

**IN-DEPTH ANALYSIS OF THE SELLER REPUTATION AND
PRICE PREMIUM RELATIONSHIP:
A COMPARISON BETWEEN EBAY US AND TAOBAO CHINA**

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ABSTRACT

Seller reputation is recognized as an essential determinant in online C2C marketplaces, but its influence on price premium remains unknown. The majority of existing studies indicate that seller reputation is positively correlated with sales price (price premium) on eBay US, but not on Taobao China. Conversely, the strong correlation between seller reputation and sales volume found on Taobao (volume effect) seldom occurs on eBay US. Seller reputation thus seems having a positive impact on sales price on eBay US but a positive impact on sales volume on Taobao. To explain this interesting difference, we conducted an in-depth analysis using data retrieved from eBay US and Taobao China, grounded in the economic theory of market structure. The findings suggest that market structure, and specifically the number of sellers, moderates the relationship between seller reputation and sales performance. In a thin market, seller reputation is positively correlated with sales price, whereas in a thick market, the impact of seller reputation is reflected in sales volume.

Keywords: Online Markets, Seller Reputation, Market Structure, Sales Performance

1. Introduction

In the last decade, the explosive growth of Internet-based commerce has given rise to a large number of online shopping websites. Unlike the traditional offline market, in which seller and buyer usually conduct transactions face to face, an online buyer can execute a transaction without actually meeting the seller. This simple, convenient online process can lead to uncertain outcomes, which increases consumer distrust. To reduce or eliminate such distrust, seller

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reputation systems in the form of reputation scores, feedback ratings, and positive feedback rate et al, have been developed in many online shopping marketplaces. Research has subsequently attempted to examine the impact of seller reputation on sales performance both theoretically and empirically.

Previous studies that attempt to understand the impact of seller reputation on sales performance are mainly based on transaction records from www.eBay.com [Livingston 2010]. As the global leader in the online C2C auction market, eBay has a well-developed seller reputation system, and millions of items are traded on the site daily. In 2011, the total value of goods sold on eBay was \$68.6 billion, more than \$2,100 every second. With the increasing popularity of the online market in China, the website www.Taobao.com has become a prominent online C2C platform and was recently ranked as the number one online C2C auction marketplace in China. By the end of 2011, Taobao had 500 million registered participants and 800 million products for sale. Taobao has 60 million visitors per day and sells 48,000 products per minute. According to the three-month Alexa traffic rankings,¹ Taobao.com is ranked 12th and ebay.com is ranked 20th worldwide. The blossoming of the online market in China has stimulated much interest among marketers. However, there is still limited research that attempts to understand the unique behavior of the online C2C market in China.

We noticed that many studies that use data from eBay US reveal a strong correlation between seller reputation and sales price. For instance, in the studies of Ba and Pavlou [2002] and Pate [2006], the seller reputation score is shown to have a positive influence on price, and this is regarded as a price premium due to a high reputation. However, studies on the same topic with the online C2C market data like Taobao in China show different results [Li et al. 2007; Liu et al. 2009]. The majority of studies using Taobao data suggest a strong correlation between seller reputation and sales volume, but not sales price [Li et al. 2007; Ye et al. 2009]. This raises the question of whether a price premium always occurs in the US market and a volume effect occurs in the Chinese market. The factors underlying this discrepancy between the US and Chinese markets have yet to be elucidated. Some researchers have attempted to attribute the difference to the dissimilarity in culture backgrounds [Hou 2007], but the argument is rather weak and the issue remains unclear. Contradictory results on the impact of seller reputation on sales price have also been reported in the US market. For example, Resnick and Zeckhauser [2002] find no significant correlation between seller reputation and sales prices, and suggest that high reputation sellers are not guaranteed a price premium.

The goal of this study is to explain the discrepancy from the perspective of market structure. Market structure can be classified based on the intensity of competition in a market. The classification criteria include the number of producers, the type of goods and services, and the degree of free information flow. Hou and Blodgett [2010] classify online markets based on one dimension of market structure: thick versus thin markets. Thick markets have a larger number of sellers and thin markets have a smaller number of sellers. We conduct a cross-country comparison of the two largest online C2C marketplaces, eBay US and Taobao China, to examine the differences in the impact of seller reputation on price premiums. In this study, we use both sales price and sales volume to measure sales performance. We investigate the underlying factors that may affect the behavior of the two online markets. We posit that it is the number of sellers that moderates the relationship between seller reputation and price premium, rather than the marketplace itself.

