

“Law of One Price” in the Internet Era

---- Search Cost, Platform Competition and Customer Lock-in

Sun Zhen J.P. Liu Taoxiong Liu*

Abstract

In this study, we use a unique dataset from Tsinghua University's iCPI database to analyze the price dispersion in the online market. The results show that the cross-platform price dispersion of the same product is a pervasive and stable phenomenon. The dispersion on weekdays, during which consumers incur higher search cost, is higher than that during the weekends. Moreover, we find a positive relationship between price dispersion and the number of platforms on which a product is listed, contrary to the classic industrial organization theory that competition leads to price convergence. We conjecture that “platform lock-in”, the phenomenon that consumers are “locked” to particular platform due to its closed-circle advertising and other related (e.g., financial support) services. These findings indicate that search costs and “platform lock-in” are two important factors for the price dispersion in online market, while platform competition cannot reduce the dispersion. The dynamics of price dispersion following a change in the number of platforms suggest that platforms do not strategically adjust prices in response to the change in market structure, which provides support for the platform lock-in hypothesis. Overall, our findings suggest that in China's highly developed online market, “platform lock-in” is a phenomenon that prevents market integration in the internet era. These findings have important implications for platform regulation and governance.

JEL Classification: E31, E50

1 Introduction

According to traditional neo-classical economic theory, there should be merely one price for one product under given demand & supply circumstance. However, the “law of one price” doesn't hold exactly in daily life due to imperfect information (Stigler, 1961; Salop and Stiglitz, 1977; Reinganum, 1979; Burdett & Judd, 1983). With the rapid development of Internet and online B2C market in the first decade of the 21st century, search cost had been greatly reduced. Therefore economists expected price dispersion would be reduced or even disappear (Bakos, 1997), such that we arrive at the ideal world governed by the “Law of one price”. Unexpectedly, price dispersion still exists in online markets according to numerous empirical studies in past 20 years (Brynjolfsson & Smith, 2000; Garicano & Kaplan 2001; Lee & Gosain 2002; Baye et al 2004; Dewan & Hsu, 2004). During the past decade, some scholars predicted that price dispersion may not hold with technology improved from PC to smartphone, as well as online market structure changed from perfect competition to oligopoly^①. Nonetheless, nowadays, we still find a consistent price dispersion among 8 main categories goods/services in China's online market, even though under whose online B2C retailing and express delivery system is highly developed.

It's universally acknowledged that the Internet makes information communication much more efficient, meanwhile price dispersion level, as an indicator of market information efficiency, doesn't significantly decrease during past decades. Did the Internet make a flat world (Friedman, 2005)? Or perhaps, as an article recently published by *Science*, that Internet especially big data & AI techniques are tearing apart this world (Lazer, Baum, Benkler et al.

^① Such as Amazon, eBay in U.S., and Tmall, JD in China.

2018). If so, oligopoly B2C retailing platforms with data & AI ability to lock in customers by accurate recommendation & closed-circle financial support services may separate the whole B2C online market into numbers of parts, as a result, price dispersion in B2C market wouldn't reduce along with more fierce platforms competition (competition positively related to dispersion) but will increase as the empirical result showed in this paper.

Using millions of daily B2C retail prices data collected by Tsinghua University iCPI team, which covered 8 main-categories 262 sub-categories, same as NBS's CPI statistical method, from Dec. 2016 to Nov.2017, this paper reached 3 main findings: (1) There's a consistent price dispersion in nowadays China's online market; (2) Generally speaking, dispersion in weekdays (Monday to Thursday) is significantly larger than that in weekends (Friday to Sunday); (3) Dispersion increases along with higher platform competition level (measured by the number of platforms selling one same kind of product). The second finding fits traditional search cost theory (Lewis & Marvel, 2011). Meanwhile, the third finding contradicts with previous industrial organization theory which based on retailers (Borenstein, 1985; Holmes, 1989), instead of platforms as we focus in this paper. We propose "lock-in" as a mechanism in which platforms' closed-circle service strategy to explain the positive correlation between price dispersion and platform competition. It's a contribution in furthermore research how B2C retailing platforms, instead of sellers, may impact market information efficiency and equilibrium price dispersion level.

2 Literature Review

Price dispersion refers to the phenomenon that homogeneous goods are set at different prices by different sellers. The "law of one price" of classical economics believes that there should be only one price for one product in a given period. The short-term price dispersion as the market's non-equilibrium state will be corrected along with information spread. Therefore, with the popularity of the Internet, the improvement of search engine efficiency, and the rapid increase in the penetration rate of the online market to the retail industry, the search cost of consumers who have to spend on the road for visiting different stores has been replaced by "clicks". The cost reduction and increase in information exchange efficiency have been expected to significantly reduce the price dispersion level of commodities. However, in the early 2000s, after Internet commerce business start-up, numbers of empirical studies on different commodity types in online markets from various countries found that price dispersion still exists remarkably. Even for some categories of product, the online dispersion level was larger than which in offline. (Brynjolfsson & Smith, 2000; Garicano & Kaplan 2001; Lee & Gosain 2002; Baye et al 2004; Dewan & Hsu, 2004; Zhao Dongmei, 2008).

