Warranty, Seller Reputation, and Buyer Experience*

Xiaogang Che† Hajime Katayama‡ Peter Lee§ Nan Shi¶

Abstract

Using data from the eBay car auction market, we test several predictions related to warranty, seller reputation, and buyer experience in determining the final prices. The existence of a warranty significantly generates a price premium, but the magnitude decreases when the seller has a more established reputation. Further, in contrast to private sellers, professional dealers, who are the 'repeated-game players' in the market, benefit less from a warranty, and moreover its substitutability for seller reputation becomes insignificant. In addition, a more established buyer with greater experience is willing to pay less for a warranty or for a professional dealership.

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†Durham University Business School, UK. E-mail: xiaogang.che@durham.ac.uk.
‡Faculty of Commerce, Waseda University, Japan. E-mail: hajime.katayama@waseda.jp.
§Quantitative Middle Office, Deutsche Bank, USA. E-mail: peter-c.lee@db.com.
¶Shanghai Academy of Social Sciences, China. E-mail: shinan@sass.org.cn.

1 Introduction

Information asymmetry, one of the most serious 'frictions' in markets, reduces confidence in trading between sellers and buyers. Owing to this importance, an extensive amount of literature has discussed the use of different market-signaling instruments to signal the quality of products and services and to improve trading opportunities. However, most of the previous studies have only looked at the signaling effects of a single instrument. Because of this, a host of fundamental questions remain unanswered, such as, how do the instruments substitute for one another when there exist multiple signaling instruments? How does such substitutability differ across different types of sellers? How do buyers, especially those with different levels of market experience, respond to the existence of multiple signaling instruments?

Among market signaling instruments, the most discussed are seller reputation and warranty. Briefly, 'reputation' can be interpreted as a summary of the historical performance of a seller, and 'warranty' is a guarantee that is issued to a buyer by the seller as a promise to repair or replace the product within a specified period of time. In this study, we investigate several hypotheses related to how warranty, seller reputation, and buyer experience determine buyers' willingness to pay in an online auction market. Studying the impacts of these two signaling instruments and evaluating their heterogeneous effects not only allows us to assess and anticipate what sellers and buyers will gain and lose as a result of the signaling mechanisms, but it can also help us better understand the relationships between different signaling instruments (mechanisms), providing insights into the questions above. Furthermore, such knowledge can aid in the design of marketplaces, providing useful implications for the creation of reputation rating systems as well as information disclosure policies.

The first question is whether buyers respond significantly to the presence of a warranty, as a product-quality signal, in determining equilibrium prices, and how the price premium from a warranty changes with varying levels of seller reputation. Surprisingly, despite an enormous body of research on warranty, only a handful of studies have empirically examined the price premium from a warranty in internet auctions, and they have reported equivocal results[1]. Our study therefore attempts to provide additional evidence on the price premium resulting from a warranty in internet auctions. Seller

[1]For example, Lewis (2011) finds that the prices of cars with warranties are 5.9% greater than those without warranties in the eBay Motors auction market, while the effect of warranty is not statistically significant in eBay auctions of used comic books (Dewally and Ederington, 2006).

reputation, on the other hand, has been broadly studied as a quality signaling strategy in online markets [2]. Therefore, it is natural to ask whether warranty and seller reputation can substitute for one another. Such substitutability remains largely unexplored in the literature; to the best of our knowledge, only one previous paper has examined seller reputation together with warranty and addressed the issue of substitutability. Using data from an online tractor auction market, Roberts (2011) empirically shows that a market-level warranty, provided by the maker in the form of a 'guaranteed or your money back' promise, cannot substitute for an individual seller's reputation, either in determining price or the probability of a sale. In contrast, our data include detailed warranty information at the individual-item level, allowing us to provide further insight into the abovementioned questions.

Second, we investigate whether private sellers benefit more from the signaling effect of warranty than professional sellers, and further, how the substitutability of warranty for seller reputation changes across the two seller types. As will be explained, our data allow us to observe whether the seller is a professional dealer or a private seller. The former is more like a 'repeated-game player' in the market who has a higher incentive to maintain a good reputation, while the latter can be interpreted as a 'one-shot player' who incurs a relatively low cost when reputation is damaged. This therefore provides a great opportunity to empirically examine the validity of a well-known theoretical prediction that when repeated interactions are possible in the market, the 'friction' from information asymmetry can be eliminated or at least mitigated and will therefore not significantly affect a buyer' willingness to pay.

Lastly, we turn to the buyer side. Intuitively, buyer experience plays an important role in determining willingness to pay for a product in a market. Moreover, the more experience a buyer has, the better the buyer will be at estimating the quality of the product. This further implies that signaling instruments like warranty, seller reputation, etc. would have less of an effect on willingness to pay when a buyer has more experience in the market. Whether this statement is true is the third question we attempt to answer. In particular, we examine how buyers with different levels of market experience respond to the presence of a warranty and to the seller being a professional dealership.

In this paper, we first frame our empirical hypotheses using a simple auction model involving bidding strategies and seller revenues. We then test these hypotheses using data from U.S. eBay, one of the biggest internet auction houses in the world. eBay

[2] See a brief literature review in Section 2.

provides a well-designed system for rating reputation, called a feedback score. A participant's feedback score, which is the cumulative record of all comments provided by partners in previously completed transactions, can be used as a proxy for market experience and reputation. Generally, a seller with a higher feedback score has a better reputation, while a buyer with a higher feedback score has more market experience. The data comprise 9005 sold car auction listings that are well-suited for our study. In each completed auction listing, we can observe detailed information about the car, warranty status, and transaction history (e.g., number of entering bidders and bids), and sellers' and buyers' feedback scores. Such information allows us to measure not only the effects of a warranty on auction prices and buyers' entry and bidding behavior, but also the effects of seller reputation and buyer experience.

Our empirical analysis is based on a 'quasi-experimental' approach, which was first introduced by Elfenbein and McManus (2010) and can be briefly stated as follows[3]: auction listings in the sample are matched into groups with the same combination of seller identity, car body type, and starting price (rounded to the nearest thousand) but with variation in terms of warranty status[4]. The advantage of matching sellers' identities and similar car features is that it helps control for unobservable seller heterogeneity and idiosyncratic characteristics in the listings, and therefore can be used to more precisely identify the impact of a warranty on buyers' bidding strategies (willingness to pay) and the final prices of auctions.

Our findings show that the presence of a warranty in an auction listing leads to a significant increase in the final price, thereby indicating that buyers positively respond to the presence of a warranty. The interaction term between warranty and seller feedback score, which is used to measure the 'substitutability,' is negative and significant for the determination of the auction prices, demonstrating that these two signaling mechanisms can indeed substitute for each other. More interestingly, this substitutability varies across different seller reputation levels. Sellers in the lowest feedback score quartile enjoy a price premium that is approximately 24 percent greater in auctions with a warranty than without a warranty. However, this benefit decreases as the seller's feedback score increases; on average, auctions with a warranty result in almost no price

[3]This approach has been widely used to investigate a variety of interesting research questions in the related literature. See Elfenbein, Fisman, and McManus (2012), who apply the same identification approach to investigate the impacts of charity in auctions; Einav, Farronato, Levin, and Sundaresan (2013) and Einav, Kuchler, Levin, and Sundaresan (2015) for the analyses of the performance of different selling strategies; and Elfenbein, Fisman, and McManus (2015) for the value of quality certifications of sellers in eBay online markets.

[4]In Section 4 we will provide our matching strategy in detail.

premium for sellers who are in the highest feedback score quartile.

We then find that, in contrast to professional dealers, the presence of a warranty has a greater effect on private sellers, who are more likely to be involved in one-time selling in the market, consistent with the theoretical view that information asymmetry becomes a more serious issue when the trading is a one-time purchase. Further, this signaling effect from warranty decreases when private sellers have better reputations; the final price decreases by around 15 percent when the seller feedback score increases by 1 percent. For professional dealers, this substitution between warranty and seller feedback score is not significant. Our finding implies that a warranty's impact is amplified for sellers who have not yet had the chance to prove their reliability to potential buyers through publicly observable information, i.e., feedback score or being a professional dealership.

We further find that the interaction terms of these two variables with the buyer feedback score are negative and significant, showing that an increase in buyer experience lowers the values of warranty and professional dealership. In other words, a more experienced buyer would rely less on signaling mechanisms to determine his or her willingness to pay.

The remainder of the paper proceeds as follows: Section 2 provides a brief review of the related literature. We describe the car auction environment on eBay in Section 3, and provide the data description in Section 4. We then offer a simple theoretical model to frame our empirical hypotheses in Section 5. In Sections 6 and 7, we present our main empirical analyses. Section 8 concludes the study.

2 Related Literature

We first provide a brief introduction for the rationale behind providing a warranty. Thereafter, we review the recent development of online marketplaces and the related reputation systems, and then discuss the contributions of our research to the literature.

