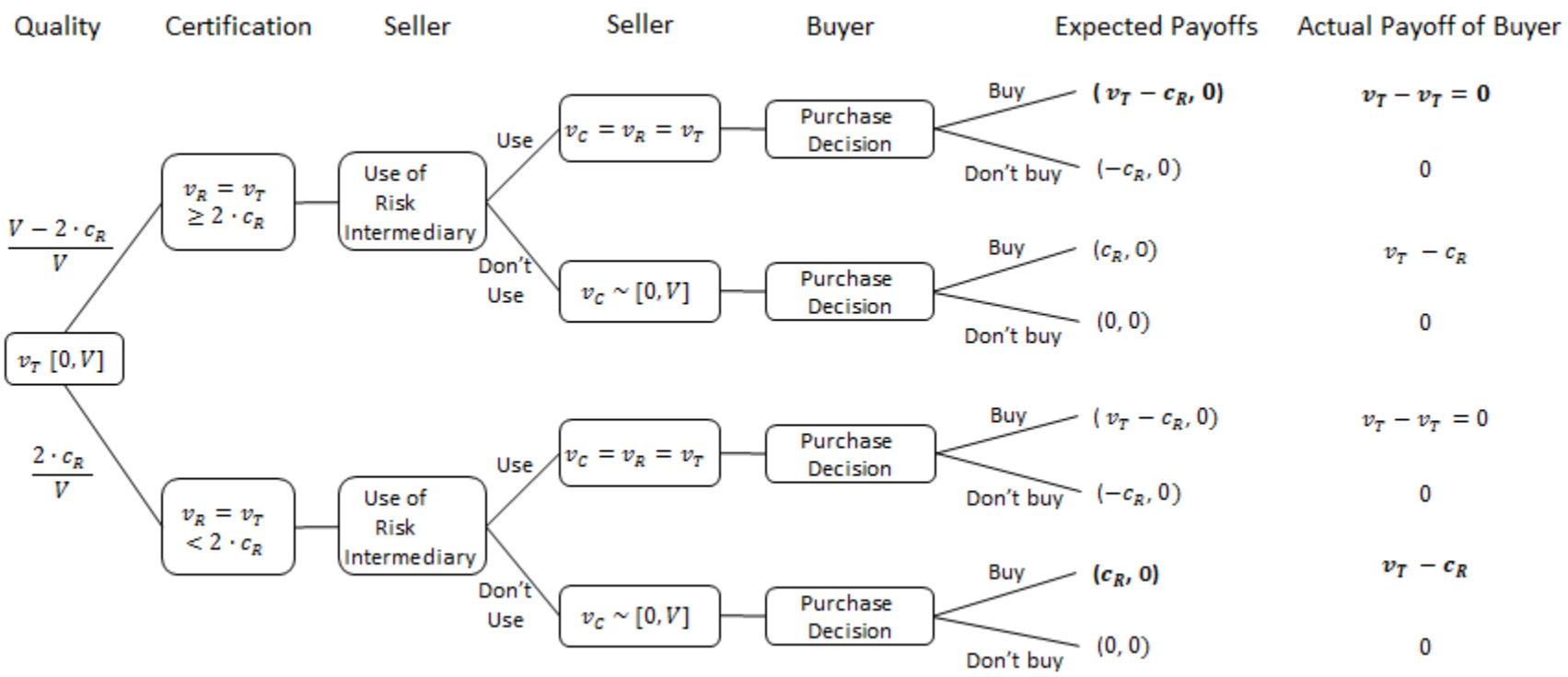
If we assume that both sellers and buyers are strategic and iterate this cognitive process infinitely, then the maximum amount of v_T when a seller does not show the certification can be calculated as the following.

$$\lim_{k=\infty} v_{MAX}^{k} = \lim_{k=\infty} \left[\left(\frac{1}{2}\right)^{k} \cdot V + \left\{ 1 - \left(\frac{1}{2}\right)^{k-1} \right\} \cdot c_R \; + \; c_R \right] = 2 \cdot c_R$$

Therefore, the buyer finally assumes that the range of true quality actually follows $U\,[0,\ 2c_R]$ when the seller does not show the certification. In this case, $E(v) = \frac{1}{2} \cdot 2c_R = c_R$ when the seller does not show the certification.

Figure 4.1 shows the game tree presenting this result. As the expected payoff for the seller is higher with certification shown when $v_T \geq 2c_R$, and higher without certification when $v_T < 2c_R$, the subgame perfect Nash equilibrium differs according to whether the true value of the product is higher than $2c_R$ or not. More specifically, when $v_T \geq 2c_R$, the subgame perfect Nash equilibrium is that a seller shows certification and a buyer purchases the product, and the seller receives $v_T - c_R$ and the buyer receives 0 from this equilibrium. When $v_T < 2c_R$, the subgame perfect Nash equilibrium is that a seller does not show certification and a buyer still purchases the product, and the seller receives c_R and the buyer receives $v_T - c_R$ from this equilibrium.

Figure 4.1: Game Tree of Market Outcomes when the Certification Is 100 Percent Accurate



4.2.2.1.2 Payoffs

From analyzing these equilibria, we can find the average payoff for sellers and buyers when there is 100 percent accurate certification as follows.

4.2.2.1.2.1 Average Payoff for Seller

$$\pi_S^{100\%} = \left(\frac{V - 2 \cdot c_R}{V}\right) \cdot \{ E(v_T \mid v_T \sim U[\, 2 \cdot c_R, V\,]) - c_R\} + \left(\frac{2 \cdot c_R}{V}\right) \cdot c_R$$

$$= \left(\frac{V - 2 \cdot c_R}{V}\right) \cdot \left(\frac{2 \cdot c_R + V}{2} - c_R\right) + \frac{2 \cdot {c_R}^2}{V}$$

$$= \frac{(V - 2 \cdot c_R) \cdot V}{2V} + \frac{2 \cdot {c_R}^2}{V}$$

$$= \frac{V^2 - 2 \cdot c_R \cdot V + 4 \cdot {c_R}^2}{2V}$$

4.2.2.1.2.2 Average Actual Payoff for Buyer

$$\pi_B^{100\%} = \left(\frac{V - 2 \cdot c_R}{V}\right) \cdot (v_T - v_T) + \left(\frac{2 \cdot c_R}{V}\right) \cdot \{E(v_T \mid v_T \sim U[0, 2 \cdot c_R]) - c_R\}$$

$$= 0 + \left(\frac{2 \cdot c_R}{V}\right) \cdot \left(\frac{2 \cdot c_R}{2} - c_R\right) = 0$$

4.2.2.2 The Market with 50 Percent Accurate Certification

4.2.2.2.1 Subgame Perfect Nash Equilibrium

When the certification is 50 percent accurate, the subgame perfect Nash equilibrium differs depending on the expected value of the product perceived by buyers. We have to consider strategic considerations of the buyer, just as we have done in the 100 percent certification case. We can calculate the actual $E(v)$ when sellers do not show the certification through the following process.

When the seller does not show the certification, the buyer first assumes that actual quality can be any value and thus follows $U\ [0,\ V]$. In this case, $E(v) = \frac{V}{2}$. Now the expected payoff for

the seller is $0.5 \cdot v_T + \ 0.25 \cdot V - c_R$ when he shows the certification, and $\frac{V}{2}$ when he does not show the certification. Therefore, the seller will show the certification if $0.5 \cdot v_T + \ 0.25 \cdot V - c_R > \frac{V}{2}$. In this case, the maximum amount of v_T when the seller does not show the certification now becomes $V - \frac{V}{2} + 2 \cdot c_R = \frac{V}{2} + 2 \cdot c_R$. Considering this, the buyer now assumes that the range of true quality actually follows $U\ \left[0,\ \frac{V}{2} + 2 \cdot c_R\right]$ when the seller does not show the certification. In this case, $E(v) = \frac{1}{2} \cdot \left(\frac{V}{2} + 2 \cdot c_R\right)$. Now, the seller shows the certification when $0.5 \cdot v_T + \ 0.25 \cdot V - c_R > \frac{1}{2} \cdot \left(\frac{V}{2} + 2 \cdot c_R\right)$. Therefore, the maximum amount of v_T when seller does not show the certification now becomes $V - V + 4\ c_R = 4\ c_R$. Again, considering this, the buyer now assumes that the range of true quality actually follows $U\ [0,\ 4\ c_R]$ when the seller does not show the certification. In this case, $E(v) = \frac{1}{2} \cdot \left(V - V + 4\ c_R\right) = 2\ c_R$. Now, the seller shows the certification when $0.5 \cdot v_T + \ 0.25 \cdot V - c_R > 2\ c_R$. Therefore, the maximum amount of v_T when the seller does not show the certification now becomes $V - 1.5V + 6\ c_R\ = -0.5V + 6\ c_R$.