The remainder of the paper is organized as follows. In Section 2, we review the literature related to the impact of seller reputation and market structure on sales performance. We present our research methodology in Section 3, including the data collection and model building procedures. We present the data analyses and the findings in section 4. Section 5 concludes the study with a discussion of the managerial implications of the findings and suggestions for future research.

2. Literature review

We first review previous studies of the impact of seller reputation on sales performance. This is followed by a review of the market structure theory and its application to online market analysis.

2.1 The Impact of Seller Reputation on Sales Performance

Online markets are believed to be beset by information asymmetry. As buyers and sellers are separated by time and distance, buyers can only evaluate items through sellers' descriptions, and the quality of a seller on fulfillment is unknown before transacting [Ghose 2009]. Reputation mechanisms may mitigate the information asymmetry problem [Smith 1987; Kauffman and Wood 2000]. As a signal of quality, reputation can reduce consumers' concern about risk, enhance the trust between buyers and sellers [Ba and Pavlou 2002; Utz et al. 2009], and thus contribute to better sales performance and higher sales prices or sales volumes [Melnik and Alm 2002].

¹ Retrieved on Jan. 11, 2012

The majority of research on the reputation-price correlation shows seller reputation to have a significant impact on auction price [Depken and Gregorius 2010], especially on eBay. A seller with a better reputation can expect to receive a higher price for an auctioned product. In a world of imperfect information, the quality of an item is difficult to observe, and thus reputation may serve as a surrogate for quality. Buyers may be willing to provide sellers with monetary incentives with the aim of receiving better quality [Shapiro 1983]. Such above-average prices are regarded as a price premium. However, Strader and Ramaswami [2002] suggest that a price premium occurs only when buyers value trust in the seller over price. Furthermore, Jin and Kato [2006] find that buyers are not always willing to pay more to high-reputation sellers, although they may intend to buy from them to reduce their transaction risks. Thus, a high reputation does not always guarantee a price premium.

A handful of studies examine the correlation between reputation and sales volume, or the likelihood of sales, of auctioned items. Dewan and Hsu [2004] use eBay data to reveal that reputation has a significant effect on the likelihood of sales. Eaton [2002] finds that negative feedback reduces the probability of sale of electronic guitars for sellers with more than 20 negative feedback postings. For buy-it-now (BIN) items, Ye et al. [2009] find a strong correlation between reputation and sales volume using data from Taobao, China.

Houser and Wooders [2006] demonstrate that positive feedback is a statistically and economically significant determinant of price. Positive ratings also influence the price premium, but the impact tends to be smaller than that of negative ratings [Lucking-Reiley et al. 2007; Standifird 2001]. However, using data from the same website, Wan and Teo [2001] find that seller feedback ratings do not have a significant effect on auction price. Table 1 summarizes the literature on the impact of seller reputation, including the type of indicator of seller reputation (i.e., positive/negative ratings), the product under review, the data source, and the price premium/sales volume effect, where “P” stands for a significant price-reputation correlation, “S” stands for a significant correlation between reputation and sales volume, and “NA” represents no significant correlation.

Table 1 Summary of studies on the impact of seller reputation

Relevant Literature	Variable	Product	Website	Reputation Effect
Ba and Pavlou 2002	Positive ratings, negative ratings	Santana CD, Camera, DVD, Windows Server, etc.	eBay	P
Melnik and Alm, 2002	Positive feedback, negative feedback	Gold coins	eBay	P
Cabral and Hortacsu, 2004	Positive, neutral and negative feedback	Laptops, coins, Beanie babies	eBay	P
Houser and Wooders 2006	Number of positive, neutral, and negative comments	Pentium III 500	eBay	P
J. Hou 2007	Positive and negative ratings, bidders	LED monitors	eBay China eBay US	P P
Canals-Cerda 2008	Rating, feedback	Paintings	eBay	P
Ghose et al. 2009	Rating, Competitors	Software	Amazon	P
Luo and Chung 2010	Reputation, Competition	Televisions, CD players, etc.	BizRate.com	P
Depken and Gregorius 2010	Feedback, overall reputation score	iPhones	eBay	P
Wan and Teo 2001	Feedbacks, duration	Coins	eBay	NA
Resnick and Zeckhauser 2002	Number of positive feedback ratings	Rio MP3 players	eBay	S
Ye et al. 2009	Positive ratings, negative ratings	Canon IXUS 700	Taobao	S
Li et al. 2007	Feedback scores, positive ratio	Game cards	Taobao	S
Zhang and Zhang 2011	Positive feedback ratio, overall reputation, average score	Kingston memory	Taobao	S
Zhao and Huang 2008	Positive ratings, negative ratings	Kingsoft 1G SD, SANDISK 128MB SD.	Taobao	P