The classical interpretation of price dispersion includes the search cost caused by imperfect information and the monopoly pricing power brought by insufficiently competitive market. From the search cost perspective, consumers still lack information because they cannot "touch" the real product but only get part of picture information displayed by online sellers (Grover V, Lim J, Ayagari R., 2006). Lewis & Marvel (2011) used Internet access traffic to study the impact of consumer search behavior on prices. Sun Puyang et al. (2017) used Internet coverage as a search cost for online consumption in different regions of China and examined the impact of online market on offline market prices. In addition, different merchants choose different trade-offs between unit profit and sales volume to form a price-dispersion online market that may still exist. For example, Baylis & Perloff (2002) found that sellers offering bad-services in the homogeneous commodity market are selling at a lower price, while sellers offering bad-quality services are selling at a higher price, which reflects a segmentation market.

The industrial organization theory also provides an explanation for price dispersion. Because of the monopolistic power of sellers, the degree of price dispersion depends on the

market structure and the intensity of competition. The traditional theory of industrial organization believes that the increase in the number of sellers and the increased competition will reduce the ability of sellers to monopolize market price, making sellers offer prices more similar to the marginal cost thus the price dispersion value is negatively correlated with the number of online sellers (Baye, Morgan & Scholten, 2004). In the offline market, there is numerous empirical research supporting this theory (Barron et al., 2004; Lach & Moraga-González 2012; Wang Xiangnan, 2018). On the online market, Haynes & Thompson (2008) found that for a given type of digital camera, larger numbers of online sellers significantly lead to smaller price dispersion.

However, on the one hand, if a higher proportion of consumers are brand loyalty, then in an increased number of sellers will produce greater price dispersion (Shilony, 1979; Rosenthal, 1980; Narasimhan, 1988; Baye & Morgan, 2001). Even though there is a lower pricing firm entry, former consumers will still purchase from firms they used to visit. A new-entry firm may only get new-entry consumers due to their lower pricing strategy. Because of the gap between the price of the newly-entry firms and existed firms, the price dispersion level will be higher as more firms get in. Empirical research in some offline markets supports this theory. For example, in the study of gasoline prices, Lewis (2008) and Chandra & Tappata (2011) found that even after controlling the average oil price of the gas station, the price dispersion of various grades of gasoline still exists remarkably, and the price dispersion has positive relationship between number of gas station.

Most empirical research on price dispersion in online markets faces serious data limitations. First of all, researchers mostly rely on "price comparison sites." Since there is no sustainable profitability for those price comparison tools, large-scale third-party price comparison websites do not exist in U.S or China nowadays. Some small price comparison tools may help, but it's doubtful towards data credibility. More importantly, the data used in the existing research can not effectively track the same commodity for a long time, so the empirical result is equivalent to the mixed cross-section regression, which can not accurately identify the price dispersion of the same commodity over periods. Such a model may even reach opposite conclusion. For example, Gerardi & Shapiro (2009) used panel data from the US aviation industry in 1993-2006 to study the impact of market competition on the price dispersion of economy class airline on a given route, confirming that competition would reduce price dispersion, which is opposite of related research by Borenstein & Rose (1994) in which merely use cross-sectional data from 2nd quarter in 1986 that lead to omission of important missing variable problem.

Secondly, in terms of research content, research on online market price dispersion has stopped around 2008, and there is very little research on China's online market. In the past decade, China has emerged as the world's largest online market with the largest number of users. Taobao, Tmall, JD and more other e-commerce platforms have surpassed many pioneers and grow up to new online retail platform giants. From books and electronic products to almost all retail categories, types of online shopping product acceptance have changed apparently. The rapid improvement of logistics system makes online shopping become more and more mainstream as daily shopping habits, which impacts the offline price much (Sun Puyang et al., 2017).

Based on the classic interpretation of price dispersion phenomenon from information economics and industrial organization theory, this paper uses the daily commodity price database from iCPI project of Tsinghua University School of Social Sciences to analyze the relationship between search cost, platform competition and cross-platform price dispersion in China's online market. Conduct empirical analysis for classic interpretations of information costs, platform monopoly power, or platform loyalty that may result in price dispersion.

Compared with previous researches' data access, the iCPI database covers a large number of products (>10,000 products, >100 online platforms), and a full range (covering all 8 categories and 262 sub-categories that in CPI survey of the National Bureau of Statistics of

China), strict requirements on product homogeneity (all products included in cross-platform sellers are manually proofread by research group researchers after screening through the program), enabling us to use big data techniques to make long-term tracking price dispersion research in China's online market.

3 Research Design

Competition in China's online market is not just between sellers but between platforms. One platform will not only sell self-operated brand products but also provide trade infrastructure for different retailers who may sell one same product. Thus, one single retailer who sells one particular product could start business on different platforms.^② The platform is not only a provider of relevant information such as commodity prices but also the comments, after-sales service, etc. Plus, search cost within platform is smaller than that cross-platform in reality. As a result, for consumers the first decision when buying goods online is the choice of platform.

Although there are numerous researches about cross-retailers price dispersion in online/offline market, we are not aware of any research on cross-platform price dispersion. Considering the strong cross-network externalities of the Internet platform (Rochet & Tirole, 2003; Weyl, 2010), we expect that the future Internet economy will show more characteristics of inter-platform competition. Therefore, the research in this paper has a strong practical significance.