In the literature of economic theory, different theoretical models have been developed to explain the prevalence of warranties in markets[5]. The existing theoretical literature since Spence (1977), which explores the impacts of warranties, focuses mainly on quality signaling. Matthews and Moore (1987) consider signaling effects of warranties

[5]See a survey by Murthy and Djamaludin (2002).

within a more complicated trading environment, in which warranties have multidimensional interactions with other selling strategies like price discrimination, bundling, etc. Lutz (1989) shows that warranties can be used to signal the quality of products when there exists information asymmetry between sellers and consumers[6]. In addition, several other papers have proposed different explanations for the prevalence of warranties in markets. For example, Heal (1977) argues that when there exists uncertainty about the quality of a product or a service, a warranty can be used as insurance by sharing the risk between consumers and sellers. Kubo (1986) examines the impacts of warranties when consumers are heterogeneous, and shows that warranties can work as a price-discrimination mechanism, in which consumers choose appropriate warranty plans according to their different income levels.

To the best of our knowledge, only a few empirical studies have looked at the effects of warranties on buyer demand and seller revenue. Specifically, Dewally and Ederington (2006) examine comic book sales in eBay auctions and find that the price of a comic book with a warranty is not statistically different from that without a warranty. In contrast, Lewis (2011) provides evidence that the presence of a warranty brings about a significant increase in the final price in the eBay Motors auction market, although warranty is not the main focus of the study. Recent work by Choi and Ishii (2010) uses data from a survey on new automobiles to investigate the impact of manufacturer-provided power train warranties in automobile markets. Their empirical results show that consumers significantly value a warranty as a signal of the unobservable quality of products. Other prior studies examine warranty with different scopes. For example, Douglas, Glennon, and Lane (1993) use survey data and examine whether a warranty induces lower quality of repair services ex-post in a less competitive automobile market. Gill and Roberts (1989) attempt to investigate the correlation between the quality of sellers and their willingness to offer a warranty.

Starting with Shapiro (1983), many researchers have theoretically analyzed the relationship between transaction price and seller reputation, with the main conclusion being that sellers with a better reputation should obtain a price premium, as reputation signals good product quality. With the development of online markets in the last two decades, a great deal of empirical research on online reputation systems has been conducted. Almost all of those studies are based on eBay's reputation system and mainly examine whether empirical observations are consistent with the theoreti-

[6]See the related studies by Courville and Hausman (1979); Grossman (1981); Gal-Or (1989); Mann and Wissink (1990); Shieh (1996); Balachander (2001), for example. For a survey, see Emons (1989).

cal predictions[7].

The review of the two strands of literature suggests that prior empirical studies have rarely examined the effect of a warranty on the final price, not to mention the interaction effect with seller reputation. By addressing these issues, we attempt to provide further insight into the determination of final prices in internet auctions. In this sense, our study can be seen as a complementary study to that of Roberts (2011), who focuses on the substitutability of market-wide warranty policies for the individual seller's reputation. Further, our study not only empirically illustrates the relationship between warranties, seller reputation, and buyer experience, but also advances the large and well-developed literature on information asymmetry and adverse selection in markets. In doing so, it aids our understanding of how sellers and buyers can utilize alternative signaling mechanisms to reputation to remedy non-observability in terms of the quality of products and the reliability of sellers. In this sense, our study complements prior studies in the field. By using eBay car auctions, Lewis (2011) provides empirical evidence that sellers benefit from disclosing more information in the market, i.e., a greater number of photos. Elfenbein, Fisman, and McManus (2012) show that sellers without an observable record of previous performance can utilize charity donations as an alternative signaling mechanism to reputation and to accelerate the speed of reputation development. Elfenbein, Fisman, and McManus (2015) study the value of sellers' quality certifications on sales and how a certification system can reduce uncertainty regarding quality in online markets.

Our study also contributes to the new and growing literature on reputation system design in online marketplaces (see Li and Xiao (2014); Cabral and Li (2015), for example). In order to maintain performance, an online marketplace as a pure market intermediary needs to consider designs for both information disclosure and a reputation rating system, as well as the associated responses of sellers and buyers. Our research complements previous research on online reputation systems, showing that a reputation rating system is of benefit for improving trading opportunities. Nonetheless, online marketplaces should continually innovate and improve signaling mechanisms that involve different seller types and buyer experiences in order to help market participants build up trustworthiness.

[7]See the related studies by Eaton (2002); Lucking-Reiley, Bryan, Prasad, and Reeves (2007); McDonald and Slawson (2002); Melnik and Alm (2002); Resnick, Zeckhauser, Swanson, and Lockwood (2006); Livingston (2005); Houser and Wooders (2006), Li (2010), Bolton, Greiner, and Ockenfels (2013), for example.

3 eBay Car Auction Market

In this section, we briefly describe the auction mechanism, sellers' choices, and the reputation system used in the eBay automotive market.

Auction mechanism. As a central market organizer, eBay provides a platform for sellers and buyers to trade items. The standard eBay auction format is a variant of a second-price auction with a specified ending time. This fixed ending time is pre-specified by sellers, with options of 1, 3, 5, 7, or 10 days. Besides auctions, sellers can use a variety of other mechanisms to sell their items. For example, sellers can use fixed price offers in the auction listings, called 'Buy-It-Now' options, which give bidders a chance to obtain the items by paying pre-specified prices before any bids are made. The option disappears after the auction listing receives a qualified bid, after which the standard bidding process begins.

eBay also provides other options that enable sellers to customize their listings. An optional starting price, for example, plays the same role as a public reserve. A secret reserve can also be set, and bidders are informed about whether it has been met during the period of bidding competition. If the final auction price is less than the secret reserve, the seller does not need to commit to the transaction. Sellers can also choose delivery methods for the auction listing, mainly regarding who should pay for the delivery fees. After the auction listing becomes active, bidders can submit their bids. When the auction ends, the bidder with the highest bid wins the object, but only pays the maximum between the second highest bid and the starting price. If the auction has a secret reserve price, the second highest bid should be greater than the secret reserve price; otherwise, the seller does not need to commit to the sale.

When creating a listing, a seller needs to choose not only the auction settings mentioned above, but also how to describe the product for sale. In the eBay car auction market, the seller is required to provide some standardized and mandatory information in the listing, including whether they are a professional dealership, the make of car, body type, model, mileage traveled, production year, etc. In addition to that information, the seller can choose to add other details in the item description by using text, photos, graphs, etc. eBay may charge some fees for posting additional information above a certain limit. For example, if a seller wants to upload more than a certain number of photos, it costs $\$0.15$ per each additional photo.

Warranty information is one of the optional listing-level choices for sellers, made along

with other listing characteristics. eBay provides four options to indicate the warranty information for the car being listed: 'Existing warranty,' 'NO existing warranty,' 'Unspecified,' and 'Enter your own choice.' Notably, for the option of 'Enter your own choice,' the seller can enter a specific description of the warranty, such as how many miles and/or years the warranty protection covers. When warranty information is included in the listing, it will be visible in the 'Item specifics' section of the listing. In Section 4, we will discuss the warranty classification strategy used in our empirical analysis in greater detail.

Feedback rating system. eBay provides a feedback system to assess the transaction histories of sellers and buyers; this is designed to mitigate information asymmetry and commitment problems. For each completed transaction, the winning bidder rates the seller in the form of a positive $(+1)$, negative (-1), or neutral (0) response, and the seller can leave a positive $(+1)$ or neutral (0) response for the winning bidder. The feedback system mainly consists of two measures: feedback score and positive feedback percentage. Feedback score is the record of overall responses. The more trading experience a seller/buyer has on eBay, the higher the feedback score that buyer/seller will obtain. Positive feedback percentage is the percentage of positive responses out of the overall number of responses. Besides these two ratings, buyers can collect additional information on a seller's historical performance by reviewing the comments of buyers from previously completed transactions. Moreover, eBay recently introduced a new and further detailed rating system to measure the quality of a seller's services, which includes the sub-categories of 'Item as described,' 'Communication,' 'Shipping time,' and 'Shipping and handling charges.' Following most of the previous related studies, we focus on seller feedback score as the main measurement of seller reputation[8].

There are several advantages to using data from eBay's online auction markets. First, in contrast to offline marketplaces, the search procedure is almost 'frictionless' in online marketplaces, where sellers and buyers benefit from reductions in searching costs; that facilitates a more precise measurement of the signaling effects of different information-disclosure mechanisms. Second, having detailed information about each transaction allows us to use extensive controls in our regressions, eliminating the possibility of the main findings arising from idiosyncratic characteristics of agents that may induce systematic differences between auction listings with and without a warranty. Third, eBay's online marketplace provides detailed information regarding bid history, dealer-

[8]See further discussions from Rob and Fishman (2005) and Roberts (2011) on why it is appropriate to use the aggregate level of comments, like seller feedback score, as an accurate proxy for seller reputation.

ship status, and feedback ratings. In most existing studies, the prices being compared are typically fixed prices rather than transaction prices, which makes it difficult (and sometimes impossible) to identify the impacts of a warranty on the variability of transaction prices[9]. In our sample of auction listings, each auction attracted a reasonably large number of bidders (approximately 10 buyers per auction), and moreover, we can observe the bidding records of all bidders. Overall, these features of our sample help us more precisely measure changes in buyers' willingness to pay in the presence of a warranty and across different types of sellers. Furthermore, the well-organized rating system of eBay gives us chances to look closely at the relationships between warranties and seller reputation and buyer experience.