In general, studies using data from eBay US reveal a significant price premium effect, whereas studies using Taobao data reveal a significant correlation between reputation and sales volume. As shown in Table 1, only one study makes cross-country comparisons using data from eBay US and eBay China. The rest mainly use data from eBay and find a price premium for high-reputation sellers. Among the four studies reviewed that use Taobao data, only one finds seller reputation to have a significant price premium effect [Zhao and Huang 2008]; the other Taobao-based studies all suggest strong correlations between seller reputation and sales volume, but not price premium [Li et al. 2007; Ye et al. 2009]. Without looking deeper into the underlying factors that may cause the different results for eBay US and Taobao China, it might be conveniently concluded that differences in culture background are responsible for the different effects of seller reputation [Hou 2007]. In this study, we take a step further to look into the possible causes of this difference to better understand both markets using the economic theory of market structure as a possible explanation.

2.2 Market Structure

Market structure can be distinguished by the number and size of firms, the extent of product differentiation, the entry conditions, and the degree of vertical integration [Sanford 2005]. Venkatesan et al. [2007] attempt to understand the impact of market structure and retailer characteristics on sales price using market competition and the price level of a product as indicators of market structure.

In the classic price competition model, price is equal to the marginal cost when at least two firms are in the market [Bertrand 1883]. However, this ideal equilibrium rarely happens in real life, and is thus referred to as the “Bertrand Paradox.” Researchers have subsequently found that price may be affected by market structure, and in particular by the number of competing firms [Dufwenberg and Gneezy 2000; Bounie et al. 2012]. Clay et al. [2001] provide evidence that more competition leads to lower prices and lower price dispersion. However, Venkatesan et al. [2006] suggest that the relationship between price and the number of sellers in a market takes an inverted “U” shape, observing that the price decreases when the number of sellers goes beyond a certain threshold. Hou and Blodgett [2010] divide online auction marketplaces into thick markets (markets with a large number of sellers) and thin markets (markets with a small number of sellers), and suggest that in a thick market buyers find it relatively easy to pay a fair price because of the availability of information about what others have recently paid for a similar product. In this study, we extend the work of Hou and Blodgett [2010] and empirically validate the impact of market structure on sales performance. As sales performance can be measured by both sales price and sales volume, we expect to see a price premium effect for products in a thin market but not for products in a thick market. Although a high seller reputation may not guarantee a price premium due to the high degree of competition in a thick market, we expect to see a sales volume effect for high-reputation sellers.

3. Method

In this section, we present the data collection process and construct the regression models for the data analysis.

3.1 Data Collection

After reviewing many potential products selling on both eBay US and Taobao, we decided to focus our study on one type of product, drinking vessels, which includes Tupperware tumblers and travel mugs. This product category was chosen due to the variety and availability of similar products sold in both markets. For ease of comparison, we collected Buy-It-Now (BIN) data for both Tupperware tumblers and travel mugs. We developed two Java-based crawlers to retrieve online data from eBay US and Taobao China for every target product for the period May 5, 2011 to January 22, 2012. After downloading the data for a product, we manually counted the number of sellers of that product.² We retained five products in which the number of sellers was either less than 50 (representing thin markets) or more than 100 (representing thick markets). BIN data on Tupperware tumblers (labeled *Tup_e*) and Starbucks coffee mugs (*SCM_e*) were collected from eBay US. Data on Tupperware tumblers (*Tup_T*), Haers travel mugs (*HTM_T*), and Pinko travel mugs (*PTM_T*) were collected from Taobao China. Figure 1 displays some example pictures of the products collected for the study. Table 2 presents the summary statistics for the product data.