Competition between platforms is not likely competition between individual firms. There are multiple sellers on each platform, so as for platforms, the supply of goods is very flexible. Considering that the Internet has greatly reduced the information cost, the platform competition is closer to the competition based on product prices portrayed by the Bertrand model. Therefore, although the number of platforms on which each item is sold is small (2-3 platforms are dominant), in theory, as long as there are two platforms, the price may be reduced to the marginal cost price along with the competition. Correspondingly, there will be no price dispersion between the same goods across platforms. Therefore, in the theory, that is, the consumer bears no search cost, and the Bertrand cross-platform competition will lead to zero price dispersion. In reality, consumers still need to take time to browse and compare information about different products. Correspondingly, factors such as information and platform loyalty lead to consumers not necessarily choosing the lowest-priced one when purchasing homogeneous goods. That is, the market structure does not conform to the Bertrand model, which will cause cross-platform price dispersion appear. This paper will discuss the search cost and platform competition form of the online market, as well as the research design used.

The search cost for one product depends on the tense of search and the time cost of one single search move (Stigler, 1961), which in turn includes the monetary and opportunity costs of searching for information (Smith, 2000). In order to examine the causal effects of search costs on price dispersion, we need to look for exogenous factors that can influence consumer search times and search opportunity costs. After controlling the intrinsic attributes of the product, the search tension is usually considered to be positively related to the number of sellers, but since there are few platforms and hardly changes quickly^③, it can be considered that cross-platform search tension doesn't change over time.

^② Technically speaking, one single retailer may give different price for one same product among different platforms as a marketing strategy.

^③ As for Amazon, eBay in U.S. and Tmall, JD, Taobao in China.

On the other hand, the cost of one single search can be considered to be very small with the help of Google. Therefore, one last main factor that affects the search cost for consumers is the opportunity cost of one single search move for different individual consumers, which depends on the income of other activities undertaken by the consumer during they search and compare prices across platforms. By using daily frequency data on the price index and distinguished weekdays and weekends, we may test that whether consumers' search costs are relatively higher on weekdays, which may cause a higher dispersion level on weekdays than weekends. Some sellers may take advantage of dynamic opportunity search cost characteristics to set relatively higher prices on weekdays and then set lower prices on weekends as if offering tempting discounts, which could be another explanation for dispersion difference between weekdays and weekends. Based on analysis above, we propose:

Hypothesis 1: The cross-platform price dispersion may be significantly higher on the working days than on the weekends/public holidays, plus the cross-platform average price is higher on weekends/public holidays than which on working days.

We use the number of platforms that sell one same product(*num.plat.*) to reflect platform competition intensity. Because one same product is usually sold in multiple online retailers on same one e-commerce platform, the *num.plat* may not change in reality. However, for consumers, only few prices can represent the platform price level(such as the official brand flagship store, the best-seller online store, or the lowest-priced online store) among numbers of displayed prices for a single product (mostly due to different retailers' marketing strategies). Past empirical studies also support that trades only occur in few numbers of retailers on one platform (Baye et al. 2004). Therefore, when we collect data for the iCPI project, only the most representative retailers on each platform are selected (the object selected first is the official brand flagship store on the platform, followed by the best-seller retailer). Under this guidance, the number of platforms in the database is likely to change due to the removal/upload of representative online store products. For example, suppose a certain product appears in the JD, Tmall, and Suning 3 platforms at the same time when it is initially included in the iCPI, then someday the retailer we select on Suning remove such product, it will cause *num.plat.* change from 3 to 2 from this day. Such elimination of an important retailer on the Suning platform will lead to a decline in the intensity of cross-platform competition. On the other hand, if the online store re-stocks the product after a certain period of time, then the *num.plat.* will be raised from 2 to 3, which will reflect an increase in competition intensity between platforms. Meantime, the increase in the *num.plat.* shows that there are more retailers entry and the market competition becomes more intensively; on the contrary, the decrease of *num.plat.* reflects the more retailers run away and a less fierce competition situation. It important that the change of *num.plat.* in this paper can be understood as the weakening proxy variable of the change in the number of real platforms. The estimated result can be regarded as a lower bound value of the platform competition effect.

As classical industry organization theory, the formation of one market structure will matter how competition impacts price dispersion. If the market monopoly power is from factors such as information, production capacity, market-entry threshold or market segmentation in time or space, then the increase in the number of sellers will reduce the ability of the original sellers to monopolize pricing, making new equilibrium price dispersion reduced. On the other hand, if the market monopoly power comes from the brand loyalty, then the entry of the new sellers will not affect the price of the old sellers with higher price and higher customer brand loyalty, which thus will increase the market price dispersion. Under the pattern of online market platform competition in China, the traditional market monopoly power is relatively weak, and consumers appear to be platform-brand loyalty as such in the traditional economy^④. Therefore,

^④ Closed circle service, financial support...

more fiercely platform competition may increase the price dispersion on such a single product. Based on this we propose:

Hypothesis 2: The relationship between the cross-platform price dispersion and platform competition depends on the characteristics of the market structure. If market monopoly power is from factors such as information, capacity, access or market segmentation, then increased competition (larger *num.plat.*) will lower down price dispersion; if market monopoly power is caused by platform-brand loyalty, then more competition will cause higher price dispersion level.

