Price Dispersion in Online Betting Markets

Oleksandr Talavera	Mo Tian	Huasheng Xiang
Swansea University	Swansea University	Swansea University

Abstract: This paper studies price dispersion and price setting behaviour in environment with different levels of managerial attention. This paper employs a unique high frequency dataset of the Eurovision Contest 2017 betting markets. Online betting markets have several special properties, such as low search costs, low menu costs, unlimited inventory, and no price discrimination. The markets are divided into four panels that reflect three different intensity levels of the markets. This paper documents that though the level of managerial attention in live periods are considerably higher than no-event periods and rehearsals periods, unexpected long durations of zero price changes are still observable during the live periods. Our findings confirm the importance of managerial attention in price setting behaviour. In addition, we find that competition can either increase or decrease price dispersion.

Keywords: Betting Markets, Price Dispersion, Managerial Attention, Competition

1. Introduction

The gambling market as a unique financial market has been increasing radically by internet. The worldwide online gambling revenue was about 46 billion U.S. dollars in 2016, which is more than 3 times of the total revenue in 2004[1]. In 2016, the Gambling Commission Industry Statistics shows that 33 percent of all gambling accounts are online gambling accounts in the UK[2]. Online gambling markets in the UK have been long benefited from the lack of tight regulation, which encourages the British market to be the largest online gambling market in the world.

Online gambling markets has smaller frictions compared to other markets, which makes the conventional theories of prices dispersion are likely to play much more limited roles. First, searching for the best price (Dahlby & West, 1986; Benabou, 1988; Morgan, Orzen, & Sefton, 2006) is no longer costly. Consumers can find the lowest price with just few clicks on price comparison. Second, physical menu costs (Sheshinski & Weiss, 1977) in online stores are much lower than brick-and-mortar stores. This allows online prices to respond to new coming shocks instantly. Third, transportation and delivery costs (Bergin & Glick, 2007) are negligible in online betting markets. The geographical distance between betting agencies and consumers is irrelevant on Internet, and therefore consumers do not need to travel around to find a physical store to bet. Fourth, betting markets do not have any limit on inventory (Borenstein & Rose, 1994) as the goods are in the form of bets that do not have any physical body.

This paper investigates the price dispersion and price setting behaviour in online betting market by using a unique high frequency data of betting odds (prices) for the Eurovision Contest 2017 collected from a betting aggregator platform. This dataset covers 42 countries in 19 different betting markets among 23 brokers. The time span of this dataset is two weeks that is much longer than the time span of sports betting markets (typically few hours or less).

We make two main contributions. First, it contributes to the literature as the first investigation of price dispersion and price setting behaviour among the betting brokers in the betting markets that are highly efficient. Previous studies on price dispersion (Baye, Morgan, & Scholten, 2004; Gorodnichenko, Sheremirov, & Talavera, 2018) focus on retail sectors. Second, our results confirm that the level of managerial attention has significant impact on price setting behaviour. The markets are divided into four different periods depending on the

[1] Financial Times https://www.ft.com/content/044a3d9e-7d1a-11e7-9108-edda0bcbc928?mhq5j=e5 retrieved on 07/10/2017
[2] Gambling Commission Industry Statistics http://www.gamblingcommission.gov.uk/news-action-and-statistics/news/2016/New-figures-show-online-gambling-is-largest-gambling-sector-in-Britain.aspx retrieved on 07/10/2017

level of managerial attention. During the grand-final broadcasting period, the level of managerial attention is the highest, whereas managers put little attention during the no-event periods. We document a set of proxies to examine the persistent of price dispersion. In we extract the bets with higher managerial attention, which allow us to see the impact of managerial attention on price setting behaviour.

Previous studies on betting markets only use one or two betting agents on events that have 2 to 10 participants (Brown A. , 2014; Brown & Yang, 2016). This paper focuses on price dispersion, and therefore we collect more betting agents and more variety of goods.

This paper finds that the online betting markets still have considerable frictions that cause price dispersion. We observe low frequency of price adjustment and long length of price spell, in the sense that the average lengths of price spell in live periods (2 to 3 hours) are about 11 hours in outright-winner market and 5 hours in top-10-finish market. This length is considerably longer than expected, suggesting high level of price stickiness.

We also find that sellers have different price setting behaviour under different level of market intensity, and therefore the predict power of traditional price dispersion sources is stronger if the costs of managerial attention are higher. However, managerial attention may not necessarily decrease the price dispersion. This is contrast to Ellison et al (2016) that if managers put more attentions on monitoring competitors' prices, the price dispersion goes smaller.

We find no evidence to support the search costs models from online betting markets. This paper shows that price dispersion tends to be smaller either if the price is extremely expensive or extremely cheap.

In contrast to any previous study, we find that competition can either increase or decrease price dispersion, depending on the market structure. Gorodnichenko & Talavera (2017) find that the more competitive market is, the less price dispersion we could observe. However, Stavins (2001) suggests that competition increases the price dispersion.

The rest of this paper is organised as 4 sections. Section 2 introduces the Eurovision Contest and betting market. Section 3 is description of data, which also provides the estimates of measures and sources of price dispersion. Section 4 presents the model we employed, regression results, and discussions. The final section concludes this paper.