² One seller may post more than one web page or online storefront for the same product. We used the seller account ID to identify sellers with more than one online storefront for a product.



Figure 1. Sample pictures of the product data collected

Table 2 Summary statistics for the product data (all prices have been converted to US dollars)

Product	Tupperware tumblers	Tupperware tumblers	Starbucks coffee mug	Pinko travel mugs	Haers travel mugs
Label	Tup_e	Tup_T	SCM	PTM	HTM
Website	eBay US	Taobao	eBay US	Taobao	Taobao
Mean Price (\$)	15	5	21	2	5
Total Number of Products	1568	1777	3264	327	1028
Products with Transactions	205	1025	398	94	362
# of items (Valid)	205	1003	398	82	282
Number of Sellers	47	215	110	43	109
Market Structure	Thin	Thick	Thick	Thin	Thick

3.2 Regression Model

We follow previous studies and measure seller reputation by the overall accumulated reputation score [Pate 2006; Hou 2007], the five-point-scale detailed seller ratings (“Item as Described”, *IaD*) [Zhang 2011], and the number of positive ratings [Ba and Pavlou 2002]. A couple of the seller profiles sampled to retrieve the seller reputation information are shown in Figure 2.

Based on these three factors, we formed the following regression models. Model-2 includes *Price* as an explanatory variable for sales volume.

(Model-1), *Price Premium*:

$$\ln Price = \beta_0 + \beta_1 \ln Reput_score + \beta_2 Detail_IaD + \beta_3 \ln Num_pos + \varepsilon$$

(Model-2), *Volume Effect*:

$$\ln Sales = \beta_0 + \beta_1 \ln Reput_score + \beta_2 Detail_IaD + \beta_3 \ln Num_pos + \ln Price + \varepsilon$$

In the above models,

Price represents the price shown on the product webpage.

Sales indicates the accumulated sales volume in the previous 30 days.

Reput_score represents the overall accumulated reputation score of the seller, using “reputation” from Taobao, and “feedback score” from eBay to calculate the positive and negative ratings that the seller received. A seller receives +1 point for each positive rating, no point for each neutral rating, and -1 point for each negative rating. A higher *Reput_score* value indicates a better seller reputation.

Detail_IaD identifies the average rating on the five-point scale detailed seller ratings for “Item as Described.” When a buyer leaves an overall feedback rating (positive, neutral, or negative) for a seller, he or she can also leave a detailed seller rating for the product purchased. A high *Detail_IaD* score suggests that the product is considered to be similar to the description.

Num_pos indicates the number of positive feedback ratings that the seller received in the previous month.



Figure 2. Reputation profile of sellers on eBay US and Taobao China

4. Analysis of the Results

We first analyze and compare the regression results for the data collected from eBay US and Taobao. We then examine the influence of market structure on sales performance.

4.1 Comparison between eBay US and Taobao China

We re-investigate the differential reputation effect on eBay US and Taobao using the data on Tupperware tumblers. We first run both regression models to examine the reputation-price (Model 1) and reputation-volume (Model 2) relationships. The results are shown in Tables 3 and 4 for eBay US and Taobao, respectively. The eBay US results indicate that reputation score has a significant impact (at $p < 0.05$) on product price, with a higher reputation score resulting in a higher price. However, no significant correlation is observed for the reputation-volume relationship. In other words, a seller on eBay US with a higher reputation can sell products at a higher price than sellers with a lower reputation, but will not necessarily achieve a larger/smaller sales volume. An interesting observation is the negative relationship (at $p < 0.01$) between Detail_IaD (“Item-as-Described”) and price. A possible explanation is that buyers tend to rate sellers higher on IaD when they consider the product to be a bargain.

Table 3 Regression results for Model-1 and Model-2 for Tup_e (thin market) from eBay US

Model	Model 1 <i>lnPrice</i>				Model 2 <i>lnSales</i>			
	B	Std. Error	p	VIF	B	Std. Error	p	VIF
<i>lnRepu_score</i>	.119**	.050	.018	2.064	-.069	.074	.354	2.122
<i>Detail_IaD</i>	-4.359***	.950	.000	1.033	-.987	1.459	.499	1.141
<i>lnNum_pos</i>	-.048	.047	.304	2.091	.122	.068	.075	2.102
<i>lnPrice</i>	-	-	-	-	-1.51	.103	.145	1.131
Adjusted R ²	.341				.168			
F	8.787***				1.450			

N=205, *** : p<0.01; ** : p<0.05; * : p<0.1.