If this process is iterated *k* times, then the maximum amount of v_T when the seller does not show the certification becomes

$$v_{MAX}^{k} = V - 0.5 \cdot k \cdot V + 2 \cdot k \cdot c_R = \ V - k \cdot (0.5 \cdot V - 2 \cdot c_R)$$

As $v_{MAX}^{k} \leq V$,

$$V - 0.5 \cdot k \cdot V + 2 \cdot k \cdot c_R \leq V$$

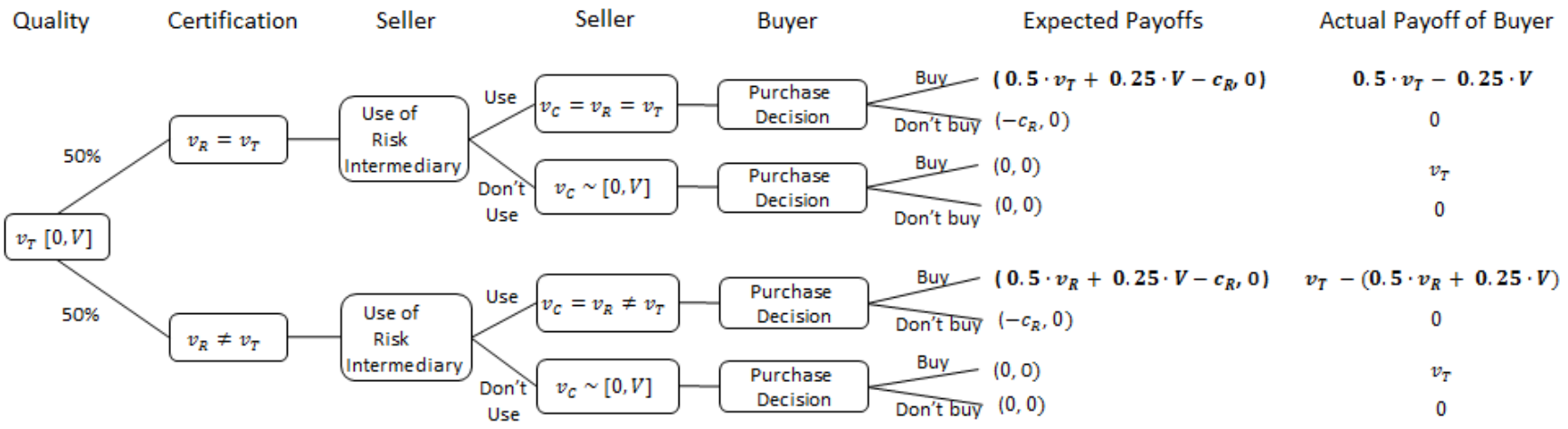
$$\therefore 0 \leq c_R \leq \frac{1}{4} \cdot V$$

Since $0.5 \cdot V - 2 \cdot c_R \leq 0$, v_{MAX}^{k} will converge to zero when this cognitive process repeats many times (i.e., as k increases). Therefore, the buyer finally assumes that the range of true quality when the seller does not show the certification is zero. In this case, the expected value when the seller does not show the certification has the following value:

$$E(v) = \frac{1}{2} \cdot 0 = 0$$

The game tree in Figure 4.2 explains this result. In this case, we consider two different cases according to whether the certification is showing the true quality or not. When the certification is showing the true quality ($v_R = v_T$), the expected payoff for a seller is higher with certification shown. Therefore, the subgame perfect Nash equilibrium is that a seller shows certification and a buyer purchases the product, and the seller receives $0.5 \cdot v_T + 0.25 \cdot V - c_R$ and the buyer receives $0.5 \cdot v_T - 0.25 \cdot V$ from this equilibrium. When the certification is not showing the true quality ($v_R \neq v_T$), the expected payoff for a seller is still higher with certification shown. Therefore, the subgame perfect Nash equilibrium is that a seller shows certification and a buyer purchases the product, and the seller receives $0.5 \cdot v_T + 0.25 \cdot V - c_R$ and the buyer receives $v_T - 0.5 \cdot v_R - 0.25 \cdot V$ from this equilibrium.

Figure 4.2: Game Tree of Market Outcomes when the Certification Is 50 Percent Accurate



4.2.2.2.2 Payoffs

From analyzing these equilibria, we can find the average payoff for sellers and buyers when there is 50 percent accurate certification as follows.

4.2.2.2.2.1 Average Payoff for Seller

$$\pi_S^{50\%} = 0.5 \times \{0.5 \cdot E(v_T \mid v_T \sim [\,0, V\,]) + 0.25 \cdot V - c_R\}$$

$$+ 0.5 \times \{0.5 \cdot E(v_R \mid v_R \sim [\,0, V\,]) + 0.25 \cdot V - c_R\}$$

$$= 0.5 \times (0.5 \cdot 0.5 \cdot V + 0.25 \cdot V - c_R) + \ 0.5 \times (0.5 \cdot 0.5 \cdot V + 0.25 \cdot V - c_R)$$

$$= \frac{1}{2} \cdot V - c_R$$

4.2.2.2.2.2 Average Actual Payoff for Buyer

$$\pi_B^{50\%} = 0.5 \times \{0.5 \cdot E(v_T \mid v_T \sim [\,0, V\,]) - 0.25 \cdot V\}$$

$$+ 0.5 \times \{E(v_T \mid v_T \sim [\,0, V\,]) - 0.5 \cdot E(v_R \mid v_R \sim [0, V\,]) - 0.25 \cdot V\}$$

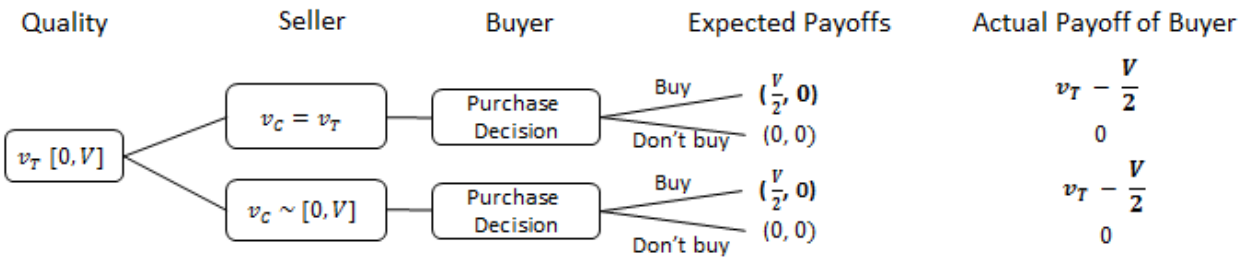
$$= 0.5 \times \{0.5 \cdot 0.5 \cdot V - 0.25 \cdot V\} + 0.5 \times \{0.5 \cdot V - 0.5 \cdot 0.5 \cdot V - 0.25 \cdot V\} = 0$$

4.2.2.3 The Market Without Certification

4.2.2.3.1 Subgame Perfect Nash Equilibrium

When there is no certification, a seller simply charges $\frac{V}{2}$ and a buyer purchases it, and the seller receives $\frac{V}{2}$ and the buyer receives $v_T - \frac{V}{2}$, as is shown in Figure 4.3.