As for hypothesis 2, we can further verify empirical results and investigate the impact of market competition on price dispersion in industrial organization theory. If market competition reduces price dispersion, the reason behind is that newly entered enterprises have adopted the corresponding price adjustment strategy (price reduction); If loyalty leads to market competition that increases price dispersion, it means that newly entered low-priced companies have not changed the pricing strategy of the original retailers. In the era of the Internet economy, price adjustments may be completed in a shorter period of time, but it is still necessary for businesses to observe changes in the market competition structure. This process takes a certain time, therefore, if market competition makes it more difficult for the platform to maintain monopoly power and has to make price adjustments, we should see the corresponding adjustment process in the daily price dispersion value before and after the change in the number of platforms. Conversely, if platform-brand loyalty makes the platform not adjust the price because of changes in the competitive environment, then the increase or decrease in price dispersion is due to the change in the number of platforms on the market, and the price dispersion will be seen when the number of platforms changes. In addition, we shall also observe the corresponding evidence from the cross-platform average price. If the competition leads to the corresponding strategic adjustment of the price of the platform, then the average price of the cross-platform of the commodity should change continuously after the number of platforms changes; on the contrary, if the platform loyalty of the consumer is high, then the average price of the cross-platform of the commodity is There will be only dispersion jumps before and after the change in the number of platforms (because of the entry or exit of a platform price), and there will be no obvious continuous changes after that.

4 Empirical Study

4.1 Sample selection and descriptive statistics

The data used in this paper is based on the iCPI project of the School of Social Sciences Tsinghua University. The iCPI project is based on the compilation method of the CPI of the NBS, and simulates the selection of the commodity basket and the weight of each layer.

Targeted on the online market, with the help of web crawler, cloud computing, and other big data system techniques, iCPI provides millions of prices for common commodities on multiple platforms per day. The data used in this paper is the first batch of exported data after the iCPI project was officially launched in Bloomberg. The range contains daily commodity price data from January 1, 2017 to November 21, 2017 for nearly one year.

During data clean process, we sweep away account errors such as the crawling position drift that may exist during data capture process. This paper considers that if the price difference of one same product on different platforms is more than twice that day, then it'll be reported as probability data error. If $\frac{p_i - \bar{p}}{\bar{p}} > \frac{1}{3}$, then the observations p_i will be removed. In addition, each item retains only one minimum price per day on one platform. After data cleaning, more than 3.7 million daily commodity price data, covering more than 10,000 items and 91 different online platforms are finally accepted.

The most commonly used indicator for price dispersion metrology is the coefficient of variation, the ratio of the standard deviation to the mean, which this paper uses. We calculate cross-platform price dispersion value for each item on daily frequency. Therefore, the data unit of this study is “product-Day”, and we have obtained nearly 2 million “Product-Day” observations.

Figure 1 provides a general description of the single-day cross-platform price dispersion of products. As can be seen from the figure, a large number of products are sold on 1-3 platforms, and the sales of products on more than 3 platforms are relatively small. Therefore, the empirical analysis of platform competition in this paper mainly makes use of the change of the *num.plat.* between 2 and 3 (when the *num.plat.* is 1, the price dispersion cannot be defined). In addition, price dispersion appears in a large number of product-day samples. The distribution of Figure 1 shows 48.6% of product-days exhibit cross-platform price dispersion. At the individual product level, 52.6% of the products had cross-platform price dispersion at least one day during the observation period. After excluding those one product only appear on single one platform, then the two ratios rise to 61.8% and 90.1% respectively, which shows that the price dispersion in the online market is still significantly widespread.

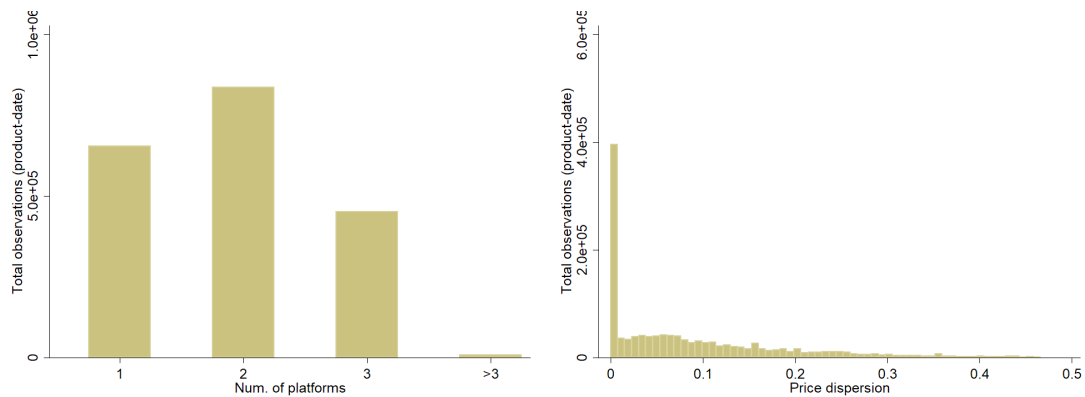


Figure 1 Distribution of *num.plat.* and price dispersion value

So is the price dispersion we observe a gradual transition from imbalance to equilibrium? In other words, is price dispersion a non-equilibrium state that will be gradually revised as the online market grows towards maturity? In order to examine this problem, we show the variation of the average value of the commodity daily price dispersion in the study time range in Figure 2. It can be seen from Figure 2 that in 2017, the price dispersion of the online market is very stable overall, and the standard deviation of cross-platform prices is maintained at around 10% of the average price, and the degree of dispersion has even increased with time. Therefore, we speculate that the online market of price dispersion in the Internet era is still a phenomenon that exists in an equilibrium for a long time.