4 The Data

The data collected from the eBay Motors website include detailed information on car auction listings successfully completed between November 2014 and October 2016. We make several sample restrictions before conducting our analysis. We first eliminate listings for which sellers are not based in the United States. We then exclude observations with an unclear setting or missing data on the listing characteristics. We also drop those observations where the car is broken but some parts are available for sale. To measure the impact of a warranty more precisely, we also eliminate listings with unclear descriptions of warranty information, such as "407-832-1759 Don't Miss IT MAke Call NOW!"

For each sampled listing, we observe the characteristics of the car, including maker, body type, age, mileage, etc., as well as the characteristics of the auction listing, including warranty status, start price, 'Buy-It-Now' option (equal to 1 if the listing has the option, 0 otherwise), listing duration (days), number of photos, whether the auction has a secret reserve price, whether the car is sold through the 'Buy-It-Now' option (equal to 1 if the listing ends with the option, 0 otherwise), and who pays the shipping fees after the transaction. We also observe other listing information, including the seller's feedback score and positive percentage, the seller's geographical location (state level), professional dealership status, bid history, number of bidders, number of bids submitted by each bidder, start time, and end time of the listing. In this section, we will first illustrate how we classify the warranty in the sample and then describe

[9] See Chu and Chintagunta (2009, 2011), for example.

the matching strategy used in the analyses. Thereafter we will present the summary statistics.

Warranty classification. As described in Section 3, a seller can choose either to simply reveal whether the car has an existing warranty, or to provide specific information about the warranty. Because of this, auction listings in the sample exhibit substantial variation in terms of warranty content, including mileage, duration, power train, engine, transmission, or a combination of the preceding, and different types of warranties, like manufacturer-approved, extended, etc. In addition, in the eBay car auction market, a market-wide protection program called 'Vehicle Purchase Protection (VPP)' is included in each listing at no additional cost. The program provides protection 'up to $\$50,000$' for non-delivery of the vehicle, undisclosed defects in the title, and certain undisclosed defects in the vehicle. Although eBay states that the VPP program is not a warranty or a substitute for buyer diligence, this program effectively covers damage to major parts, including the engine, transmission, etc., and reimburses the lost amount if buyers submit the request within 45 days after the transaction is completed. In this sense, we may skew our sample toward auction listings that have warranties with longer specified time periods. However, this can be interpreted as a strength rather than a weakness in our analysis, since the existence of market-wide protection makes our analysis more likely to reflect the conscious behavior of buyers who understand the impacts of an individual-level warranty in transactions.

The usable data consist of 9005 cars successfully sold through auction listings, with 92150 bidders in total. The key variable of interest, the warranty, is classified as follows: the warranty dummy is equal to one if the auction listing indicates an 'Existing warranty' or includes any specified warranty information (e.g., '90 days,' '3-month warranty,' '10000 miles') or similar descriptions (e.g., 'only power train') under the option of 'Enter your own choice,' while it is equal to zero if the seller has chosen the option of 'No existing warranty' or 'Unspecified,' or has provided any information indicating the lack of a warranty (e.g., 'no warranty included') or similar descriptions (e.g., 'expired,' 'sold as is') under the option of 'Enter your own choice', or has left the section blank[10]. After the classification of all the car auction listings in the sample, approximately 52 percent have a warranty status equal to one, or 4668 auctions.

Matching strategy. Our 'quasi-experimental' approach consists of the following: we

[10]In Section 7, we will group warranties into different subcategories of 'days and miles,' 'warranty on car parts,' and 'existing warranty (including certified pre-owned warranty),' and will then separately examine their impacts on final price and the relationship with seller reputation.

match auction listings in our sample into groups based on the same seller identity, car body type, start price (rounded to the nearest thousand), but with variations in the warranty status. This results in each group having at least one auction listing with a warranty status equal to one, and at least one auction with a warranty status equal to zero. By doing so, the group-fixed effect helps us control for the idiosyncratic characteristics of sellers, e.g., some buyers may strictly prefer to purchase cars from professional dealers or from specific regions due to the consideration of shipping costs.

We now explain the definition of seller identity used in the matching process. Sellers in the eBay car auction market can be distinguished by their usernames. Thus, for professional dealers who normally sell multiple cars on eBay, we use their eBay usernames as identities. However, we cannot do the same for private sellers, as most only sell one car on eBay (approximately 81 percent of the private sellers in our sample list only one car). Instead, we use the combination of the private seller's geographic location (state level) and feedback score quartile as the private seller's identity. The reason for including private sellers' geographical locations is due to the fact that the shipping cost of a car, which is in addition to the price paid to the seller, is not negligible, and potential buyers must take it into account when submitting their bids.

Our analysis relies on the assumption that cars with the same body type and start price are substitutes. This assumption is not unreasonable for several reasons[11]. In eBay's car auction market, almost all of the auction listings are for used and well-traveled cars, and in the purchase guide 'What to Look for When Buying a Used Car Online' on the eBay Motors website, the first suggestion for potential buyers is that 'it is important to set up a budget before searching for a used car online.' Thus, it is very likely that the pool of buyers who are interested in purchasing in the market are more sensitive to price than brand. Furthermore, one of the main search algorithms on eBay Motors is 'shop by type,' which returns all of listings of the selected body type. This also indicates how potential buyers search the car listings.

Overall, this matching strategy minimizes the unobservable heterogeneity from auction characteristics and seller characteristics, while focusing on the systematic differences between auctions with and without a warranty, and the bidding behavior of buyers in response to the presence of a warranty.

Summary statistics. Table (1) presents the summary statistics for the full sample. On

[11]There is a large body of literature discussing the relationship between price sensitivity and brand loyalty, see Krishnamurthi and Raj (1991), and Allenby and Lenk (1995), for example.

average, the cars sold in the auction listings are relatively new but well traveled; the mean and the median car age are approximately 2.65 years and 3 years, respectively, and the mean and the median mileage are around 29040 miles and 22135 miles, respectively. The average listing duration is around 6.6 days, and approximately 94 percent of the auction listings require the winners to pay the shipping costs[12]. Around 23 percent of all auction listings have a secret reserve, and the auction listings include 15 photos on average. Since the auction format in eBay's auto market is second-price, the final price of a listing is equal to the maximum between the (public and/or secret) reserve price and the second-highest bid. Approximately 20 percent of the listings have a 'Buy-It-Now' option. If the listing is ended by a bidder exercising the 'Buy-It-Now' option, the final price is equal to the 'Buy-It-Now' price, which was predetermined by the seller. In the full sample, approximately 5 percent of all listings are sold through the 'Buy-It-Now' option. On average, each listing attracted 10 bidders and received around 30 bids during the bidding process.

In the full sample, there are 1000 professional dealers and 1333 private sellers, offering 7358 and 1647 car auction listings, respectively. Although professional dealers only make up around 43 percent of sellers in the sample, they share approximately 82 percent of auction listings. The sellers are well experienced, with mean and median feedback scores of 968 and 360, and most of them maintain a 100 positive feedback percentage, suggesting that they understand the rules of the marketplace and seller feedback rating system. As presented in Table (1), the professional car dealers (with mean and median feedback scores of 1151 and 473, respectively) have more experience than private sellers (with mean and median feedback scores of 151 and 93, respectively). In addition to the variables listed in Table (1), we can also observe the bid history for each auction listing, including bidders' names, time, and number of bids submitted by a bidder.

Following the matching criteria characterized above, we generate the matched sample. Of 9005 auction listings, only about 41 percent are matched into 206 groups. In the matched sample, there are 3722 auction listings and each group has 18 car auction listings on average. We provide the summary statistics of the matched sample in Table (2). In the sample, we observe that 3476 auctions matched into 130 groups are listed by

[12]Most eBay listings in other item categories, such as books, cell phones, computers, etc., charge flat fees or no fee for shipping within the United States. However, eBay car auctions are different from other item categories. In most cases, it is expensive to ship cars, especially across different states, and thus most car auction listings require the winners to pay the shipping fees – more than 97% in our sample. See Tyan (2005); Hossain and Morgan (2006); Brown, Hossain, and Morgan (2010) for analyses of the impact of shipping cost on prices and bidding behavior.

professional dealers. Listings from private sellers only make up a small proportion of approximately 7 percent of all matched auction listings, accounting for 246 auctions in 76 groups. Like the full sample, professional car dealers have more experience in the market (median feedback score of 641) than private sellers (median feedback score of 94).

In Table (A1) of the Appendix, we regress other auction variables that a seller can decide for an auction listing, including number of photos, secret reserve, duration, and shipping fees, on warranty and its interaction terms with professional dealerships and the natural log of seller feedback score. The results show almost no correlations between the warranty, the interaction terms, and the listing choices. Out of 8 regressions, only the correlation between the interaction term and duration is significant at the 10% level. This seems to suggest that warranty cannot be substituted by other auction choices.

5 An Illustrative Model

In this section, we construct a simple theoretical model to illustrate how warranty, feedback score (seller and buyer), and professional dealership status affect buyers' willingness to pay (bids) and seller revenue in a second-price auction. At the same time, we frame our empirical hypotheses based on the predictions of the theoretical model.