2. The Eurovision and Betting Market

2.1. The Eurovision 2017

Before introducing the data, it is important to get some knowledge of the Eurovision Song Contest (Eurovision). The Eurovision is original released in 1956. Now it becomes to the most popular international live TV song competition. Each competitor submits a new original song and performs live in the competition. It is annually hosted by the winning country of the previous year. All the participating countries are the members of the European Broadcasting Union. In 2017, 42 countries participated in the competition. The formal competition is divided into three stages that are rehearsals, semi-finals, and grand-final. The timetable has been attached in appendix (Table A1). The semi-finals split into two groups, which were held on 9th May and 11th May respectively. Each group has 18 participating countries. The best 10 of each group will be promoted to the grand-final. Furthermore, the hosting country Ukraine and the big-five-countries, which include France, Germany, Spain, and United Kingdom, were automatically qualified to the grand-final. Therefore, a total of 26 countries were guaranteed to the final stage.

The voting system used in 2017 is a positional voting system. Each participating country has their own professional jury that is made up of five music industry professionals. The juries are responsible for evaluating and judging the overall performance of other countries' singer(s). Based on their evaluations, the best 10 countries get 12, 10, 8, 7, 6, …, 2, 1 points, respectively, sorted by the order. The points from juries are counted for 50 percent of the final score. The rest 50 percent comes from televoters. Same as the jury, the audience of each participating country votes the points to their 10 favourite songs. Notably, both juries and televoters cannot vote for their own country. The owner of highest final points wins the contest of the year.

2.2. The Betting Market

In this paper, we focus on the Eurovision betting book market in the UK. In the betting book market, prices are quoted in the form of odds. Usually, the odd is shown as either decimal or fraction form (Appendix figure A1 shows a screenshot of the fraction form and figure A2 shows the decimal form). The decimal odds are equal to the sum of one unit of stake and expected returns of one unit of stake. In other words, decimal odds are equivalent to the gross return of one unit of bet. The value of fraction odds is equal to the value of decimal odds minus one, which is equivalent to expected net profit. Because the denominator can be any integer equal

to or larger than one, the numerator is equal to the expected net profit of the amount of denominator. For example, if the decimal odds for an event is 2.5, then the fraction odds will be 3/2. As decimal number is more straightforward and easy to use, we collect the data in the form of decimals. The following example explains how the decimal odd works. Suppose the decimal odds for an event happening is 5, then for every pond stake will have 5 minus 1 pound, which is 4 pounds, as profit if the event occurs. Therefore, the odds must be higher than one, otherwise the demand of that event will be zero. On the other hand, if the betted event does not happen, the gamer will lose all the stakes that have been placed.

Importantly, the level of an odds corresponds to the expected probability of the relevant event occurring. In other words, if an event is likely to happen with a high probability in the future, the corresponding odds will be small. Odds are quoted from 1.01 to 1000 in betting markets. One over the odds, $1/Odds$, is the implied win probabilities (IWP) from 99% (odds of 1.01) to 0.1% (odds of 1000). We use the implied win probabilities as the measure of prices (Brown & Yang, 2016; Brown & Yang, 2017).

Although the betting odds have some common features as commodity prices or stock prices, it also has some differences. Betting odds have visible potential returns with certain chances whereas the surplus utilities of commodities are invisible and difficult to measure. From this sight, betting odds are much more similar to the stock prices and binary options. However. compared to stock prices, betting odds are more likely to have the feature of price stickiness in the whole life time.

3. The Data

We obtain high frequency panel data on the betting odds (prices) of the Eurovision 2017 UK betting market that includes 42 participating countries, 23 brokers, and 19 different markets through a betting aggregator platform provided by Easyodds. The list of all participating countries has been attached in appendix (Table A2). Although we have 19 different markets, we only focus on the two of the biggest markets: outright-winner market and top-10-finish market. The number of observations from outright-winner market accounts for 38.17 percent of the total observations and the observations of top-10-finish market holds 11.27 percent. The price data is collected from 29 Apr 2017 21:20:45 to the end of the Eurovision.

The frequency of our data varies over time as the expected frequency of arrival shocks are changing with the process of the contest. We collect the data about every 10 minutes from the beginning 29th April 2017 21:20 to 13th May 2017 11:30. From 13th May 2017 11:30, we collect the data about every 5 minutes until 13th May 2017 16:30. After that, the frequency of the data is about 2.5 minutes until 13th May 2017 18:02:30. Thereafter, we collect the data every 75 seconds until the end of contest.

In addition, we record a timetable and final version of press schedule. The timetable contains the exact times of each event happening, on show periods, and voting points released, which are accurate to seconds. Since the data set is recorded at very high frequency, we can easily match the recorded information to the price adjustments. The full coverage of the Eurovision 2017 with high frequency allows us to have a better understanding of how online prices react to every single shock and arrival news. However, our data do not cover the offline betting odds, so we cannot identify the movements of offline prices. This comprehensive data set also allow us to analyse the online price setting behaviours through the competition between brokers, examine the factors that lead to price dispersion across sellers, as well as investigate the impact of market characteristics on price adjustments.