Figure 4.3: Game Tree of Market Outcomes Without Certification



4.2.2.3.2 Payoffs

From this market outcome, we can find the average payoff for sellers and buyers when there is no certification as follows.

4.2.2.3.2.1 Average Payoff for Seller

$$\pi_S^{No\ Certification} = \frac{V}{2}$$

4.2.2.3.2.2 Average Actual Payoff for Buyer

$$\pi_B^{No\ Certification} = E(v_T \mid v_T \sim [\,0, V\,]) - \frac{V}{2}$$

$$= \frac{V}{2} - \frac{V}{2} = 0$$

4.2.3 Predictions

The result of the analysis can be summarized as in Table 4.1.

Table 4.1: Payoffs for Sellers and Buyers

	Average Payoff for Seller	Average Actual Payoff for Buyer
Certification is 100% accurate	$\frac{V^2 - 2 \cdot c_R \cdot V + 4 \cdot {c_R}^2}{2V}$	0
Certification is 50% accurate	$\frac{1}{2} \cdot V - c_R$	0
There is no certification	$\frac{1}{2} \cdot V$	0

From this result, we can come up with the following implications about the profit of sellers and buyers according to the accuracy of certification.

4.2.3.1 Seller's Profit

First, the relationship between the payoff under 100 percent certification and under 50 percent certification is as follows.

$$\pi_S^{100\%} - \pi_S^{50\%} = \frac{V^2 - 2 \cdot c_R \cdot V + 4 \cdot {c_R}^2}{2V} - \frac{1}{2} \cdot V + c_R$$

$$= \frac{V^2 - 2 \cdot c_R \cdot V + 4 \cdot {c_R}^2 - V^2 + 2 \cdot V \cdot c_R}{2V}$$

$$= \frac{4 \cdot {c_R}^2}{2V} = \frac{2 \cdot {c_R}^2}{V} \geq 0$$

Therefore, the payoff for a seller under 100 percent certification is higher than the payoff for a seller under 50 percent certification.

Second, the relationship between the payoff under 50 percent certification and no certification is as follows.

$$\pi_S^{50\%} - \pi_S^{No\ Certification} = \frac{1}{2} \cdot V - c_R - \frac{1}{2} \cdot V = -c_R \leq 0$$

Therefore, the payoff for a seller under 50 percent certification is lower than the payoff for a seller under 0 percent certification.

Third, the relationship between the payoff under 100 percent certification and no certification is as follows.

$$\pi_S^{100\%} - \pi_S^{No\ Certification} = \frac{V^2 - 2 \cdot c_R \cdot V + 4 \cdot {c_R}^2}{2V} - \frac{1}{2} \cdot V$$

$$= \frac{V^2 - 2 \cdot c_R \cdot V + 4 \cdot {c_R}^2 - V^2}{2V}$$

$$= \frac{-c_R \cdot V + 2 \cdot {c_R}^2}{V} = \frac{c_R \cdot (2 \cdot c_R - V)}{V} \leq 0$$

$$(\because 0 \leq c_R \leq 0.25 \cdot V)$$

Therefore, the payoff for a seller under 100 percent certification is always lower than the payoff for a seller under no certification.

From this result, we can find the relationship between payoffs for sellers as follows:

$$\frac{1}{2} \cdot V \geq \frac{V^2 - 2 \cdot c_R \cdot V + 4 \cdot {c_R}^2}{2V} \geq \frac{1}{2} \cdot V - c_R$$

$$\therefore \pi_S^{No\ Certification} \geq \pi_S^{100\%} \geq \pi_S^{50\%}$$

Therefore, the analytic model predicts that the payoff for sellers without certification is the highest, and the payoff for sellers with 100 percent certification is higher than the payoff for sellers with 50 percent certification. We can see that the major factor explaining this difference is the cost of certification (c_R), as the seller profit will be the same in all three conditions if the cost of certification is zero (i.e., if $c_R = 0$). We believe this originates from the assumptions that buyers are all risk-neutral and that sellers and buyers are strategic. More specifically, a strategic and risk-neutral buyer considers the cost of certification when predicting the seller behavior and calculating the expected value of the product, and a strategic seller maximizes profit by charging the highest price possible according to the buyer's expected value. Therefore, the cost of certification affects both the seller's information disclosure and the buyer's expected value calculation, ultimately leading to a decrease in seller's profit when certification is available. Moreover, as 50 percent certification causes more uncertainty than 100 percent certification in terms of predicting the effect of certification cost, the seller's expected profit is lower with 50 percent certification than with 100 percent certification. This explains why seller profit is the highest with no certification and the lowest with 50 percent certification.

4.2.3.2 Buyer's Profit

As is shown in Table 4.1, the payoff for a buyer will always be zero regardless of the accuracy of certification (i.e., $\pi_S^{100\%} = \pi_S^{50\%} = \pi_S^{No\ Certification} = 0$) when sellers can charge flexible price up to the buyer's expected payoff and maximize their profits. Again, this is because we assume that buyers are all risk-neutral and both sellers and buyers are extremely strategic.

4.3 Experimental Analysis

4.3.1 Outline

We now observe the behaviors of sellers and buyers under information asymmetry using incentive-based economic experiments. Our experiments attempt to test the predictions from the model regarding the impact of the noise of certification on various market outcomes such as the profit of the seller and the buyer and the level of information disclosure. As is explained above, this method has several advantages that are especially helpful to the research question of this study. First, we can actually observe the level of information disclosure with this method, as we have information about both the true quality of products and the seller's claimed quality. Although understanding the actual level of information disclosure is important in the related studies, there have rarely been similar attempts to examine it. As our economic experiments can accurately measure the level of information disclosure, it provides some important implications regarding sellers' behavior under information asymmetry. This is, to the best of our knowledge, the first study of certifications and information disclosure that employs an economic laboratory experiment and observes whether the seller fully discloses or not. Second, as the participants of the experiment have actually been paid cash rewards according to how they perform in the business deals during the experiment sessions, we believe it can reproduce the actual decisions of buyers and sellers in real market settings. Therefore, the results of the experiments are expected to provide us with useful observations regarding the behavior of sellers and buyers under information asymmetry.

4.3.2 Procedure

The participants consist of 58 undergraduate students at a private university located in one of the major cities in the U.S.. The participants were given a course credit for participating in

the experiments, and cash rewards were also provided at the end of the experiment sessions according to their performances. We have conducted three experimental sessions in total and 18 to 20 subjects have participated in each session. Within each experimental session, three treatment conditions—a market without certification, a market with 50 percent accurate certification, and a market with 100 percent accurate certification—have been tested. We have varied the orders of treatments for each different session to avoid any bias from carryover effect. The first session starts with no certification and ends with 50 percent certification, the second session starts with 50 percent certification and ends with 100 percent certification, and the third session starts with 100 percent certification and ends with no certification. Each treatment consists of 15 decision rounds, and thus each subject participated in 45 decision rounds in total, providing 2,610 observations of buyer and seller decisions from 1,305 transactions in total. For each decision round, we have randomly and anonymously assigned the subjects into the roles of buyers and sellers and matched them in a pair, and observed their decisions to maximize their profits under various certification types. The matching procedure was repeated every round, and the participants were re-matched with another player for each of the 45 decision rounds. Moreover, the roles of the participants were also randomly switched. In other words, each participant played a role of either buyer or seller for every different decision round. The experiments were implemented using z-Tree software (Fischbacher 2007). Before beginning the experiments, we loudly read the instructions with the participants and help them understand the procedure. We also provided two practice decision rounds for every treatment (i.e., six practice rounds in total for each participant) so that participants could get used to the decision-making procedure and their payoff structure before beginning actual experiments.

For the experiment, we have set the maximum quality level of the product as 180 (i.e., $V = 180$), and the cost of certification as 20 (i.e., $c_R = 20$). We have intentionally set the cost of certification to stay within the boundary condition of the model ($0 \leq c_R \leq 0.25 \cdot V$) but not to be too low, as the model shows that if the effect of certification cost is very low, then the impact of certification will not differ much across different treatments. We have not indicated the type of the product to avoid any potential bias related to a specific product category. The final cash rewards for the participants were calculated by converting the sum of their points for the 45 decision rounds at a rate of $1.00 per every 100 points.