5.1 Warranty and seller reputation

Suppose a seller sells a single indivisible item by employing a second-price, sealed-bid auction. There are N risk-neutral bidders, where $1 < N < \infty$. The quality of the item is not revealed to the winner until after the transaction has taken place. This information asymmetry therefore causes uncertainty for all bidders. We assume here that there is the probability $p \in (0, 1)$ that the item is of high quality and all bidders' private values, denoted by v_i, $i = 1, 2, ..., N$, are independently drawn from a common, atomless distribution G over support $[0, \bar{v}]$, where $0 < \bar{v}$, $G(0) = 0$, $G(\bar{v}) = 1$, and $g \equiv G'$. There is the probability $1 - p$ that the item is of low quality and we assume that all bidders value the item as zero for convenience. To simplify the theoretical analysis, we

assume that the seller must sell the item and thus cannot set a reserve price [13]. The probability p depends on both the seller's feedback score (as a proxy for reputation), denoted by $F_s \in [0, +\infty)$, and warranty, denoted by $W \in \{0, 1\}$. The seller's feedback score F_s reflects their trading history and experience in the trading marketplace; the higher the seller's F_s, the more reliable and reputable the seller is and further, the more likely that the item is of high quality. Warranty is a binary choice variable for the seller; $W = 1$ if the item has a warranty, and $W = 0$ if the item does not have a warranty. Now treating F_s and W as continuous variables, we further assume that fix F_s, $p(F_s, W = 1) > p(F_s, W = 0)$, and $\partial^2 p(F_s, W)/\partial F_s \partial W < 0$. This reflects how warranty as a signal from the seller reduces uncertainty and makes the item more attractive. However, the negative cross derivative implies that the impact of warranty on the probability p decreases when the seller has a higher feedback score.

Now let us examine the equilibrium bidding strategy and seller revenue in the auction game. Bidders observing the seller's F_s and W then decide how much to bid, denoted by $b_i \in [0, +\infty)$. With the probability $p(F_s, W)$, the payoffs of a bidder i with private value v_i from submitting a sealed bid of b_i can be described as follows: $p(F_s, W)v_i - \max_{j \neq i} b_j$ if $b_i > max_{j \neq i} b_j$; otherwise, zero. It can be clearly seen that the equilibrium bidding strategy should be for the bidder to bid his 'true' value in the auction, that is,

$$b_i(F_s, W, v_i) = p(F_s, W)v_i. \tag{1}$$

Equation (1) shows that the amount a buyer is willing to pay (bid) in an auction depends on not only his private value but also the uncertainty parameter, which is determined by the seller's reputation and the warranty status. Based on the bidding strategy, the seller's expected revenue, denoted by $ER(F_s, W)$, can be stated as follows:

$$ER(F_s, W) = N(N-1)p(F_s, W) \int_0^{\bar{v}} v(1 - G(v))G(v)^{N-2} g(v) dv. \tag{2}$$

Equations (1) and (2) imply that $b_i(F_s, W, v_i)$ and $ER(F_s, W)$ increase when the item has a warranty, i.e., $W = 1$, and further, the effect of a warranty on $ER(F_s, W)$ decreases as F_s increases, i.e., $\partial^2 ER(F_s, W)/\partial F_s \partial W < 0$. Next, we will discuss the relationship between warranties and high-quality items. When an item is of low quality, the auction winner will realize after the transaction that the value of the item is zero, $v_i = 0$. This

[13] In fact, it is easy to show that our theoretical analysis and the following hypotheses are not affected when the seller can offer a reserve price (public and/or secret) in the auction.

can be interpreted as a 'product failure.' If the item has a warranty, it becomes costly for both the seller and the winner to repair or replace the item, and other associated costs also exist, such as time cost, cost of damage to seller's reputation, etc. However, this would not be true if the item is of high quality. Thus, in order to distinguish his products from low-quality items, the seller has the incentive to reveal the warranty information for a high-quality item in the auction listing.

The theoretical analysis above provides our first main empirical hypothesis concerning the relationship between warranties and buyers' willingness to bid, which can be stated as follows:

Hypothesis 1. A warranty as a signal of high quality increases buyers' willingness to bid, all else being equal.

A higher seller feedback score implies a more established reputation, and it is thus more likely that the item in the auction will be of high quality. Therefore, bidding offers will be commensurate with a 'high-quality type' of product. As a result, this will lower the signaling effect of a warranty as well as the price premium to the seller, which leads to the following hypothesis:

Hypothesis 2. Seller feedback scores and warranties are substitutes, implying that a seller with a more established reputation (higher seller feedback score) will obtain a relatively lower premium from a warranty, all else being equal.

As mentioned in Section (3), sellers in the eBay car auction market can be classified into two types: professional dealers and private sellers. Thus, it will be interesting to examine how a warranty affects bidders' bidding strategies and the associated seller revenues across both types of sellers. Here, status as a professional dealership can be interpreted as another signaling measure for the quality of the product. To represent this, we replace seller feedback score F_s in equations (1) and (2) with professional dealership status, denoted by $D \in \{0, 1\}$, where $D = 0$ indicates a private seller and $D = 1$ indicates a professional dealer. We can then re-write $b_i(D, W, v_i)$ and $ER(D, W)$ accordingly, and intuitively arrive at the following hypothesis:

Hypothesis 3. Compared to professional dealers, private sellers enjoy more benefits from warranties, all else being equal.

In other words, $\big[ER(D = 1, W = 1) - ER(D = 1, W = 0)\big] < \big[ER(D = 0, W = 1) - ER(D = 0, W = 0)\big]$. In the market, professional dealers are more like 'repeated-game players' and thus have stronger incentives to maintain a good reputation, as it

would be more costly for dealers if their reputation were damaged. In contrast, private sellers are more like 'one-shot players,' and thus signaling mechanisms like a warranty would be more effective for them to use to signal the quality of the product. This is consistent with the previously-mentioned theoretical prediction that information asymmetry should become relatively less important when repeated iterations are possible in the market, implying that signaling mechanisms will provide relatively lower benefits for professional dealers.

Further, it is of interest to examine the substitutability of warranties for feedback scores across the two types of sellers. Since the signaling effect of a warranty is more useful for private sellers, we would expect that the substitutability of a warranty for a private seller' reputation would be more significant than with professional dealers. Technically speaking, the interaction term between warranties and a private seller's feedback score should be negative and significant for determining the final price of the auction. However, this substitutability should not be significant for professional dealers, who are the 'long-term players' in the market.

Hypothesis 4. There exists a significant substitution between warranties and feedback scores for private sellers but not for professional dealers, all else being equal.

5.2 Warranty, professional dealership status, and buyer experience

We next examine how buyers with different experience levels respond to the presence of a warranty and to different types of sellers in the auctions. As mentioned before, eBay buyers also have their own feedback scores, which represent the number of historical transactions each buyer has completed. Thus, we can use feedback scores to measure buyers' experiences in the marketplace. We denote a buyer's experience by $F_b \in [0, +\infty)$. We further define $\alpha \in [0, 1]$ as the capability of the buyer to assess all information in the auction as a function of F_b. Intuitively, the more experience a buyer has, the better he or she will be at estimating the quality of the good.

In an auction, fixed bidder i's private value v_i, both $\alpha(F_b)$ and $p(F_s, W)$ (or $p(D, W)$) jointly determine the bidder's willingness to bid b_i in equation (1) as well as the seller's expected revenue ER in equation (2), which further implies that F_b can substitute for the signaling effects of W and D. This suggests the following testable hypothesis:

Hypothesis 5. A buyer with more experience (as measured by buyer feedback score) is less willing to pay a premium for the presence of a warranty or for a professional

dealership, all else being equal.

6 Empirical Analysis

In this section, we start by investigating the impacts of a warranty and its relationship to seller reputation in the determination of equilibrium prices. This corresponds to Hypotheses 1 and 2. Furthermore, we explore how this relationship varies across different types of sellers, which relates to Hypotheses 3 and 4. Thereafter, we examine Hypothesis 5. Finally, we conduct robustness checks for our results by considering different specifications.

6.1 The impacts of warranty and substitution for seller feedback score

We assume that the natural log of the final price (Final price) depends on the presence of a warranty (Warranty), the level of seller reputation as measured by seller feedback score (SFeed), and a set of control variables (Controls) in the following manner:

$$\begin{aligned}\ln(Final\ price_{ig}) = \alpha_g + \beta Warranty_{ig} + \gamma Warranty_{ig} \times \ln(SFeed_{ig}) \\ + \delta Controls_{ig} + \varepsilon_{ig},\end{aligned} \tag{3}$$

where g indexes a group of auction listings matched by seller identity, car body type, and start price; i indexes a specific listing within the matched group; α_g captures the group fixed effect; and ε_{ig} is an error term that captures unobserved characteristics varying within the group. The interaction term in equation (3) captures the substitutability of warranty for seller reputation and its coefficient γ, reflects how buyers' responses to warranties vary with seller feedback scores.