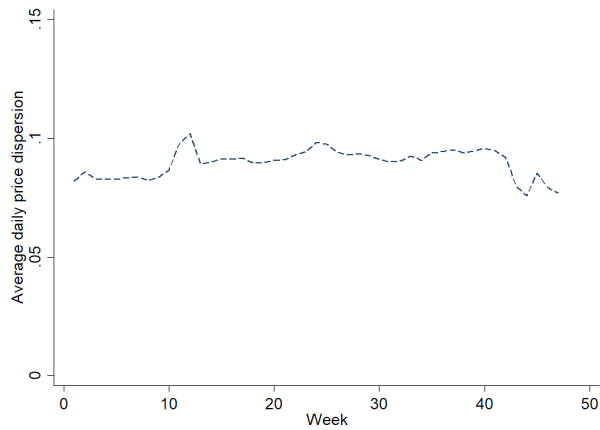


Figure 2 Average level of price dispersion over time

Table 1 gives a statistical description of the price dispersion of eight commodity categories and other related information. It can be seen that price dispersion exists in various commodity categories. The dispersion values in clothing, food and other high-frequency consumption are relatively small, and the dispersion values in traffic and communication, residential and other low-frequency consumption are relatively large, which is consistent with life experience. In addition, Table 1 also gives the average price of each major category. The transportation and communication categories include a variety of vehicles, and the residential category includes a small number of extra-large batches of building materials, so the average price is significantly higher. Considering the huge differences in the internal commodities of each category and the price showing a severely skewed distribution, we chose to control its logarithmic price in the empirical analysis. Table 1 gives the average of the log prices for each major category. The logarithmic price shows that the average price of the major categories of transportation and communications is significantly higher after reducing the impact of some special products.

Table 1 Price Dispersion, Price, *num.plat* in each Major Categories of Products

Major Categories	observations	Price dispersion	SSD of price dispersion	Mean price	Mean log price	Number of products	Mean <i>num.plat</i>
Transportation and communication	83,082	0.1099	0.1153	3544.47	6.27	426	2.03
Health care	164,449	0.0732	0.0899	758.99	4.29	1,289	1.30
Residence	102,197	0.1043	0.1166	82385.91	4.83	837	1.28
Education, culture and recreation	377,405	0.0926	0.0979	1237.95	5.36	2,140	1.90
Household articles and service	324,072	0.0985	0.0973	1096.25	5.50	1,313	2.28
Clothing	321,006	0.0748	0.1103	345.26	5.22	1,793	1.79
Food, tobacco & liquor	497,699	0.0854	0.0980	72.82	3.51	2,502	2.04
Other articles and services	85,518	0.1037	0.1117	925.50	5.48	500	1.96

Note: "Other supplies and services" mainly include jewelry watches, beauty salon services, and Nursing services, which are consistent with the catalogue of the NBS.

Finally, Figure 3 provides a descriptive plot of the price dispersion value and the relationship between the two key variables, weekdays/weekends, and the number of platforms. In order to better compare the overall difference in price dispersion when the values of the variables are different, we gather the graphs and plot them on average in weeks. We did not see a clear relationship between price dispersion and weekdays/weekends, but the price dispersion

seems to decrease as the number of merchandise on sale platforms increases. It should be noted that the statistical description given in Figure 3 corresponding to the mixed section data does not take into account the differences in the inherent properties of the commodity. Therefore, the comparison here may be affected by other missing variables. For example, as shown in Table 1, daily necessities (food, tobacco & liquor, etc.) are more expensive than consumers because they are often purchased, consumers have a better understanding of their information, so their price is less dispersion; When selling on more platforms, that is, across commodity comparisons, we will see a negative correlation between the number of platforms sold and the commodity price index. In other words, Figure 3 shows a negative correlation between price dispersion and the *num.plat* using model regression. However, the price dispersion here is not caused by platform competition, but because of the missing variables—the more complete information brought about by the consumable properties of the goods—there is no cross-sectional data that does not include any changes in the *num.plat*. In fact, the use of mixed-section regression does observe a negative correlation between weak price dispersion and the *num.plat.*, contrary to the panel regression model. This further validates the issue of studying price dispersion and the importance of using product panel data.

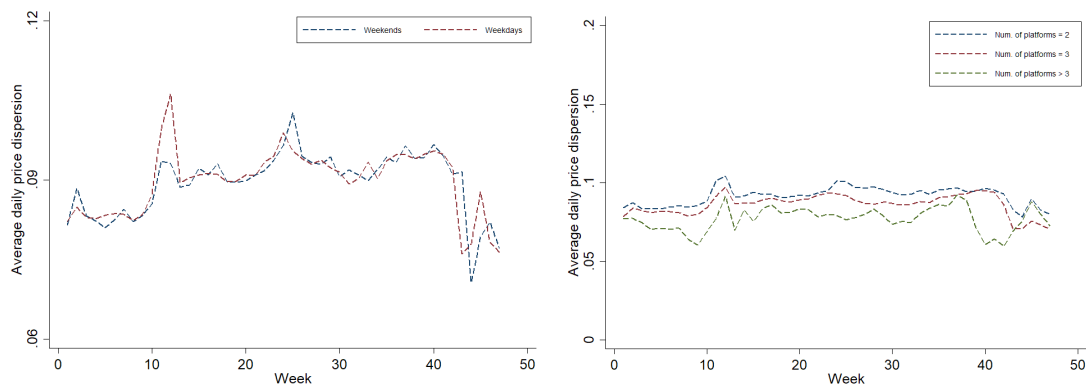


Figure 3 Relationship between *num.plat* & mean price dispersion in weekdays/weekends