The regression results using data on Tupperware tumblers from Taobao show the correlation between reputation and sales price to have no statistical significance. In contrast, the results show a strong correlation (at $p < 0.01$) between positive rating and sales volume (see Table 4). The regression results for the two models using different data sources show significantly different results.

Table 4 Regression results for Model-1 and Model-2 for Tup_T (thick market) from Taobao, China

	Model 1 <i>lnPrice</i>				Model 2 <i>lnSales</i>			
	B	Std. Error	p	VIF	B	Std. Error	p	VIF
<i>lnRepu_score</i>	-.005	.007	.513	3.350	-.131***	.034	.000	3.351
<i>Detail_IaD</i>	.008	.029	.779	1.002	-.010	.139	.945	1.002
<i>lnNum_pos</i>	.005	.010	.622	3.346	.651***	.046	.000	3.347
<i>lnPrice</i>	-	-	-	-	.282*	.154	.067	1.001
Adjusted R ²	.023				.542			
F	.179				102.711***			

N=1003, *** : p<0.01; ** : p<0.05; * : p<0.1.

4.2 Influence of market structure

To examine the effect of market structure on eBay US, we collected Buy-It-Now (BIN) data on Starbucks coffee mugs (SCM_e), which have a larger number of sellers, and show the regression results in Table 5. Although both the Tup_e and SCM_e data were collected from eBay US, the results are very different. There are only 47 sellers of Tup_e, which is considered a thin product market. As there is less competition among the sellers, it is more likely that sellers with a high reputation will achieve a price premium. As expected, seller reputation is significantly correlated with price (see Table 5). SCM_e has a total of 110 sellers in the data that we collected, which is considered a thick market. As the competition among the sellers is tenses, it is less likely that a seller with a high reputation will raise the sales price without hurting his or her sales volume. Again, as expected, no significant correlation is observed between seller reputation and price, but a significant correlation between seller reputation and sales volume is identified for SCM_e. This interesting connection has not been previously identified in past research using eBay US data. Both results are in agreement with our hypotheses (see Section 2.2).

To further validate our hypotheses, we collected data from Taobao for the same period. We selected one product representing a thin market, Pinko travel mugs (PTM_T), which has 43 sellers, and one product representing a thick market, Haers travel mugs (HTM_T), which has 109 sellers.

Table 5 shows the regression results for Model-1 and Model-2 for all five products. We classify markets with less than 50 sellers as thin markets and markets with more than 100 sellers as thick markets. In the two thin markets, one from eBay US and one from Taobao, statistically significant positive correlations between reputation and price are observed, but not for the reputation-volume relationship. For the three thick markets, one from eBay US and two from Taobao, no statistically significant correlation between reputation and price is found, but statistically significant correlations between reputation and sales volume exist for both products.

To summarize, the regression results are all in accordance with our hypotheses based on the thin/thick market structure theory of Hou and Blodgett [2010]. The products sold on eBay US and Taobao behave similarly according to the corresponding market structure. For sellers with high reputations, a price premium can be expected only when there are few competitors in the market. That is to say, in a thick market, there is a significant correlation between reputation and price. As when there are many competitors both seller and buyer are acting as “price takers,” an individual is not sufficiently influential to affect the price of an item. It is thus hard to obtain a price premium in a

highly competitive market. However, high reputation sellers can still benefit from higher sales volumes, and thus have a better overall sales performance.

Table 5 Summary of all regression results

Model		Market Size	Thin Markets (Small)		Thick Markets (Large)		
			Tup_e	PTM_T	Tup_T	SCM_e	HTM_T
Model-1 Price Premium (lnPrice)	lnRepu_score	.119** (.050)	-.030 (.038)	-.005 (.007)	.038 (.039)	-.025 (.025)	
	Detail_IaD	-4.359** * (.950)	.872** (.406)	.008 (.029)	-.093 (.094)	-.055 (.105)	
	lnNum_pos	-.048 (.047)	.011 (.050)	.005 (.010)	-.015 (.038)	.043 (.039)	
	Adj-R ²	.341	.288	.023	.068	.071	
	F	8.787***	2.346*	.179	0.609	0.466	
Model-2 Volume Effect (lnSales)	lnRep_score	-.069 (.074)	-.203 (.153)	-.131*** (.034)	-.113** (.049)	.038 (.057)	
	Detail_IaD	-.987 (1.459)	-1.962 (1.684)	.010 (.139)	-.075 (.118)	.058 (.235)	
	lnNum_pos	.122 (.068)	.418 (.201)	.651*** (.046)	.186*** (.048)	.201** (.088)	
	lnPrice	-.151 (.103)	-.259 (.457)	.282* (.154)	-.299*** (.063)	-.082 (.135)	
	Adj-R ²	.168	.267	.542	.298	.284	
F	1.450	1.473	102.711***	9.485***	6.037***		