In equation (3), $Controls$ contain observable variables of the characteristics of the car and of the auction listing, including the natural log of car age, the natural log of mileage, whether the car is used, the number of photos, who pays shipping costs (equal to 1 if the winner pays for shipping, 0 otherwise), secret reserve status, listing duration, 'Buy-It-Now' option, whether the listing ends through the 'Buy-It-Now' option, number of entering bidders, and the week-fixed effects (which week of the year the listing starts). For inference, we use robust standard errors clustered at the seller level.

For comparison purposes, we also run regressions with the full sample of 9005 auction

listings, including the group-fixed effect, the week-fixed effect, and all control variables for the observable characteristics of sellers and auctions. This serves as a benchmark to examine whether our main results from the matched sample are systematically driven by dropping unmatched observations.

The estimated results are reported in Table (3). In columns (1) and (2), we provide the results for the model without the interaction term, based on the full sample and the matched sample, respectively. We find that on average, the final price in an auction is approximately 11 percent greater with a warranty than without it. This reflects that the presence of a warranty affects the transaction prices paid for cars by buyers in the auctions. Though we do not report all of the estimated coefficients of the control variables in Table (3) for the sake of space, they are found to be consistent with what would be intuitively expected. For example, car age and mileage, the most important characteristics of a used car, are negatively correlated with the final price, and the sellers' choices for the auction listing, like having a secret reserve, the number of photos, etc., also influence the final price.

The results for equation (3) are presented in column (3) (the full sample) and in column (4) (the matched sample). In both regressions, the results for the warranty dummy remain qualitatively similar in the sense that buyers respond positively to a warranty; the average price premium in the auction listings with a warranty is increased by approximately 60 percent for a seller with no transaction history in the market. More interestingly, the coefficients of the interaction term are negative and significant at the 1 percent level; on average, the price premium for listings with a warranty is decreased by 8 percent for each percent the seller's feedback score increases, suggesting that a better reputation on the part of the seller lowers the price premium from the warranty. These results are in support of Hypotheses 1 and 2.

To further investigate how a warranty affects the final price of an auction for different levels of seller reputation, we analyze a variant of equation (3): we classify all sellers in the sample by feedback score quartiles, where the cutoffs are 123, 360, and 801. The warranty dummy is interacted with an indicator variable that is equal to 1 if the seller belongs to the particular feedback score quartile:

$$\begin{aligned}\ln(Final\ price_{ig}) = \alpha_g + \beta Warranty_{ig} + \sum_{j=2}^{4} \gamma_j \Big(Warranty_{ig} \times SFeedQ(j)_{ig} \Big) \\ + \delta Controls_{ig} + \varepsilon_{ig},\end{aligned} \tag{4}$$

where $SFeedQ(j)$ is the dummy for the jth quartile. The coefficients of interest are γ_j ($j = 2, 3, 4$), capturing the effects of the warranty on the final price in each of the seller feedback score quartiles. The estimation results are presented in columns (5) (the full sample) and (6) (the matched sample). Though the interaction term with the second seller feedback score quartile is not significant, there exists a monotonic and decreasing trend in the price premium from a warranty as a function of seller feedback score quartile. The presence of a warranty increases the average final price by around 24 percent for sellers in the lowest feedback score quartile, but sellers in the highest feedback score quartile obtain almost no increase in the final price in the presence of a warranty. This analysis provides further evidence to support Hypothesis 2.

6.2 Impacts of warranty across different seller types

To investigate Hypothesis 3, we first consider the interaction term of warranty and professional dealership in equation (3), and inquire as to whether a warranty and professional dealership status are substitutes. We present the estimation results in columns (7) and (8) of Table (3). Consistent with our hypothesis, the coefficients of the interaction term are negative and significant at the 1 percent level; although a warranty, on average, generates a price premium of 52 percent for sellers, professional dealers in fact obtain a very small price premium (approximately 4 percent) in auction listings with a warranty. This provides supporting evidence that a professional dealer will enjoy less of a price premium from having a warranty in an auction listing.

We then separate sellers from the full and matched samples into two sub-categories according to their professional dealership status, and further investigate how the price premium varies across the sub-categories. As shown in the theoretical model, a warranty as a quality signaling mechanism will have more impact for private sellers but less for professional dealers. This is because information asymmetry is a more serious issue for 'one-shot players' in markets. We would then expect professional dealers to obtain a relatively lower price premium in auction listings with a warranty, in contrast to private sellers. Moreover, when private sellers establish better reputations (measured by feedback scores), the signaling benefits of a warranty become lower. To examine this, we re-estimate columns (1) to (4) of Table (3) for these two sub-categories of sellers.

Table (4) reports the estimation results. Columns (1) – (4) for the private seller subcategory show that the estimated coefficients for warranty are positive and significant at the 1 percent level, while the interaction terms with seller feedback score are negative

and significant, indicating that a warranty induces a price premium for private sellers but that this premium decreases with increasing seller feedback score. In contrast, as seen in columns (5) – (8) for the professional dealer sub-category, the coefficients for warranty are positive and significant, but the magnitude of the estimated coefficients for warranty are relatively smaller; with a warranty, the final price is increased by 50 percent for private sellers but only by 5 percent for dealers. More importantly, columns (7) and (8) show that for professional dealers, the interaction terms between warranty and seller feedback score are not significant. These results, consistent with empirical Hypotheses 3 and 4, indicate that private sellers benefit more from a warranty, but that this benefit decreases when private sellers have higher feedback scores. Nonetheless, since professional dealers are the 'long-term players' and are more reputable in the market, the signaling effect and substitutability of warranty become insignificant.

6.3 Buyer experience

In this subsection, we examine the final empirical hypothesis – Hypothesis 5 – regarding how buyers' responses to warranties and professional dealerships vary with their buying experience. Our first interest here is in analyzing bidders who participate in auction listings both with and without warranties so as to identify the effect of a warranty on a buyer' willingness to pay. Moreover, this analysis will also help us clarify the concern that the price premium resulting from a warranty, as shown in the analyses above, could be driven by the possibility that auctions with a different warranty status systematically attract distinct segments of consumers. To analyze this, we modify the matching strategy as follows: we match the auction listings into groups with the same combination of bidder identity, car body type, and start price (rounded to the nearest thousand), but with a variation in warranty status. Since a bidder may submit multiple bids in an auction, we restrict here our attention to the maximum bid submitted by the bidder as the dependent variable in each auction listing in the matched groups. After matching, it turns out that the matched sample includes 5828 groups (the number of bidders who submitted bids in auctions with and without a warranty) and each group on average contains approximately 12.6 auction listings.

We then regress the maximum bid on the warranty, and the interaction term with buyer feedback score (which is used to capture the buyer's experience in the auction market). In the analyses, we also include all of the observable variables related to the characteristics of the car, the auction, and the seller as controls, as in the baseline estimation

(equation (3)). The results of the regressions are presented in Table (5). Columns (1) and (2) are the regression results for the full sample and the matched sample, respectively, with the finding that the estimated coefficients of warranty remain positive and statistically significant at the 1 percent level. More notably, the interaction terms are negative and significant, indicating that buyers with more market experience are willing to pay less for a warranty.

To further investigate the relationship between buyer experience and their responses to professional dealerships, we next examine whether buyers with a higher feedback score will pay less in auctions run by professional dealerships. For this purpose, we match the auction listings into groups with the same combination of bidder identity, car body type, and start price, but with variation in professional dealership status. Following Hypothesis 5, if professional dealership status can be used to reveal the quality of the product, then the interaction term between the professional dealership and the buyer feedback score is expected to lower the price premium for professional dealers. We report the results of the regressions in columns (3) and (4) of Table (5). As expected, status as a professional dealership significantly affects the price premium, increasing the final price by approximately 15 percent, and the coefficients on the interaction terms are negative and significant, indicating that the final price is reduced by around 4 percent.

Consistent with Hypothesis 5, buyers positively respond to the presence of a warranty and to professional dealerships, implying that there exist signaling effects of both market instruments that reduce information asymmetry and increase buyers' willingness to pay. However, when buyers obtain more experience and understand the market better, their willingness to pay for these market signaling instruments decreases.

6.4 Robustness checks

In the above empirical analyses, we have examined the relationships between warranty, seller reputation, and buyer experience. One may argue that these results could be driven by other unobservable factors. In this section, we consider a variety of alternative explanations to examine the robustness of our results.

6.4.1 Buyers' willingness to pay

In the auction listings, the final price is the second highest bid, but the value of the winning bid is not observable in the data. One may argue that our results only hold true for winners but not for other bidders, as only those bidders (winners) who prefer a warranty would be attracted to entering auctions with a warranty and submitting higher bids. To address this question, we replicate the estimations in Tables (3) and (4) by using the third to the fifth highest bids in the matched auction listings as the dependent variables.

As mentioned previously, we can observe in the data the entire bidding procedure for each auction listing. We first rank all of the bids in the auction listing by the bid values and then repeat our analyses by regressing the natural log of the b-highest bid, where $b = 3, 4, 5$, as the dependent variable in equation (3) using the matched sample. We also include the same controls as previously used in the estimations. We report the results for the ranked bids in panel A of Table (6). Our findings show that, on average, the third, fourth, and fifth highest bids received in auction listings with a warranty are significantly greater than those of listings without a warranty. This indicates that not only do the winners respond positively to the presence of a warranty but also other bidders do as well. More importantly, a similar pattern is observed for the relationships between warranty and seller feedback score and professional dealership across the regression results, suggesting that a warranty can substitute for seller feedback score and professional dealership status, as suggested in Hypotheses 1 and 2.