Each decision round starts with the seller offering an item to the matched buyer and ends with the buyer choosing whether to purchase the item. Before offering an item, the seller first observes its true value randomly assigned between 0 to 180, where each number between 0 and 180 has an equal chance of being drawn by the software. After observing the true value of the item, the seller chooses to certify the value when the certification is available, or just announces the value without certification, and the cost of 20 is incurred when the seller certifies the value, which is deducted from the participant's points. The seller then chooses the price of the item that will be offered to the buyer between 0 and 180 in decimals up to two places. Upon receiving the information about either the certified value or the announced value of the item and the price, the buyer chooses whether to purchase the item at the price offered by the seller or not. The buyer does not know the true value before purchase but only observes either the certified or announced value, and the certified value can be either equal to true value or not depending on the types of certification (i.e., according to whether the certification is 100% or 50% accurate).

4.3.3 Payoff Calculation

The seller's points in each round are calculated as follows. If the seller chooses to certify and the buyer purchases the item, then the seller's points is equal to *price – 20* (certification cost). If the seller chooses to certify and the buyer does not purchase the item, then the seller's point is equal to *-20*, which is lower than zero. If the seller chooses not to use certification and the buyer purchases the item, then the seller's point is equal to the *price*. If the seller chooses not to use certification and the buyer does not purchase the item, then the seller's point is equal to *zero*. Therefore, the seller's points increase with a higher price as long as the buyer purchases the product. However, the seller also needs to consider whether the buyer will purchase the product or not.

The buyer's points in each round are calculated as follows. If the buyer purchases the item, then the buyer's point is equal to the *true value – price*. Note that the true value, not certified or announced value, determines the buyer's points. If the buyer does not purchase the item, then the buyer's point is equal to *zero*.

4.4 Experimental Results

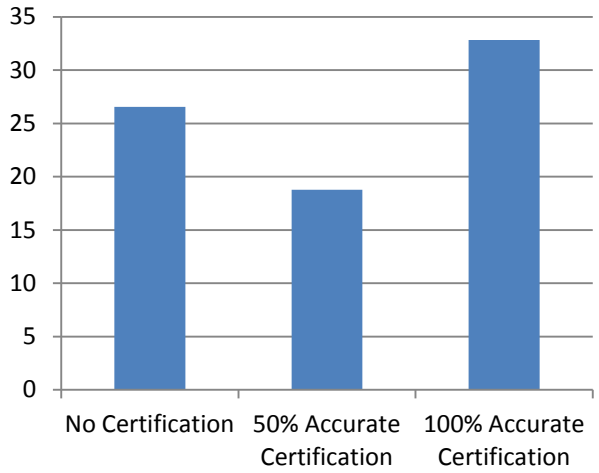
The experimental analysis has provided us with 2,160 observations of buyer and seller's decisions in 1,305 individual transaction rounds in total. We now analyze the behaviors of sellers and buyers observed from the experiment by investigating the profit of sellers and buyers, the level of information disclosure, and other empirical regularities. As the participants in the study make multiple decisions, we cluster the standard errors at the subject level in all following statistical analysis to control potential within-subject correlation.

4.4.1 Seller's Profit

4.4.1.1 Primary Observation

We first observe sellers' average profits across three different conditions of certification. The result shows that sellers have earned 26.55, 18.76, and 32.81 on average when there is no certification, when the certification has 50 percent accuracy, and when the certification has 100 percent accuracy, respectively. This result is also presented in Figure 4.4.

Figure 4.4: Average Profit of Sellers Across Three Conditions



The ordinary least square (OLS) regression of seller's profit on certification types shows that the observed impact on seller profit is significant, as the seller profit is significantly higher with no certification than with 50 percent certification (p = 0.005), and significantly higher with 100 percent certification than with no certification (p = 0.025), as is shown in Table 4.2. Therefore, this result is only partially consistent with the model prediction. First, the model predicts that seller profit with 50 percent certification will be the lowest, and the experimental result is consistent with this prediction. However, although the model predicts that seller's profit will be lower with 100 percent certification than with no certification, the experimental results show that the seller profit is actually the highest with 100 percent certification. Therefore, we

now try to understand the reason for this discrepancy between the model and actual behavior of seller and buyer, by exploring what actually drives the profit for 100 percent certification, and why the profit is the lowest with 50 percent certification.

Table 4.2: Regression of Seller's Profit on Certification Types

(# obs. = 1,305)	Coefficient	Standard Errors	*z*-stat.	*p*-value
Constant (Base=No Certification)	26.47	2.141	12.37	0.000
50% Accurate Certification	-7.74	2.780	-2.79	0.005
100% Accurate Certification	6.24	2.779	2.25	0.025

4.4.1.2 Profit Variation Conditional on Purchase

Now, we attempt to compare the profit across three conditions conditional on whether a buyer makes a purchase or not, in order to figure out what is actually driving the profit variation. The regression results are shown in Table 4.3. We can find some interesting observations about the patterns in seller profit here. First, when buyers do not make purchase, the profit is highest with no certification (p = 0.000), but the profits from 100 percent certification and 50 percent certification do not differ from each other (p = 0.175). This is consistent with the explanation from the analytic model: as sellers have to pay the certification cost even when buyers do not purchase the product, the profit should be higher with no certification than with certification when buyers do not purchase the product. Second, when buyers do make purchase, the seller profit is not significantly different across all three conditions (p = 0.051 and 0.875). This is a somewhat surprising result, as sellers do not seem to make more profit with more accurate certifications. So the regression conditional on purchase shows that the absolute level of profit from purchase does not contribute to the overall profit difference, while the cost of certification does make the profit under no certification higher than the other cases, when buyers do not

purchase. Therefore, we can conclude that there should be some factors that drive the profit variation found across three conditions, other than the absolute size of profit conditional on purchase.

Table 4.3: Regression of Seller's Profit on Certification Types Conditional on Purchase

	Coefficient	Standard Errors	*z*-stat.	*p*-value
Conditional on No Purchase (#obs. = 686)				
Constant (Base=50% Accurate Certification)	-8.66	0.554	-15.64	0.000
No Certification	8.67	0.688	12.59	0.000
100% Accurate Certification	1.02	0.748	1.36	0.175
Conditional on Purchase (#obs. = 619)				
Constant (Base=No Certification)	63.09	3.199	19.72	0.000
50% Accurate Certification	-6.93	3.558	-1.95	0.051
100% Accurate Certification	0.52	3.312	0.16	0.875

4.4.1.3 Purchase Probability

4.4.1.3.1 The Effect of Purchase Probability

As the absolute size of profit does not contribute to the variation in overall profit, we can guess that purchase probability might be the reason behind profit differences across three conditions. We now check this conjecture with some statistical analysis. We first run a logistic regression of purchase probability on certification types, and the result is shown in Table 4.4. The result provides an important finding, as the purchase probability of a 100 percent certification case is significantly higher than other cases ($p = 0.000$), while the purchase probability between no certification and 50 percent certification is not different ($p = 0.945$). Therefore, buyers make purchases much more frequently when the certification available is 100

percent accurate than when it is 50 percent accurate or when there is no certification, but buyers' purchase incidences do not differ between when the certification is 50 percent accurate and when there is no certification. As we have also found from previous analysis that the size of profit when buyers make purchases does not differ across all three conditions, we can conclude from this result that what drives the variation in seller profit is actually the impacts of different certification types on purchase probability. In other words, seller profit is the highest with 100 percent certification as buyers purchase products much more frequently than with 50 percent certification or no certification.