Notes: ***: p<0.01; **: p<0.05; *: p<0.1; standard errors are listed in parentheses; all VIFs are less than 3.347.

5 Conclusion and Discussion

In this study, we attempt to gain a deeper understanding of the different effects of seller reputation on different online C2C markets. We focus on eBay US and Taobao China, the two largest online C2C markets in the world. The results suggest that it is the market structure, and specifically the number of sellers, that moderates the relationship between seller reputation and sales performance in online marketplaces. In a thin market with fewer sellers, seller reputation is positively correlated with sales price, whereas in a thick market with more sellers, the impact of seller reputation is reflected in sales volume.

The main contribution of this study is to provide a clear and uniform explanation for the empirical results using data from both US and China markets. Unlike previous research that attempts to attribute the dissimilarities identified in US and Chinese online markets to the difference in culture background of the two countries, we explain the phenomena based on the different behavior of thick and thin markets. Grounded in the economic theory of market structure, we show that the different results are due to the different number of sellers in each product market.

In a thin market where there are few sellers, seller reputation is positively correlated with product price but not with sales volume. Conversely, in a thick market, where there are many sellers, seller reputation is positively correlated with sales volume but not with product price. The reason for this result is that in a thick market, greater competition leads to lower prices and lower price dispersion [Clay et al. 2001], and it is relatively easy for buyers to pay a fair price because of the availability of information regarding what others have recently paid for a similar product [Hou and Blodgett 2010].

Although market structure theory has been discussed and applied in many economics and marketing studies, our study is unique in that it conceptualizes market structure as the moderator of the impact of seller reputation on sales performance. We also empirically validate the thick/thin market theory proposed by Hou and Blodgett [2010].

There are several important managerial implications that can be drawn from the findings of this research. For example, sellers in online C2C markets could adopt different pricing strategies for different products or market structures. In a thin market, sellers with a high reputation can set the price higher than sellers with a low reputation for the same product. However, low reputation sellers should by no means try to set a price that is similar to or higher than that of high reputation sellers. In a thick market, high reputation sellers should not raise prices higher

than those of low reputation sellers of the same product to achieve a higher sales volume and better overall sales performance. Low reputation sellers in a thick market may be able to improve sales by lowering the price. Whether in a thick or thin market, the findings of this research yet again confirm the importance of seller reputation to overall sales performance. It is thus crucial for online sellers to allocate resources and devote efforts to gaining and maintaining high reputation scores and positive ratings. The managers of online C2C marketplaces such as eBay and Taobao should recognize the importance of seller reputation information, and devise better mechanisms that more accurately reflect the true reputation of a seller to help buyers make informed decisions, thereby improving customer satisfaction with the website.

A limitation of this research is that it focuses on only one possible factor, market structure, to explain the difference in seller reputation behavior. While the market structure theory may be the major cause of the identified discrepancy, other factors, such as product characteristics (category, value) may also have moderating effect on the seller reputation and sales performance relationship. A separate study should be conducted to understand the influence of other factors on seller reputation effect, such as the returns policy. Another possible future research direction is to look at the impact of other components of market structure on the relationship between seller reputation and sales performance. We simply use the number of sellers as a proxy for market structure, but there are other factors that could be used to classify markets, such as the extent of product differentiation. The effects of the three variables (reputation score, detailed Item-as-Described rating, and positive ratings) used to represent seller reputation in Models 1 and 2 varied among the five products studied. For example, a statistically significant impact of reputation score was found on eBay US but not Taobao China, whereas a statistically significant impact of positive ratings was identified in both markets. More empirical data should be collected that covers a range of more diverse products to further validate our theory.

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