We further separate the matched groups according to professional dealership status, and re-estimate the impacts of warranties. Columns (7) – (12) of panel A confirm the predictions of Hypotheses 3 and 4 that private sellers, in contrast to professional dealers, will obtain a higher premium from the presence of a warranty, and that the size of the price premium from the warranty gradually decreases with increasing seller feedback score. For professional dealers, the impacts of a warranty and its substitutability for seller feedback score are relatively ambiguous; in the regressions it is only significant for the fifth highest bid. Overall, the main qualitative patterns in these examinations are unaffected, providing further evidence to strengthen our results.

6.4.2 Bidder entry and bidding times

We next deal with the concern that the impacts of a warranty and its substitutability for seller reputation in the determination of final price are possibly driven by the warranty attracting more entries by bidders and/or inducing each bidder to submit more bids, but not by the warranty increasing bidders' willingness to pay. When we estimated equation (3), we already included the number of bidders in each auction listing as a control variable and showed that the estimated relationships are robust after controlling for entry by bidders (see Table (A2) of the Appendix). This implies that the results obtained above are not driven by more entries.

In each auction listing, we can observe the number of bidders who have entered and the number of bids each bidder has submitted. To further confirm our results, we use these two variables (the number of bidders and number of bids) to examine the impacts of a warranty on bidders' entries and bidding times. Specifically, by using the matched sample, we estimate a variant of the baseline model in equation (3), in which the dependent variable is separately replaced by the two variables. In the regressions, we also include all other control variables as before. We present the results of the regressions in panel B of Table (6). Here, the estimated coefficients for warranty and its interactions are not significant, supporting the argument that our results are not driven by more entries and more frequent bidding times by bidders. The non-significance of warranty and its interaction terms can be easily explained when we take into account buyers' perspectives about entry decisions in an auction listing. When a buyer is deciding whether to enter the auction, she needs to make a trade-off between the following two effects: on one hand, a warranty encourages the buyer to enter and to bid more for the object, and on the other hand, due to other buyers' higher willingness to pay, bidding becomes more competitive and this in turn discourages buyer entry. The existence of this tradeoff explains the results in panel B. Overall, these analyses suggest that more entries and more frequent bidding times by bidders are unlikely to explain our results.

6.4.3 Tests for correlation with other optional choices

Here, we analyze whether warranty status is systematically correlated with other key auction attributes in the determination of the final price in the auction; these other attributes include start price, secret reserve, number of photos, listing duration, and

buyer shipping. Specifically, we separately add the interaction terms of warranty with those variables into equation (3) and examine whether the impacts of a warranty and its interaction terms with seller feedback score and professional dealership status are affected under these specifications using the matched sample. We present the regression results in Table (7).

Besides a warranty, other informational mechanisms can be used to signal the quality of cars in auction listings. For example, Lewis (2011) shows that posting more photos reduces information asymmetry between sellers and buyers, and therefore increases the price premium in the listing. Thus, the interaction term between warranty and number of photos captures the correlation between these two signaling mechanisms. Bajari and Hortacsu (2003) empirically show that a secret reserve price is more often used with high-value items than with low-value ones. The interaction terms with the natural log of the start price and the secret reserve dummy can be used to capture the possible correlation between the value of the car and the likelihood of buyers paying a warranty premium for high-value cars. In addition, we examine the interaction terms with listing duration and buyer shipping, which helps us see whether sellers prefer to use particular options combined with warranty in an auction listing. Results are reported in columns (1) – (5). We further conduct similar estimations for the interaction term between warranty and professional dealership status in columns (6) – (10). Interestingly, warranty and its interaction terms with seller feedback and professional dealership status remain unaffected (positive and significant at the 1 percent level), although the magnitudes of the estimated coefficients vary across these estimations. Overall, these analyses demonstrate the robustness of our results after including additional controls.

6.4.4 Different car categories

Finally, as an additional robustness check, we examine whether our results hold for different car categories. We classify car body types into four different sub-categories: 'Sedan and Hatchback,' 'SUV,' 'Coupe and Convertible,' and 'Van.' We then fix the sub-categories and re-group the auction listings according to the combination of seller identity and start price (rounded to the nearest thousand). After matching, these four sub-categories include 129 groups for 'Sedan and Hatchback,' 44 for 'SUV,' 32 for 'Coupe and Convertible,' and 25 for 'Van.' We re-estimate equation (3) and Table (8) reports the estimated coefficients for warranty and its interaction terms with seller feedback score

and professional dealership status across the four car sub-categories, separately. As expected, within most of the sub-categories, we observe that warranty still significantly affects the price premium and that the coefficients on the interaction terms are negative and significant. Note that warranty seems to ambiguously affect the price premium in the 'Van' sub-category. This may be due to the small number of observations.

7 Specified Warranty

In the analyses above, our attention was focused on the dummy variable of warranty and its impacts on price premium in the auction listing, and across different types of sellers. However, as mentioned regarding 'warranty classification' in Section 4, there in fact exists a variety of warranties, including different protection policies covering different parts of a car. It would thus be interesting to inquire whether our results vary across different types of warranties.

To analyze this question, we first classify auction listings with an 'Existing warranty' as a sub-category, and then briefly classify the rest of the auction listings, which include specified warranty information in the category of 'Enter your own choice,' into two different sub-categories: 'Day and/or mileage' ('DM' for short), and 'Warranty on parts' ('Parts' for short). Note that we classify the auction listings with 'Certified warranty' into the sub-category of 'Existing warranty.' We then create dummy variables for the sub-categories according to the detailed warranty information provided in the auction listing. The dummy variable for the 'Existing warranty' sub-category is equal to 1 if the listing indicates an existing warranty, that the warranty has been extended, or that a 'Certified Warranty' is provided; otherwise, the dummy is equal to 0. The dummy variable for the 'DM' sub-category is 1 if the seller includes any warranty specifications for duration and/or mileage; otherwise, 'DM' is equal to 0. The dummy variable for the 'Parts' sub-category is equal to 1 if the seller specifies an included warranty covering any specific parts of the car, such as 'power train,' 'engine,' etc.; otherwise, 'Parts' is 0. Note that the sub-categories 'DM' and 'Parts' are not necessarily mutually exclusive, as warranty information in some listings covers more than one sub-category, e.g., '75000 miles or 30 months on extended warranty.'

We next follow our matching strategy to group the listings separately for the three warranty sub-categories. In each matched group for a specified warranty sub-category, we ensure variation in the specific warranty information such that at least one listing

should belong to the specified warranty sub-category, and at least one listing does not have any warranty. After matching, the 'DM,' 'Parts,' and 'Existing warranty' sub-categories include relatively small numbers of groups, with 53, 39, and 191 groups, respectively and 48, 57, and 18 auction listings in each group, on average. We then re-estimate equation (3) and report the estimated coefficients for the three warranty sub-categories, separately, in Table (9). In columns (1), (5), and (6) for the 'DM' and 'Existing warranty' sub-categories, the final prices are significantly affected. Moreover, we observe a similar pattern to the analyses above, where the impact of a specified warranty decreases as the seller feedback score increases. This analysis further confirms our findings that seller reputation can be a substitute for a warranty. However, as seen in columns (3) and (4), the estimated coefficients for the 'Parts' sub-category are insignificant. This is possibly because the value of a warranty on a specific car part is relatively low, and so it is very likely for its impact in an auction listing to be negligible.

8 Conclusion

In this paper, we find through our analyses that the presence of a warranty induces higher willingness to pay on the part of buyers, and that its impact varies across different seller reputation levels: the better the seller reputation is, the lower the price premium, implying that warranty and seller reputation, both of which can signal the quality of a product, have a clear and strong substitution relationship. More interestingly, this signaling effect varies across different types of sellers; in contrast to private sellers, professional sellers, who are the 'long-term players' in the market and therefore have a higher incentive to maintain a better reputation, obtain less benefit from a warranty, and its substitutability for seller feedback score becomes relatively insignificant. This provides empirical evidence to support the theoretical predictions in the literature. Finally, our findings show that buyer experience plays an important role in determining willingness to pay and can substitute for signaling mechanisms; a buyer who has more market experience will pay less of a premium for a warranty and for buying from a professional dealership.

Although this study focuses on eBay's online car market, our findings have implications for other markets with information asymmetries. As mentioned before, this study is especially relevant to our understanding of how different information disclosure mechanisms affect buyers' willingness to pay and determine gains and losses for different

types of sellers. In this sense, our study stresses the importance of paying attention to the interactions among these signaling mechanisms and their effects on consumer preferences. Our results also provide a better understanding of how trust can be built up between market participants through different forms of information disclosure, suggesting that marketplaces like eBay should not only continuously innovate and improve their reputation rating systems for monitoring sellers, but also take into account the impacts of other factors, like seller type and buyer experience.