Table 4.4: Regression of Purchase Probability on Certification Types

	Coefficient	Standard Errors	*z*-stat.	*p*-value
Constant (Base=No Certification)	-0.31	0.110	-2.83	0.005
50% Accurate Certification	0.01	0.140	0.07	0.945
100% Accurate Certification	0.60	0.140	4.29	0.000

obs. = 1,305

Therefore, this also provides some clues on why the prediction from the analytic model is different from experimental results. The model anticipates that buyers will always purchase the product as sellers will always offer a price that is lower than the expected value. As it turns out that buyers do not always make a purchase and purchase probability systematically varies with respect to the certification accuracy, we can think of the following reasons regarding the discrepancies between the model prediction and experimental results. First, the buyer's reaction to the seller's suggested price and claimed value might differ from the model assumption as they are not homogenous in terms of risk sensitivity and there are risk-sensitive buyers in the market. Therefore, some buyers do not purchase even when the expected value is higher than the suggested price because of risk sensitivity, and therefore purchase probability should actually

differ across different certification types. It is also consistent with the findings from Essay 1 that the distribution of customers' risk sensitivity provides the incentive for low-type sellers to disclose quality information. Second, although the model assumes that both sellers and buyers are strategic and consider the other player's potential reaction when making decisions, it may be possible that they are not that strategic and only use limited cognitive processes. Therefore, it is possible that sellers cannot fully understand buyers' expected value as buyers are not very strategic either. Hence, with 50 percent certification, this effect of bounded rationality can be the highest as there are a lot more uncertainties in both buyers' and sellers' behavior, resulting in the lowest profit for sellers. Based on this understanding, we explore more about seller and buyer behavior under information asymmetry.

4.4.1.3.2 Factors Affecting Purchase Probability

As purchase probability is found to be the main driver of seller profit, we now investigate what is then affecting purchase probability in each of three cases, in order to more accurately understand the effect of certification on seller and buyer behavior.

No certification case. We first run a logistic regression of purchase probability on various factors when there is no certification. As is shown in Table 4.5, when there is no certification, purchase probability is significantly affected by the suggested price ($p = 0.000$), but claimed value does not have a significant effect ($p = 0.17$). Therefore, when there is information asymmetry but no certification mechanism is available, then buyers only decide to purchase based on the price of the item. This is consistent with the model assumption that buyers only assume the average value and do not regard the seller's claimed value as important when there is no certification. In other words, any quality claim is "cheap talk" when there is no certification mechanism available.

50 percent certification case. We then run a logistic regression of purchase probability on various factors when there is 50 percent certification. As is shown in Table 4.5, when there is 50 percent certification, purchase probability is significantly affected by the claimed value (p = 0.012), suggested price (p = 0.000), and whether certification is used by the seller (p = 0.000). Among these factors, whether the seller has used certification or not has a dominant effect on purchase probability. Therefore, buyers will purchase more when the claimed value is higher, the price is lower, and the seller offers certification. Again, this result is inconsistent with the model prediction, as the model predicts that the buyer will always purchase the product as sellers offer the product at a price lower than the expected profit of the buyer. As is explained, we believe that some of the reasons for the discrepancy are the existence of risk-sensitive buyers and incomplete strategic considerations of buyers and sellers.

100 percent certification case. Now we run a logistic regression of purchase probability on various factors when there is 100 percent certification. As is shown in Table 4.5, when there is 100 percent certification, purchase probability is significantly affected by the claimed value (p = 0.000), suggested price (p = 0.000), and whether certification is used by the seller (p = 0.000). Among these factors, whether the seller has used the certification or not has a dominant effect on purchase probability. Therefore, when there is 100 percent certification available, buyers will purchase more when the claimed value is higher, the price is lower, and the seller offers certification. This result is again inconsistent with the model result as the model predicts that the buyer will always purchase the product since sellers will sell the product at a price lower than expected profit of the buyer. Again, we believe that possible reasons for the discrepancy are the existence of risk-sensitive buyers and incomplete strategic considerations of buyers and sellers.

Table 4.5: Regression of Purchase Probability on Various Factors

	Coefficient	Standard Errors	*z*-stat.	*p*-value
No Certification (#obs. = 435)				
Claimed value	0.01	0.004	1.37	0.170
Suggested price	-0.26	0.005	-5.43	0.000
50% Certification (#obs. = 435)				
Claimed value	0.01	0.005	2.51	0.012
Suggested price	-0.03	0.006	-4.56	0.000
Use of certification	1.53	0.254	6.03	0.000
100% Certification (#obs. = 435)				
Claimed value	0.02	0.005	4.16	0.00
Suggested price	-0.04	0.007	-5.52	0.000
Use of certification	3.44	0.359	9.56	0.000

4.4.1.3.3 Comparison of the Factors Affecting Purchase Probability

The preceding analysis on the factors affecting purchase probability has shown that claimed quality, suggested price, and whether to use certification all affect buyers' purchase decisions. Therefore, we now compare those factors across three conditions to understand what makes the differences in purchase probability.

Claimed quality. One interesting aspect of claimed quality is the possibility that a quality claim without certification is regarded as "cheap talk" by buyers. As is discussed above, Jin and Kato (2006) have shown that some sellers actually overstate their quality claims and buyers trust them, showing that the quality claim without certification actually has significant impact on buyer decisions in the baseball card market. Essay 2 has shown similar findings, as the quality

claim without certification actually increases potential demand level in the baseball card market. However, Essay 2 has also found that claims without certification have not affected the demand in the collectible coin market, meaning that those claims are regarded as "cheap talk." Therefore, it is interesting to see that whether a quality claim without certification is "cheap talk" in our case. Although the analysis of the no certification case above shows that quality claims of sellers do not affect purchase probability, we haven't checked the same effect for 50 percent and 100 percent certification cases. Therefore, we run additional regressions for 50 percent and 100 percent certification, using those transactions where no certification is used. According to Table 4.6, when no certification is used, the seller's claimed value does not affect the decision to purchase in both the 50 percent and the 100 percent certification cases (p = 0.802 and 0.997, respectively). Therefore, we can say that any claim without certification always works as "cheap talk" in all three conditions in our data.

Table 4.6: Regression of Purchase Probability When Certification Is Not Used

	Coefficient	Standard Errors	*z*-stat.	*p*-value
50% Certification (#obs. = 253)				
Claimed value	0.001	0.006	0.25	0.802
Suggested price	-0.02	0.008	-2.80	0.005
100% Certification (#obs. = 149)				
Claimed value	-0.00002	0.006	-0.00	0.997
Suggested price	-0.011	0.009	-1.34	0.181

Suggested price. We also try to check whether sellers charge different prices to buyers in different certification conditions. For this analysis, we first define two new variables regarding a seller's pricing policy. The first variable is consumer surplus, which is defined as *true product*

value – suggested price. In order to consider the scale effect from the size of true value, we define the second variable, surplus ratio, as *surplus ÷ true product value*. After creating these variables, we run OLS regressions of these price variables on different certification conditions. The result in Table 4.7 shows that the seller's pricing scheme does not differ with respect to the certification types. More specifically, consumer surplus with no certification is same with 50 percent certification (p = 0.991) and 100 percent certification (p = 0.424) cases, and the surplus ratio is also same across different certification types (p = 0.657 and 0.367). Therefore, we can see that pricing policy is not the main driver of the difference in the seller's profit.

Table 4.7: Regression of Consumer Surplus on Certification Types

	Coefficient	Standard Errors	*z*-stat.	*p*-value
Regression of Surplus (True Value – Suggested Price) (#obs. = 1,305)				
Constant (base=no certification)	13.29	2.03	6.54	0.000
50% accurate certification	0.03	2.87	0.01	0.991
100% accurate certification	-2.29	2.87	-0.80	0.424
Regression of Surplus Ratio (Surplus/True Value) (#obs. = 1,298)				
Constant (base=no certification)	-0.55	0.18	-3.05	0.002
50% accurate certification	-0.11	0.25	-0.44	0.657
100% accurate certification	0.23	0.25	0.90	0.367

Frequency of using certification. The analysis above has shown that whether a seller has used certification or not is a dominant factor in a buyer's decision to purchase. Therefore, we attempt to compare the frequency of certification usage between 50 percent certification and 100 percent certification cases by observing the logistic regression results of the probability of using certification. According to Table 4.8, sellers with 100 percent certification use certification much

more frequently than sellers with 50 percent certification ($p = 0.000$).[18] As the seller's claimed quality without certification is "cheap talk" and does not affect purchase probability and suggested price is also the same across all conditions, we can conclude that the frequency of using certification is the main driver of the difference in purchase probability between the 100 percent case and the 50 percent case.