4.2 The relationship between price dispersion and search cost and platform competition

This paper analyzes the relationship between price dispersion and the opportunity cost of consumer search (using weekdays and weekends as proxy variables) and platform competition (the number of platforms used as proxy variables) by constructing a fixed-effect panel regression model at the commodity level. The model controls both the price (log value) and the date of the item. The basic regression model used in this paper is as follows:

$$Dispersion_{it} = \beta_1 D_{Dow} + \beta_2 D_{\#platform} + c_i + \log(price_i) + date + \varepsilon_{it}$$

D_{Dow} is the dummy variable of each day of the week, $D_{\#platform}$ is the categorical variable of the number of platforms on which the commodity i is sold, and the *num.plat* is greater than 3. c_i represents the fixed effect of the commodity, and the basic regression controls both the average price of the commodity and the linear date effect. Among them, β_1 and β_2 are the two sets of coefficients we care about. Considering that the price of internal goods in the same category may be affected by the same macroeconomic factors, and the correlation is considered as much as possible at the highest category level, the standard deviation in return is in the category of commodities (40 in total) Do agglomeration. Considering the large amount of data used in this paper, the regression results are reported at the significance levels of 0.05, 0.01 and 0.001. The regression results are reported in Table 2.

Table 2 Relationship between Price Dispersion, Search Cost and Platform Competition

	(1)	(2)	(3)	(4)	(5)	(6)
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	Dispersion	Dispersion	Dispersion	Dispersion	Dispersion	Price
Day						
Monday	7.163e-04*** (4.768)		7.146e-04*** (4.269)		6.145e-04** (3.267)	2.692e-03*** (4.713)
Tuesday	1.193e-03*** (6.182)		1.193e-03*** (6.033)		1.230e-03*** (5.257)	3.922e-03*** (5.441)
Wednesday	1.097e-03*** (5.951)		1.028e-03*** (5.479)		1.069e-03*** (5.230)	4.277e-03** (3.486)
Thursday	4.919e-04*** (3.866)		4.951e-04*** (3.940)		3.208e-04* (2.350)	2.444e-03*** (4.403)
Friday	1.658e-04 (0.877)		1.302e-04 (0.680)		-4.110e-05 (-0.230)	1.331e-03* (2.201)
Saturday	2.413e-04* (2.040)		1.572e-04 (1.286)		6.635e-05 (0.570)	9.247e-04 (1.399)
<i>num.plat</i>						
2						-0.023* (-2.131)
3		0.016*** (10.900)	0.016*** (10.904)	0.018*** (11.360)	0.016*** (7.267)	-0.023 (-1.818)
>3		0.024*** (5.971)	0.024*** (5.969)	0.026*** (5.969)	0.023*** (7.250)	-0.036* (-2.379)
Log (Price)	0.105*** (6.072)	0.104*** (6.083)	0.104*** (6.082)	0.103*** (5.947)	0.108*** (6.525)	
Date	1.375e-05 (1.113)	1.999e-05 (1.641)	2.002e-05 (1.643)	Fixed-Effect	2.620e-05* (2.422)	1.020e-04*** (3.562)
<i>N</i>	1,299,809	1,299,809	1,299,809	1,299,809	1,063,465	1,955,428

In order to test the robustness of the model, in models (1) and (2), we examine the two key variables of workday/weekend and number of platforms, respectively. Two sets of variables were added simultaneously in model (3). Model (1) - (3) controls the average price (logarithm) and date (linear variable) of the product across platforms. The estimated performance of the model is very stable. We found that the price of the same commodity in the four days from Monday to Thursday was significantly higher than Friday, Saturday, and Sunday. Since Monday to Thursday are working days, consumers have higher opportunity costs for investing in online shopping searches, and the corresponding search costs are higher. Higher search costs increase the price dispersion value. According to Hypothesis 1, we speculate that some sellers may take the opportunity to adjust the price of goods and take advantage of the higher cost of consumer search to obtain higher profits. In model (6) we return the logarithmic price of the commodity as a dependent variable and find that the average price of the commodity is indeed higher than Friday to Sunday in four days of the week. And the effect has a certain economic significance, on Tuesday, Wednesday, the average price of goods is 0.4% higher than the weekend. These findings validate the hypothesis 1. Another consistent explanation is that online sellers offer discounts for attracting more passengers on weekends, and the “original price” on which the discount is based will be raised in the previous Monday to Thursday days to make it more tempting on weekends. Power discount. In the middle of the week, consumers have higher search costs and cannot fully compare prices. Different stores selling this product may be upgraded to different degrees. Since the discounted low price is usually easily converged by cost constraints, it is not capped on the so-called “original price” that was raised from Monday to Thursday for the manufacturing discount. Therefore, it shows a greater price dispersion in the first four days of the week.