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Table 1: **Descriptive Statistics for the Full Sample of Auction Listings**

	Obs.	**Min**	**Max**	**Mean**	**Median**	**S.D.**
Auction Characteristics						
Start Price	9005	0.01	389900	3774	200	12830.99
Photos	9005	0	20	15.15	20	6.98
Secret Reserve Price	9005	0	1	0.23	0	0.42
Buy-It-Now Option	9005	0	1	0.20	0	0.40
Sold as Buy-It-Now	9005	0	1	0.05	0	0.23
Buyer Shipping	9005	0	1	0.94	1	0.23
Duration	9005	3	10	6.63	7	1.53
Final Price	9005	150	599984	20328.34	16850	17328.09
Number of Bidders	9005	1	34	10.36	11	5.84
Number of Bids	9005	1	171	30.17	30	19.73
Car Characteristics						
Car Age	9005	1	4	2.65	3	1.05
Mileage	9005	1	999999	29040.74	22135	29445.69
Seller Characteristics						
Seller Feedback Score	9005	1	21147	968.72	360	2329.2
Seller Positive Feedback Percentage	9005	0	100	96.82	100	16.22
Professional Dealership	9005	0	1	0.82	1	0.39
Warranty Status						
Warranty	9005	0	1	0.52	1	0.5
By Auction Listings						
Professional Dealers						
Seller Feedback Scores	7358	1	21147	1151.66	473	2539.88
Seller Positive Feedback Percentage	7358	0	100	98.76	100	8.94
Private Sellers						
Seller Feedback Scores	1647	1	646	151.47	93	160.19
Seller Positive Feedback Percentage	1647	0	100	88.19	100	31.48

Table 2: **Descriptive Statistics for the Matched Sample of Auction Listings**

	Obs.	**Min**	**Max**	**Mean**	**Median**	**S.D.**
Auction Characteristics						
Start Price	3722	0.01	31000	412.22	200	1480.33
Photos	3722	1	20	18.2	20	4.82
Secret Reserve Price	3722	0	1	0.1	0	0.3
Buy-It-Now Option	3722	0	1	0.08	0	0.28
Sold as Buy-It-Now	3722	0	1	0.02	0	0.13
Buyer Shipping	3722	0	1	0.98	1	0.16
Duration	3722	3	10	6.87	7	1.1
Final Price	3722	150	117100	19717.63	18007.5	9896.73
Number of Bidders	3722	1	29	12.84	13	4.79
Number of Bids	3722	1	149	36.48	35	16.98
Car Characteristics						
Car Age	3722	1	4	2.44	2	1.03
Mileage	3722	1	227082	23299.9	18519	20297.79
Seller Characteristics						
Seller Feedback Score	3722	1	13258	1097.15	582	2296.37
Seller Positive Feedback Percentage	3722	0	100	99.27	100	7.01
Professional Dealership	3722	0	1	0.93	1	0.25
Warranty Status						
Warranty	3722	0	1	0.69	1	0.46
By Auction Listings						
Professional Dealers						
Seller Feedback Scores	3476	1	13258	1164.5	641	2361.49
Seller Positive Feedback Percentage	3476	0	100	99.78	100	1.81
Private Sellers						
Seller Feedback Scores	246	1	606	145.52	94	136.49
Seller Positive Feedback Percentage	246	0	100	92.19	100	25.43

Table 3: **The Impacts of Warranty and Substitution for Seller Feedback Score**

ln(Final Price)	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Warranty	0.111***	0.109***	0.601***	0.602***	0.242***	0.244***	0.522***	0.527***
	(0.03)	(0.03)	(0.15)	(0.16)	(0.05)	(0.05)	(0.09)	(0.09)
Warranty × lnSFeed			-0.087***	-0.088***				
			(0.03)	(0.03)				
Warranty × SFeedQ(2)					-0.081	-0.098*		
					(0.05)	(0.06)		
Warranty × SFeedQ(3)					-0.215***	-0.213***		
					(0.06)	(0.06)		
Warranty × SFeedQ(4)					-0.254***	-0.249***		
					(0.06)	(0.06)		
Warranty × Dealer							-0.474***	-0.481***
							(0.09)	(0.09)
Matched groups	No	Yes	No	Yes	No	Yes	No	Yes
R^2 (Adjusted)	0.11	0.12	0.11	0.13	0.11	0.13	0.12	0.15
Observations	9005	3722	9005	3722	9005	3722	9005	3722

Note: For convenience, we denote the natural log of seller feedback score by 'lnSFeed,' professional dealership by 'Dealer,' and seller feedback score quartiles by 'SFeedQ(j),' where $j = 2, 3, 4$. All control variables are displayed in Table (A2). We also include the week-fixed effect in all regressions above. In columns (1), (3), (5), and (7), we include the group-fixed effect with the same seller identity, car body type, and start price. Standard errors clustered at the seller level are in parentheses. $***$, $**$, and $*$ denote significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

Table 4: **The Impacts of Warranty Across Different Types of Sellers**

	Private Sellers				**Professional Dealers**			
ln(Final Price)	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Warranty	0.533***	0.589***	1.355***	1.267***	0.050**	0.046**	0.219*	0.232*
	(0.09)	(0.10)	(0.35)	(0.39)	(0.02)	(0.02)	(0.13)	(0.13)
Warranty × lnSFeed			-0.187**	-0.155*			-0.029	-0.032
			(0.08)	(0.08)			(0.02)	(0.02)
Matched groups	No	Yes	No	Yes	No	Yes	No	Yes
R^2(Adjusted)	0.31	0.37	0.33	0.39	0.10	0.13	0.10	0.13
Observations	1647	246	1647	246	7358	3476	7358	3476

Note: For convenience, we denote the natural log of seller feedback score by 'lnSFeed.' In all the regressions above, all control variables and the week-fixed effect are included. In columns (1), (3), (5), and (7), we also include the group-fixed effect with the same seller identity, car body type, and start price. Standard errors clustered at the seller level are in parentheses. $***$, $**$, and $*$ denote significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

Table 5: **Bidder Experience and Willingness to Pay**

ln(Final Price)	**(1)**	**(2)**	**(3)**	**(4)**
Warranty	0.355***	0.359***		
	(0.03)	(0.03)		
Warranty × lnBFeed	-0.013**	-0.015***		
	(0.01)	(0.01)		
Dealer			0.153***	0.164***
			(0.06)	(0.06)
Dealer × lnBFeed			-0.041***	-0.044***
			(0.01)	(0.01)
Matched groups	No	Yes	No	Yes
R^2(Adjusted)	0.06	0.06	0.06	0.06
Observations	92150	73598	92150	56089

Note: For convenience, we denote the natural log of buyer feedback score by 'lnBFeed' and professional dealership by 'Dealer.' In all the regressions above, all control variables and the week-fixed effect are included. In columns (1) and (3), we also include the group-fixed effect with the same seller identity, car body type, and start price. In columns (1) and (2), listings are grouped with variation in warranty, and in columns (3) and (4), listings are grouped with variation in professional dealership status. Standard errors clustered at the buyer level are in parentheses. $***$, $**$, and $*$ denote significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

Table 6: **Robustness Checks**

Panel A: Bid Distribution							**Full Sample**			**Private Sellers**			**Professional Dealers**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**			
	ln(3rd)	**ln(3rd)**	**ln(4th)**	**ln(4th)**	**ln(5th)**	**ln(5th)**	**ln(3rd)**	**ln(4th)**	**ln(5th)**	**ln(3rd)**	**ln(4th)**	**ln(5th)**			
Warranty	0.605***	0.474***	0.507**	0.477***	0.771***	0.505***	1.159***	0.946**	1.379***	0.297	0.168	0.477***			
	(0.20)	(0.10)	(0.21)	(0.10)	(0.16)	(0.11)	(0.35)	(0.36)	(0.47)	(0.24)	(0.22)	(0.17)			
Warranty × lnSFeed	-0.090**		-0.072*		-0.120***		-0.140*	-0.108	-0.191*	-0.044	-0.020	-0.076***			
	(0.04)		(0.04)		(0.03)		(0.08)	(0.08)	(0.11)	(0.04)	(0.04)	(0.03)			
Warranty × Dealer		-0.431***		-0.427***		-0.465***									
		(0.10)		(0.11)		(0.12)									
Matched groups	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes			
R^2(Adjusted)	0.03	0.04	0.05	0.06	0.12	0.13	0.36	0.36	0.38	0.03	0.05	0.12			
Observations	3652	3652	3577	3577	3484	3484	234	224	218	3418	3353	3266			

Panel B: Numbers of Bidders and Bids	**(1)**	**(2)**	**(3)**	**(4)**
	ln(bidders)	**ln(bidders)**	**ln(bids)**	**ln(bids)**
Warranty	-0.032	0.022	0.118	0.082
	(0.07)	(0.05)	(0.14)	(0.08)
Warranty × lnSFeed	0.005		-0.022	
	(0.01)		(0.02)	
Warranty × Dealer		-0.028		-0.101
		(0.05)		(0.09)
Matched groups	Yes	Yes	Yes	Yes
R^2(Adjusted)	0.03	0.03	0.02	0.02
Observations	3722	3722	3722	3722