Table 4.8: Regression of the Probability of Using Certification on Certification Types

(#obs. = 870)	Coefficient	Standard Errors	*z*-stat.	*p*-value
Constant (Base=50% Accurate Certification)	-0.36	0.14	-2.59	0.010
100% Accurate Certification	1.10	0.15	7.27	0.000

4.4.1.4 Summary

Overall, the analysis has found various interesting patterns about seller profit under different certification conditions. First of all, seller profit is the highest with 100 percent certification and the lowest with 50 percent certification, unlike the predictions from the analytic model. Our analysis shows that seller profit does not differ across three cases when buyers purchase the product, while the no certification case brings the highest profit when buyers do not purchase the product because of the certification cost. We have also shown that the difference in profit is caused by purchase probability rather than the absolute size of profits. Moreover, while purchase probability is driven by claimed quality, price, and certification usage, the only factor that is significantly different between different certification conditions is the frequency of certification usage.

[18] Based on this result, we also run another regression of the probability of using the certification in the 50 percent certification case and find that sellers use 50 percent certification more frequently when the actual value of the product is higher ($p = 0.000$).

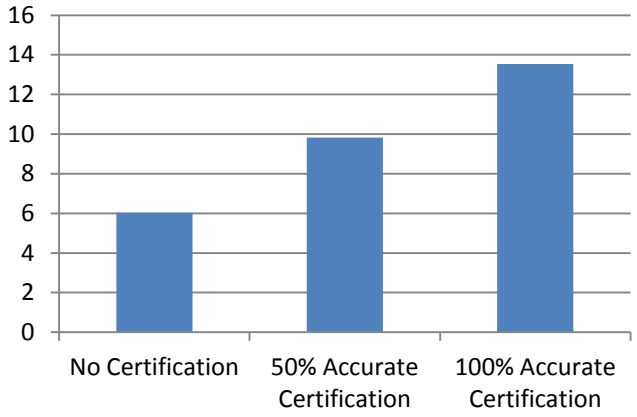
Therefore, from this analysis, we can conclude that sellers with 50 percent certification do not use certification as often as sellers with 100 percent certification, and this leads to both lower purchase probability and lower seller profit in the 50 percent case. On the other hand, sellers with 100 percent certification use certification a lot more frequently and thereby have higher purchase probability than the no certification case and the 50 percent certification case, which also leads to the highest seller profit among all three conditions. This empirical result also provides some self-explanation of why the results deviate from model prediction, as the overlooked factors such as bounded rationality of sellers and buyers or the existence of risk-sensitive buyers may be related to the fact that the purchase probability is generally much higher with the certification shown and that sellers with 50 percent certification do not use certification as often as sellers with 100 percent certification. Therefore, future research can extend this analytic model to relax those assumptions and come up with more feasible predictions.

4.4.2 Buyer's Profit

4.4.2.1 Primary Observation

We observe buyers' average profits across three different conditions of certification. The primary observation shows that buyers have earned 6.92, 9.82, and 13.54 on average when there is no certification, when the certification has 50 percent accuracy, and when the certification has 100 percent accuracy, respectively. This result is presented in Figure 4.5.

Figure 4.5: Average Profit of Buyers Across Three Conditions



We run an OLS regression of buyer's profit on certification types and find that the above mentioned impact of certification types on buyer profit is significant, as it is significantly higher with 50 percent certification than with no certification (p = 0.048), and significantly higher with 100 percent certification than with 50 percent certification (p = 0.050), as is shown in Table 4.9. Therefore, unlike the model finding that buyer profit will all be same and zero, experimental results show that buyer profit is always positive and different across certification types. We believe the positive profit originates from the fact that sellers do not actually charge maximum price to buyers as assumed in the model. We have actually found from observing the variables created in **4.4.1.3.3** (surplus and surplus ratio) that the seller's suggested price is generally lower than true value and thus consumer surplus is always positive on average across all conditions. Therefore, the model assumption that sellers will charge maximum price is not actually feasible in real market settings. In the next section, we also explore the reason why buyer profit shows varying patterns across three conditions.

Table 4.9: Regression of Buyer's Profit on Certification Types

(# obs. = 1,305)	Coefficient	Standard Errors	*z*-stat.	*p*-value
Constant (Base=50% Accurate Certification)	9.80	1.37	7.14	0.000
No Certification	-3.77	1.91	-1.98	0.048
100% Accurate Certification	3.73	1.91	1.96	0.050

4.4.2.2 Profit Variation Conditional on Purchase

When buyers do not purchase, their profit will always be zero. Therefore, here we run a separate regression of buyer profit on the condition that buyers have made purchases, in order to understand what drives the variation in buyers' profit. The results from Table 4.10 shows that when buyers purchase the product, buyer profit is significantly lower with no certification case than with 50 percent or 100 percent certification ($p = 0.025$) cases, and the buyer profit is not different across 50 percent and 100 percent cases ($p = 0.769$). Therefore, the buyer gets more profit from purchase when there is certification of any type than when there is no certification. The fact that buyer profit from purchase is actually the same between the 50 percent case and the 100 percent case is also supported by the finding from the analysis on the level of information disclosure in a following section. More specifically, we also analyze whether sellers fully disclose quality information across all three conditions and find that the seller's level of dishonesty is same across the 50 percent certification case and the 100 percent certification case, but it is the highest with no certification. This may explain why buyer profit does not differ between 50 percent and 100 percent conditions, but is lower with no certification, when they make purchases. We explain more about the level of dishonesty in the following section.

Table 4.10: Regression of Buyer's Profit on Certification Types When Purchased

(# obs. = 619)	Coefficient	Standard Errors	*z*-stat.	*p*-value
Constant (Base=50% Accurate Certification)	23.06	2.92	7.89	0.000
No Certification	-8.82	3.94	-2.24	0.025
100% Accurate Certification	1.08	3.69	0.29	0.769

As there is no profit difference across three conditions when buyers do not make a purchase, and the profit is also the same across 50 percent and 100 percent certification cases when buyers make a purchase, we can conclude that the difference in buyer profit between 50 percent certification and 100 percent certification is again due to the fact that the purchase probability is significantly higher with 100 percent certification than with other two cases. Therefore, the findings from the section **4.4.1.3** about various factors affecting purchase probability can also be applied to explain the variation in buyer profit.

4.4.2.3 Summary

When buyers make purchases, the case of no certification gives them the smallest profit, possibly due to incomplete information disclosure (explained in the next section), and 100 percent certification gives the highest profit as buyers purchase most frequently in this case. This is why buyer profit is the highest with 100 percent and the lowest with no certification.

4.4.3 Level of Information Disclosure

Buyer profit from purchase may depend highly on whether the seller has made full disclosure or not, since buyers cannot evaluate the actual value of the product before purchase and only make decisions based on the seller's claimed value. Therefore, if a seller has made less

than full disclosure and overstate the quality, the buyer's actual profit from purchase should be lower than the case where the seller has made full disclosure.

As is mentioned, one interesting aspect of our economic experimental method is that we can actually observe the level of information disclosure as we know both the true value of the product and the seller's claimed value. Therefore, we have created a new variable measuring the level of dishonesty of the sellers by subtracting true quality from the seller's claimed quality based on the understanding that if the seller's claimed quality is higher than the true quality, then the seller is not fully disclosing quality and being dishonest. The regression result of dishonesty level on certification types is shown in Table 4.11. In this regression, we have also controlled for the true value of the product.

The results show that sellers exaggerate the quality significantly more when certification is not available ($p = 0.041$). However, the level of information disclosure is not significantly different between 50 percent certification and 100 percent certification ($p = 0.924$). In other words, sellers tend to disclose more if there exist any types of certification mechanism in the market regardless of its quality, while they tend to bluff more if there is no certification available. This also explains the result from **4.4.2** that buyer profit from purchase is significantly lower with no certification but does not differ between 50 percent and 100 percent certification. As sellers tend to fully disclose with certification regardless of the accuracy, buyer profit is also higher with any types of certification conditional on purchase.