Models (1)–(3) show that the cross-platform price dispersion value has a significant positive correlation with the *num.plat* on which the commodity is located on a single day. The

results show that when the *num.plat* on the day of the commodity changes from 2 to 3. At that time, the price dispersion value will increase by 0.016. The average price dispersion in the data is about 0.090, so the increase or decrease in the *num.plat* is very significant for price dispersion, which will result in a 17.8% change. Considering that changes in the *num.plat* in the iCPI database can only partially reflect changes in platform competition, the impact of full platform competition on price dispersion should be greater. The price dispersion did not decrease because of the increase in the *num.plat*. This finding is inconsistent with the traditional competition leading to a more uniform market price, and supports Hypothesis 2. If the consumer has high platform loyalty, the new platform cannot be obtained by many customers because of the low price. Therefore, the original platform will not lower the price due to the impact of the new platform. Then, after the new platform enters, the cross-platform price dispersion of goods will rise. In model (6), we also see some weak negative correlation between the increase in the *num.plat* and the average price of commodities, which is consistent with the interpretation of consumer platform loyalty.

Model (4) and model (5) tested the robustness of the regression results. Model (4) focuses on the robustness of platform competition and price dispersion results. Considering that only the date is controlled as a linear variable, there may be other missing variables that change over time, and model (4) adds a fixed effect for each day. The regression results show that the *num.plat* is very robust to the estimation of price dispersion.

In model (5), we further cleaned the data and removed data that was continuously maintained for less than 15 days after the *num.plat* changed. On the one hand, if there is a very short-term change in the *num.plat*, it is not excluded because the data crawling process is flawed; on the other hand, if a platform enters or exits the market for too short a time, and we have not observed the existing platform of the market. The strategy of price adjustment. Then we may not be able to distinguish whether the existing platform does not adjust the price because of consumer loyalty, or because the time is too short to make the corresponding price adjustment. After removing the data on the changes in the number of short-term platforms, the results of the model are still robust.

Table 2 has some other findings. The linear date variables added by the model are not significant overall, indicating that in 2017, the price dispersion of cross-platform merchandise did not change significantly over time. The rise and dispersion of commodity prices have a positive correlation, and this result also supports the hypothesis of platform loyalty to some extent. Consumers often show greater loyalty when the price of the item is higher – risk aversion makes consumers reluctant to risk buying on low-priced but unfamiliar platforms. Therefore, the price dispersion of goods across platforms will be higher.

4.3 Dynamic effects of price dispersion with the *num.plat*

In order to further verify that the impact of platform quantity changes on price dispersion is consistent with the consumer's platform loyalty hypothesis, we use the model of Table 2 (5) to observe the change process of the 15-day commodity price dispersion value before and after the change in the *num.plat*. To this end, we estimate a dynamic effect model, taking the day when the *num.plat* changes as a reference group, and examining the size of the price dispersion around this day. The control variables of the model are shown in Table 2 (5). Because the model estimates a large number of parameters, for ease of comparison, we plot the coefficients of the estimated results with their 95% confidence intervals (Figure 4).

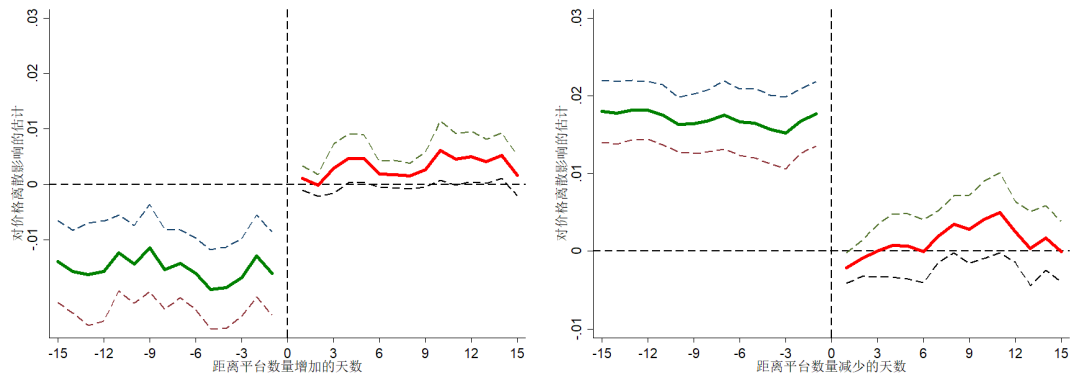


Figure 4 Change of price dispersion before and after the change of *num.plat*

The dynamic estimation of the price dispersion before and after the change of the *num.plat* shows that the price dispersion has changed correspondingly after the *num.plat* changes, and the change is entirely due to the change in the *num.plat* itself. In the period before or after the *num.plat* changed, there was no obvious change in the price dispersion of commodities across platforms. Therefore, the price dispersion observed in the previous section increases (or decreases) as the *num.plat* increases (or decreases) due to changes in the *num.plat*, new platforms entering or exiting; not because the platform feels the market structure A change caused by a strategic price adjustment. These results support the hypothesis that consumers have platform loyalty, that is, consumers will not change their choice of consumer platforms because of the entry of new platforms, so the market has no platform to adjust pricing due to changes in the competitive environment. These results support price-dispersion changes due to the entry of new low-cost platforms in the market, or the exit of a low-cost platform. The addition of platform sellers to the market means that competitive lower prices can be offered, and because consumers are loyal to existing platforms, existing platforms do not adjust prices because of new competition. After the *num.plat* increases, the dispersion value of the commodity price becomes larger. Conversely, a low-priced platform seller exits the market (sold out or can't continue to insist on low prices), and the reduction in the *num.plat* at this time will result in a smaller cross-platform price of the commodity. The above discussion means that the increase in the *num.plat* should be accompanied by a decrease in the average selling price of the goods, and the reduction in the *num.plat* should be accompanied by an increase in the average selling price of the goods. We perform a dynamic regression on the logarithmic price of the commodity and plot the coefficients and the 95% confidence interval in Figure 5. Although the results of the model estimates do not have clear conclusions, these estimates provide some evidence of the relationship between price and the *num.plat* in terms of changes in price levels.