Note: For convenience, in panel A we denote the natural log of the ith highest bid by 'ln(ith).' We denote the natural log of seller feedback score by 'lnSFeed,' and professional dealership by 'Dealer.' In all the regressions above, all control variables and the week-fixed effect are included. Standard errors clustered at the seller level are in parentheses. $***$, $**$, and $*$ denote significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

Table 7: **Tests for Correlation with Other Optional Choices**

ln(Final Price)	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
Warranty	0.809***	1.009***	0.519***	0.739***	0.537***	0.705***	0.653***	0.403***	0.608***	0.505***
	(0.17)	(0.20)	(0.12)	(0.19)	(0.20)	(0.11)	(0.13)	(0.10)	(0.15)	(0.17)
Warranty × lnSFeed	-0.081***	-0.102***	-0.081***	-0.085***	-0.089***					
	(0.03)	(0.02)	(0.02)	(0.03)	(0.03)					
Warranty × Dealer						-0.439***	-0.453***	-0.371***	-0.475***	-0.481***
						(0.09)	(0.09)	(0.10)	(0.09)	(0.09)
Photos	0.046***					0.038**				
	(0.02)					(0.02)				
Warranty × Photos	-0.015***					-0.013***				
	(0.00)					(0.00)				
ln(Start Price)		0.004					-0.007			
		(0.03)					(0.03)			
Warranty × ln(Start Price)		-0.062***					-0.029*			
		(0.02)					(0.02)			
Reserve			-0.088					0.010		
			(0.09)					(0.09)		
Warranty × Reserve			0.470***					0.295***		
			(0.09)					(0.10)		
Duration				0.025					0.016	
				(0.02)					(0.02)	
Warranty × Duration				-0.022					-0.013	
				(0.02)					(0.02)	
Shipping					-0.027					0.036
					(0.11)					(0.12)
Warranty × Shipping					0.074					0.023
					(0.15)					(0.14)
Matched groups	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2(Adjusted)	0.14	0.14	0.15	0.14	0.13	0.15	0.15	0.15	0.15	0.15
Observations	3722	3722	3722	3722	3722	3722	3722	3722	3722	3722

Note: For convenience, we denote the natural log of seller feedback score by 'lnSFeed,' professional dealership by 'Dealer,' secret reserve price by 'Reserve,' and buyer shipping by 'Shipping.' In all the regressions above, all control variables and the week-fixed effect are included. Standard errors clustered at the seller level are in parentheses. $***$, $**$, and $*$ denote significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

Table 8: **The Impacts of Warranty Across Different Car Categories**

ln(Final Price)	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Warranty	0.689***	0.501***	0.802***	0.512***	0.184	0.538***	-0.653	-0.160
	(0.22)	(0.11)	(0.24)	(0.18)	(0.21)	(0.14)	(0.40)	(0.24)
Warranty × lnSFeed	-0.105***		-0.130***		0.004		0.107	
	(0.04)		(0.04)		(0.03)		(0.06)	
Warranty × Dealer		-0.472***		-0.480**		-0.480***		0.148
		(0.11)		(0.18)		(0.15)		(0.25)
Matched groups	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2(Adjusted)	0.12	0.13	0.23	0.23	0.19	0.22	0.32	0.31
Observations	2326	2326	1024	1024	350	350	316	316

Note: For convenience, we denote the natural log of seller feedback score by 'lnSFeed,' and professional dealership by 'Dealer.' Columns (1) and (2) are for 'Sedan and Hatchback'; columns (3) and (4) for 'SUV;' columns (5) and (6) for 'Coupe and Convertible;' columns (7) and (8) for 'Van.' In all the regressions above, all control variables and the week-fixed effect are included. Standard errors clustered at the seller level are in parentheses. $***$, $**$, and $*$ denote significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

Table 9: **The Impacts of Specified Warranties**

ln(Final Price)	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
DM	0.213*	0.395				
	(0.12)	(0.39)				
DM × lnSFeed	-0.038**					
	(0.02)					
DM × Dealer		-0.419				
		(0.39)				
Parts			0.154	-0.180		
			(0.28)	(0.16)		
Parts × lnSFeed			-0.027			
			(0.04)			
Parts × Dealer				0.159		
				(0.15)		
Existing Warranty					0.649***	0.518***
					(0.16)	(0.08)
Existing Warranty × lnSFeed					-0.086***	
					(0.03)	
Existing Warranty × Dealer						-0.447***
						(0.09)
Matched groups	Yes	Yes	Yes	Yes	Yes	Yes
R^2(Adjusted)	0.12	0.12	0.11	0.11	0.14	0.15
Observations	2561	2561	2243	2243	3508	3508

Note: For convenience, we denote 'Day and/or Mileage' by 'DM,' 'Warranty on Parts' by 'Parts,' the natural log of seller feedback score by 'lnSFeed,' and professional dealership by 'Dealer.' Standard errors clustered at the seller level are in parentheses. $***$, $**$, and $*$ denote significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

APPENDIX: Table A1 - Tests for Correlation between Warranty and Other Characteristics

	(1) Photos	(2) Reserve	(3) Duration	(4) Shipping	(5) Photos	(6) Reserve	(7) Duration	(8) Shipping
Warranty	0.464	0.072	-0.303	-0.017	0.386	0.094	0.127	-0.031
	(0.48)	(0.08)	(0.24)	(0.03)	(0.69)	(0.07)	(0.23)	(0.03)
Warranty × lnSFeed	-0.051	-0.009	0.065*	0.003				
	(0.09)	(0.01)	(0.04)	(0.00)				
Warranty × Dealer					-0.243	-0.082	-0.075	0.038
					(0.70)	(0.07)	(0.23)	(0.03)
Constant	18.184***	0.066***	6.921***	0.976***	18.174***	0.067***	6.960***	0.975***
	(0.14)	(0.02)	(0.09)	(0.00)	(0.14)	(0.02)	(0.10)	(0.00)
Matched Sample	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2 (Adjusted)	0.01	0.02	0.02	0.01	0.01	0.02	0.01	0.01
Observations	3722	3722	3722	3722	3722	3722	3722	3722

Note: For convenience, we denote the natural log of seller feedback score by 'lnSFeed,' professional dealership by 'Dealer,' secret reserve price by 'Reserve,' and buyer shipping by 'Shipping.' In all the regressions above, the group-fixed effect and week-fixed effect are included. Standard errors clustered at the seller level are in parentheses. $***$, $**$, and $*$ denote significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

APPENDIX: Table A2 - Effects of Other Listing Characteristics on Auction Outcomes

ln(Final Price)	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
ln(Car Age)	-0.124***	-0.130***	-0.125***	-0.128***	-0.127***	-0.131***	-0.121***	-0.123***
	(0.03)	(0.04)	(0.03)	(0.04)	(0.03)	(0.04)	(0.03)	(0.04)
ln(Mileage)	-0.034***	-0.033**	-0.034***	-0.034**	-0.033***	-0.032**	-0.037***	-0.037***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Reserve	0.171***	0.205***	0.169***	0.204***	0.169***	0.201***	0.160***	0.191***
	(0.06)	(0.08)	(0.06)	(0.08)	(0.06)	(0.08)	(0.05)	(0.07)
Shipping	-0.061	-0.008	-0.060	0.001	-0.058	-0.005	-0.049	0.044
	(0.07)	(0.11)	(0.07)	(0.11)	(0.07)	(0.11)	(0.07)	(0.12)
Photos	0.056**	0.112*	0.051*	0.100*	0.050*	0.098*	0.056**	0.109*
	(0.03)	(0.06)	(0.03)	(0.06)	(0.03)	(0.06)	(0.03)	(0.06)
Buy-It-Now Option	-0.031	-0.037	-0.035	-0.049	-0.058	-0.069	-0.065	-0.093
	(0.05)	(0.05)	(0.05)	(0.05)	(0.09)	(0.09)	(0.09)	(0.08)
Sold as Buy-It-Now	0.069*	0.227***	0.069	0.228***	0.071*	0.228***	0.073*	0.237***
	(0.04)	(0.07)	(0.04)	(0.06)	(0.04)	(0.07)	(0.04)	(0.06)
Duration - 3 days	-0.118**	-0.029	-0.123**	-0.032	-0.117**	-0.028	-0.117**	-0.026
	(0.05)	(0.06)	(0.05)	(0.06)	(0.05)	(0.06)	(0.05)	(0.06)
Duration - 5 days	-0.059	-0.084*	-0.061	-0.079*	-0.062	-0.081*	-0.057	-0.077
	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)	(0.05)
Duration - 7 days	-0.038	-0.018	-0.042	-0.021	-0.046	-0.025	-0.038	-0.017
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Number of bidders	0.019***	0.019***	0.019***	0.019***	0.019***	0.019***	0.019***	0.019***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Note: For convenience, we denote secret reserve price by 'Reserve,' and buyer shipping by 'Shipping.' Standard errors clustered at the seller level are in parentheses. $***$, $**$, and $*$ denote significance at the 1 percent, 5 percent, and 10 percent levels, respectively.