Table 4.11: Regression of Dishonesty on Certification Types

(# obs. = 1,305)	Coefficient	Standard Errors	*z*-stat.	*p*-value
Constant (Base=50% Accurate Certification)	58.79	3.11	18.89	0.000
No Certification	4.78	2.33	2.05	0.041
100% Accurate Certification	-0.22	2.33	-0.10	0.924
True Value of the Product	-0.47	0.02	-25.75	0.000

4.4.4 Other Empirical Findings

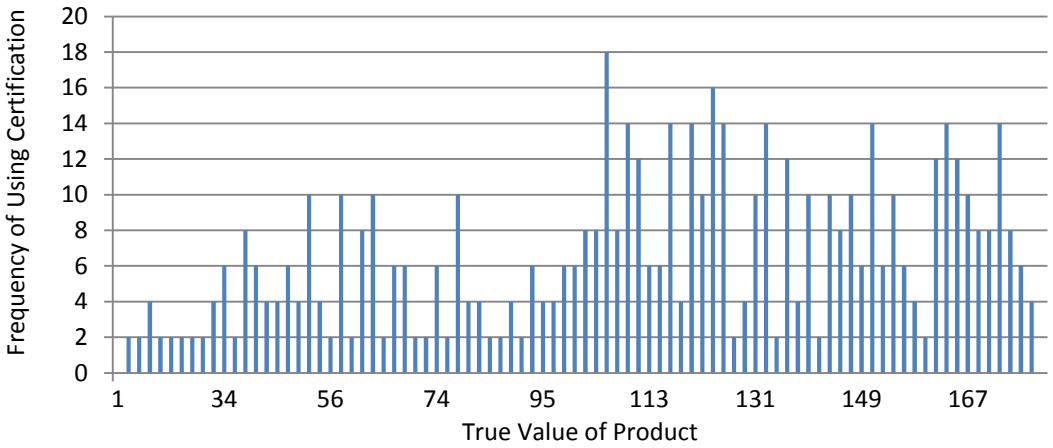
Other than checking the main predictions of the model about seller profit and buyer profit and explaining the discrepancy between model and experimental results, the data also provides many other interesting findings, some of which we explore in the following sections.

4.4.4.1 Certification Cost as Threshold

One of the analytic model's main assumptions is that certification cost affects the behavior of sellers and buyers, and it actually is the main driver explaining the difference in seller profit across three conditions. The model has also predicted that, when there is 100 percent accurate certification available, sellers will use certification when the true value is higher than two times the value of the cost of the certification (i.e., $2c_R$). We try to check if the threshold actually exists in the data. First, we run a simple logistic regression of the usage of 100 percent certification on whether true value is higher than the threshold level, which is 40 in this case. The results shows that sellers uses the certification significantly more often if the true value is higher than 40. However, this does not mean that the threshold level is 40, and we have also plotted the frequency of certification usage with respect to the true value of the product in Figure 4.6. Although we can see that sellers use certification more with higher product value, we cannot

confirm that there is a clear threshold level in terms of the certification cost. Future research may consider more about the threshold level and its implications for certain market outcomes.

Figure 4.6: Frequency of Certification Usage (with 100% Accurate Certification)



4.4.4.2 Social Welfare

We have found from the previous analysis that seller profit shows the following pattern: 100 percent > no certification > 50 percent, while buyer profit shows the following pattern: 100 percent > 50 percent > no certification. Based on these results, we can also measure the level of entire social welfare. We thus create welfare variable by adding seller profit and buyer profit from each transaction and run a regression of this variable on the types of certifications. The result in Table 4.12 shows that the entire social welfare is the highest with 100 percent certification, but does not differ between 50 percent certification and no certification. This provides some interesting policy implications, as inaccurate certification does not seem to increase the entire social welfare since it provides the lowest seller profit, although it is shown to at least increase buyer profit. Therefore, if a new certification mechanism is being considered for an industry where there is no certification system available, they should carefully consider the quality of the certification as inaccurate certification may decrease entire social welfare, when

considering the cost to establish a new certification system. However, it should help to introduce this noisy certification, if the principal purpose is to increase consumer welfare.

Table 4.12: Regression of Social Welfare on Certification Types

(# obs. = 1,305)	Coefficient	Standard Errors	*z*-stat.	*p*-value
Constant (Base=50% Accurate Certification)	28.52	2.78	10.25	0.000
No Certification	4.07	3.69	1.10	0.270
100% Accurate Certification	17.69	3.68	4.80	0.000

4.4.4.3 Irrational Behaviors

The experimental results also provide some interesting findings regarding the behaviors of sellers and buyers. We can observe some irrational behaviors from the experimental results that are not consistent with the basic assumptions of economics that individuals maximize utility. Here we investigate those irrational behaviors of sellers and buyers.

4.4.4.3.1 Lower Claimed Value of Sellers

While we have analyzed the degree of dishonest claims above, we can also find some odd decisions of sellers regarding their claimed value of products. In 166 out of 1,305 total transactions, we can observe that sellers actually claim the value as lower than the actual value. This does not seem like a logical decision, as a high claim is generally regarded as the way to attract more customers or increase purchase probability, and even when the seller is being honest with good intentions, he does not have to claim lower than actual value.

The reason for this irrational behavior can be presumed as follows (For this analysis, we only observe the cases when sellers do not use the certification or there is no certification available). First, some sellers may believe that, when without certification, claiming too high

quality may discount the trustworthiness of the claim ("too good to be true"), especially when the actual product quality is high. Therefore, sellers with higher-quality products may want to lower their claims when there is no certification or they do not use certification. Our statistical analysis supports the claim and shows that it is significantly more likely for sellers to claim lower than true quality as true quality gets higher, in 100 percent certification (p = 0.000), 50 percent certification (p = 0.000), and no certification (p = 0.000) cases. Second, sellers may also claim lower than actual quality when they decide to increase purchase probability with lower price. As price is found to be a significant factor affecting purchase probability when without certification, sellers may want to decrease price and also lower the quality claim in order to make their pricing strategy more trustworthy. This is also supported by our statistical analysis, as it is significantly more likely for sellers to claim lower than true quality as their suggested price gets lower, in 100 percent certification (p = 0.002), 50 percent certification (p = 0.000), and in no certification (p = 0.000) cases. Therefore, while it may look pointless for sellers to claim lower than actual quality, there are possibly several logical reasons behind this irrationality.

4.4.4.3.2 Abandonment of Buyer Profit

We also observe irrational decisions of buyers, as some buyers abandon obvious profit during the experiments. More specifically, when there is 100 percent certification and sellers show the certification, buyers also have the correct information about the true value of the product before purchase. However, even when buyers know that the suggested price is lower than the true value, in some cases they have not purchased the product and abandoned obviously certain profit. Among the 271 transactions where sellers show 100 percent certification and the suggested price is lower than actual value, 55 buyers (20.3%) do not purchase the product. This seems absurd as these buyers could have increased their profit by simply purchasing the products.

We believe that this is due to the fact that they regard fairness as more important than profit in certain cases, as they do not want to help sellers who offer only a very small amount of buyer surplus. For example, among the 29 transactions where consumer surplus is less than 5, 15 buyers (51.7%) decide not to purchase the item. Our statistical analysis also supports this claim, as lower consumer surplus has a significant impact on increasing buyer's irrationality ($p = 0.000$). One interesting fact is that buyers can actually punish those stingy sellers by not purchasing their products, as sellers have to pay the certification cost regardless of buyer's purchase decisions. For some buyers, those punishments might have mattered much more than earning small profits.