Figure 5 Control platform effect, dynamic change of price dispersion before and after $\Delta num.plat$

4.4 Robustness test

In this paper, the coefficient of variation is chosen for the price dispersion measure, which is the ratio of the standard deviation to the mean. One possible concern with the calculation of the coefficient of variation is that it is more sensitive to the *num.plat*, especially when the *num.plat* is generally small in this study. In this section, we use another price-dispersion indicator that is relatively insensitive to the *num.plat*. The relative price difference is the ratio of the highest price to the lowest price across platforms and the lowest price. The relative spread can also be defined for only one platform. We use the relative price difference as the dependent variable and repeat the model (1)-(4) of Table 2. The regression results are reported in Table 3.

Table 3 Relationship between relative price difference, search cost & platform competition

	(1)	(2)	(3)	(4)
Day				
Monday	4.097e-04 (1.738)		9.882e-04*** (4.575)	1.152e-02** (3.305)
Tuesday	1.610e-03*** (3.688)		1.590e-03*** (4.934)	9.568e-03** (2.774)
Wednesday	2.080e-03*** (4.910)		1.342e-03*** (4.753)	4.956e-02*** (8.183)
Thursday	1.083e-03* (2.569)		8.179e-04*** (4.490)	9.888e-03** (2.892)
Friday	9.725e-04** (3.435)		9.570e-05 (0.402)	9.024e-03** (2.756)
Saturday	4.590e-04 (1.904)		2.719e-04 (1.644)	9.716e-03** (3.294)
<i>num.plat</i>				
2		0.159*** (18.304)	0.159*** (18.304)	0.161*** (17.947)
3		0.232*** (17.557)	0.232*** (17.560)	0.236*** (17.385)
>3		0.274*** (15.206)	0.274*** (15.207)	0.279*** (15.034)
Log (price)	0.028** (2.893)	0.034** (2.987)	0.034** (2.987)	0.033** (2.950)
date	-5.281e-05* (-2.695)	2.195e-05 (1.325)	2.202e-05 (1.328)	
<i>N</i>	1955428	1955428	1955428	1955428

The model results show that the relative price difference is higher on the working days than the weekend, and the *num.plat* is positively correlated with the relative price difference. The result of using the relative price difference as a price dispersion indicator is very robust overall.

5 Conclusion and Discussion

Search cost and platform competition are two sources of price dispersion that this paper concern about. Instead of cross-sellers as former studies, we test the cross-platforms price dispersion of online market products. According to the classical information economics theory, the increase in consumer search costs will increase the level of market price dispersion; while the industrial organization theory believes that price dispersion depends on the market structure,

and more intense competition may cause sellers to formulate low prices near the cost tolerance line, thereby reducing price dispersion levels. But if consumers show higher platform loyalty, more intense competition will increase the price dispersion of goods.

Utilizing more than 3.7 million iCPI databases of daily cross-platform commodity price data from January to November 2017, and calculating price dispersion data of nearly 2 million product-days, fixed-effect panel regression found cross-platform prices of products price dispersion values are significantly higher during the weekdays from Monday to Thursday than holidays from Friday to Sunday, and the average price in weekdays is also higher. This conclusion supports the search cost theory for price dispersion. The opportunity cost of consumer search is higher on weekdays, and platform sellers will use this opportunity to make more frequent price adjustments, and the average price is higher than the weekend. On the other hand, the cross-platforms price dispersion of products has a significant positive correlation with the *num.plat* they are listed on, contrary to the interpretation of traditional industrial organization competition theory and the interpretation based on platform loyalty. Considering that the *num.plat* used in this paper is only a weak proxy variable, the actual effect will be stronger than the results estimated in this paper.

The platform loyalty discussed in this article refers to the phenomenon that the users are bounded to use a certain platform, and would not change platform even if there are lower price from other platforms, but not just the user's consumption habits, platform services, or platform reputation. loyalty. In fact, the phenomenon of "lock-in" between users and platforms may be caused by other factors that are not directly related to consumption. Especially in China, online platforms tend to be out of consumption area, providing a full range of additional services that can lock consumers. (Lewandowski, 2016), such as social network, credit scores, and even financial support within each platform's business circle. These forms will further strengthen consumer "loyalty" to the platform. The findings of this paper suggest that this loyalty to the platform may have negative social welfare effects. Consumers are less likely to cross-platform search, while platform sellers take advantage of differentiated pricing behavior when consumers are searching for higher costs. Considering that China's online market will continue to flourish in the next few years, it is expected that the market retail sales will account for more than 50% of the global online market in 2019. Platform competition and its pricing strategies have important economic and social benefits. The findings of this paper have implications for China's platform supervision and governance in the Internet area.

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