4.4.5 Robustness Check of Previous Models

We have also run some robustness checks for our empirical analysis in Essay 2 by running similar regressions with our experimental data. Although Essay 2 has used number of bidders as the dependent variable and run a count data regression, we instead use purchase probability as the dependent variable and run a logistic regression to check whether those variables in Essay 2 again show significant effects with this data. The results from Table 4.13 shows that most of the key variables from Essay 2 have also shown the same significant effects in the experimental data. Whether the seller uses the certification or not, claimed value, and suggested price are all significant in the basic models for both the 50 percent certification and the 100 percent certification cases. Moreover, the interaction effects in the alternative specification are also all significant in both the 50 percent and the 100 percent cases. These results suggest that the empirical results from Essay 2 are feasible in our experimental data, and the findings of Essay 2 regarding the economic incentive for low-type sellers to disclose quality information are all robust and authentic. Moreover, the significance of the interaction effect shows that the

asymmetric effect of certification also exists in our experimental data and thus sellers with higher than average quality gain more from revealing weaknesses.

Table 4.13: Regression of Previous Model Specifications with Experimental Data

	50% Certification				100% Certification			
	Basic Model		Alternative Model		Basic Model		Alternative Model	
Dummy for Certification Usage	1.529	***	0.117		3.435	***	1.714	***
	(0.254)		(0.561)		(0.359)		(0.635)	
Claimed Value	0.012	**	0.006		0.023	***	0.018	***
	(0.005)		(0.005)		(0.005)		(0.006)	
Suggested Price	-0.028	***	-0.029	***	-0.037	***	-0.046	***
	(0.006)		(0.006)		(0.007)		(0.008)	
Interaction Between Certification Usage and Claimed Value	N/A		0.014	***	N/A		0.019	***
			(0.005)				(0.006)	
Observations	435		435		435		435	
Chi-squared	46.8	***	49.14	***	92.5	***	86.45	***
d.f.	3		4		3		4	

* p<0.1.
** p<0.05.
*** p<0.01.

4.5 Discussion

In this essay, we have tried to determine the effect of noisy certification on various market outcomes such as seller profit, buyer profit, and the level of information disclosure. The analytic model has predicted that seller profit will be the lowest with 50 percent certification and the highest with no certification mostly due to the certification cost, and that buyer profit will always be zero. This is somewhat surprising result as certification helps neither sellers nor buyers, suggesting that there is no need to use certification in a market with information asymmetry when we consider the certification cost. However, our experimental analysis has shown different results and suggested that there should be more factors determining the effect of certification on market outcomes than certification costs. We have come up with the following observations.

First, the seller profit is actually the highest with 100 percent certification and the lowest with 50 percent certification. The reason behind this pattern is twofold. Seller profit is highest with 100 percent certification because buyers purchase more frequently with 100 percent certification than with 50 percent or no certification. Seller profit is also the lowest with 50 percent certification as sellers have to pay for the certification cost although buyers do not purchase more with 50 percent certification than with no certification. Second, buyer profit is the highest with 100 percent certification and the lowest with no certification. This is again due to the fact that buyers purchase more frequently with 100 percent certification, and that the level of the seller's dishonesty is much higher with no certification. In other words, buyer profit is the lowest with no certification because sellers exaggerate the quality more (i.e., are more dishonest) than when certification of either type is available.

Therefore, we have found that inaccurate certification does not help sellers, as it provides the lowest profit. On the other hand, inaccurate certification actually helps buyers, as sellers disclose more information even with inaccurate certification and thus buyer profit is higher than with no certification. Sellers thus might want to have either a highly accurate certification or no certification at all, as inaccurate certification is worse than no certification. However, it is different for buyers, as even an inaccurate certification mechanism would help buyers by providing higher profit. In terms of a public policy point of view, we have found that overall social welfare increases only with 100 percent certification, and 50 percent certification does not really affect social welfare compared with no certification. Therefore, policy makers or other third-party certification providers should carefully consider the quality of the certification system before introduction, as inaccurate certification may actually decrease entire social welfare, especially when considering the cost to establish the new system. This essay also provides

specific strategies for marketing managers on how to deal with information asymmetry in markets. When there is no certification available in a market under information asymmetry, it is better for sellers to focus on pricing strategy then on overstating the quality, as the quality claim is not trusted by buyers ("cheap talk"). When there is certification available, using the certification and disclosing more information contributes a lot toward increasing the profit regardless of its accuracy, since any quality claim without certification does not affect buyer behavior ("cheap talk," again), and the use of certification significantly increases purchase probability. Other than these main findings, this essay has also provided various interesting implications about market outcomes under information asymmetry, such as the effect of certification on social welfare and irrational behaviors of sellers and buyers. We have also confirmed that the findings of Essay 2 are replicated with our experimental data.

Overall, the findings from the analytic model and the experimental analysis agree that an inaccurate certification does not help sellers as much as an accurate certification does, and is even worse than no certification. This finding is somewhat counterintuitive, as people believe that certification generally helps sellers, and it may be able to provide some important implications to certain sellers who attempt to manipulate the certification system to increase short-term profit, as any noise added to the certification system will eventually work against the sellers. The result of this essay that it is better for everyone (i.e., both sellers and buyers) to have a solid and accurate certification system is consistent with the findings from Essay 1 in that the certification may provide economic incentives for sellers to fully disclose quality information and increase social welfare. Moreover, the variation in the effects of different certification systems found from this essay may also provide an explanation about the empirical results of Essay 2 where the economic incentive for information disclosure differs across different product

categories. Future research may extend the findings from this essay and provide more evidence regarding the effect from the noise of the certification on various market outcomes by exploring other observational market data.

5. CONCLUSION

This dissertation has provided a framework for understanding information asymmetry in markets by verifying the economic incentives for low-type sellers to fully disclose their types through analytic models, experimental analysis, and market data analysis. This study has attempted to achieve this goal by focusing on how risk intermediaries such as third-party certifications can reduce perceived risk of customers and encourage sellers to voluntarily reveal weaknesses, and provided several important findings.

Essay 1 has explained whether, when, and how a low-type seller's information disclosure can enhance the seller's profitability and also increase the market demand through an analytic model and experiments. Essay 2 has confirmed the predictions of Essay 1 by comparing the economic incentives for disclosing and concealing low-quality information through the sales data of various collectible items. This essay has also shown that voluntarily revealing weakness is more effective when sellers are selling products of higher than average quality than when they are selling products of lower than average quality, and that the incentive for information disclosure differs across different market circumstances. Essay 3 has explicitly investigated the effect of the certifications of different qualities on various market outcomes through an analytic model and an economic experiment, and shown that an inaccurate certification is worse than no certification for sellers but beneficial to buyers. This essay has also found that using the certification and disclosing quality information is the best strategy to increase profit under information asymmetry. With these results, this dissertation is expected to present an important theoretical basis and empirical evidences to solve various market dilemmas under information

asymmetry. This study also supports the literature on voluntary disclosure as the findings suggest that mandatory disclosure or government intervention might not be necessary to solve adverse selection issues in markets.

Therefore, this dissertation aims to contribute to both academia and industry with important implications ranging from the analysis of "lemons" markets to regulatory policies about market frauds, as this is one of the first attempts to analyze the economic incentives for low-type sellers to voluntarily reveal their types and understand how to design optimal certifications, to the best of our knowledge. For researchers, this dissertation may provide new explanations about some market phenomena under information asymmetry that have not been fully understood so far, such as why some online sellers do not restrict negative product reviews posted by customers. For managers, this dissertation provides specific guidelines about how to communicate weaknesses of their products and services, by showing how and when voluntarily disclosing low quality benefits the seller. The universality of this dissertation makes the findings applicable to most market situations, as no product or service is perfect in customers' eyes and sellers always have to deal with unfavorable information about their product or services. For example, as for the firms mentioned in the introduction of this dissertation, automobile manufacturers might want to share the information about accurate MPG but instead release related documents or videos of their mileage tests at the same time as "certifications" of quality, and olive oil sellers can also frankly and explicitly communicate the actual grades of their oils and provide customers opportunities to fully evaluate the product. This dissertation may even provide some implications to certain non-market settings such as public policies, political campaigns, and personal communications, because of the universality in the contexts used in the analysis. After all, this dissertation suggests that the most effective strategy under information

asymmetry is not to conceal weaknesses, but to employ appropriate risk-reduction methods and fully disclose the truth. Honesty might be the best policy.

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