Because the frequency of shocks comes in at very different level among different periods, we hypothesise that the price setting behaviour is different among different periods. Thus, we divide the contest into four different periods that are pre-event, no-event, rehearsals and semi-finals, as well as grand final periods. Pre-event period is the period before the first rehearsal happened. Literally, no-event periods do not have any hard information coming in to the markets. Rehearsals and semi-finals periods cover all the rehearsals and semi-finals. As expected, different period does have different price setting behaviour. This can be reflected from the summary statistics and regression results. Detailed discussion is presented in the section 4.2.

We focus on the good level in this paper, each possible outcome in a specific market provided by a single broker is defined as a unique good. For example, Betfair (a betting agency) offers the odds 23 for Armenia winning in the outright-winner market at 05 May 2017 20:30:54, which is defined as a unique good at that time. Unfortunately, we do not have information on trading volumes. Thus, we cannot capture the momentum and trend. However, the full coverage of price data is long enough to allow us accurately measure broker entry and exit, impact of arrival information, and price behaviour during the whole contest. In short, this dataset on

online betting prices provides a relatively comprehensive information on online pricing behaviour.

3.1. Summary of the Data

Notation

We use $IWP_{c,b,m,t}$ to denote the implied win probability that is offered by broker (seller) b for country (good) c in market m at time t. We denote the set of all participating countries, all brokers, all markets, and all the time as C= {1, …, N}, B= {1, …, S}, M= {1, …, L}, and T= {1, …, T}, respectively, where N is the number of participating countries in the dataset and S is the number of brokers. We use subscripts c, b, and m to indicate a specific subset of C, B, or M that correspond to a given participating country or broker or market. For example, $N_{b,m}$ is the number of goods offered by broker b, and $C_{b,m}$ is a subset of C that indicates the set of all goods offered by broker c in market m. Similarly, $S_{c,m}$ is the number of brokers offering good c, and $B_{c,m}$ belongs to the set B that contains all brokers that offer good c in market m.

Price Distribution

It is important to know how odds are distributed in these markets. If the odds are randomly distributed, the market is inefficient, which means the odds may not adjust across the betting brokers. To illustrate this, we compute the average ln deviation of the IWP of broker b from the median IWP across brokers by using the equation below,

$$\ln \overline{IWP}_{c,b,m} = \frac{1}{T}\sum_t ln(IWP_{c,b,m,t}/\widehat{IWP}_{c,m,t})$$

Figure 1 shows the average ln IWP distribution for all the participating countries in outright winner market and top 10 finish market, respectively. The horizontal axis indicates deviations from the median IWP and the vertical axis is the density of deviations. In outright winner market, most IWP are within 1 unit of the median price. In top 10 finish market, most IWP are within 0.2 unit of the median price. The IWPs are mostly distributed around the median price. Especially, the densities of 0 deviation IWP in both markets have the highest weights. This means that most brokers tend to set the prices around or on the median prices. In other words, the IWPs are not randomly distributed, and these markets do have efficiency at a certain degree.

In order to see the effects of managerial attention on price dispersion predictors, we select the best 5 countries in outright-winner market and ranked 5 to 15 countries in top-10-finish market to run addition regressions. Compared to other participants, the selected countries are considered as having higher managerial attention. The summary statistics for the selected countries are also reported in each table.

Figure 1. Distribution of Average ln IWP

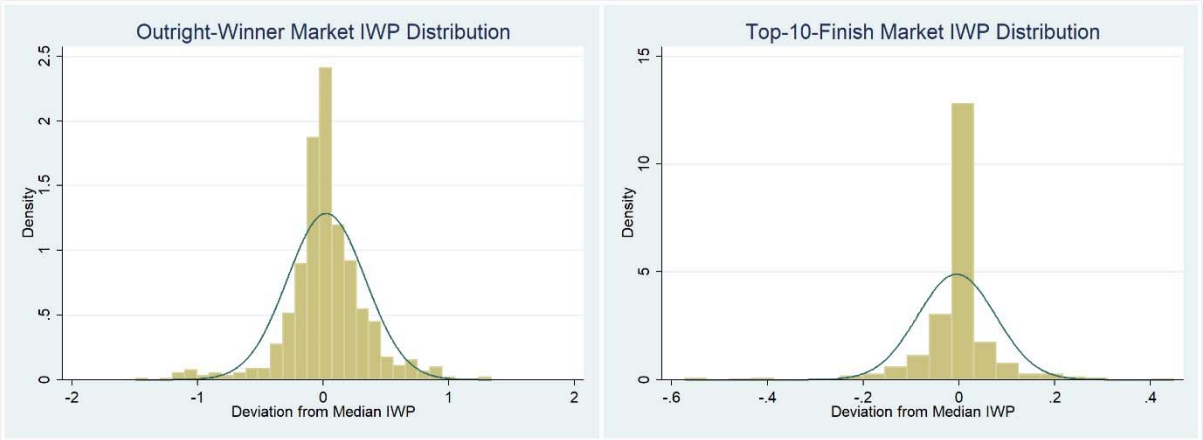


Table 1. Distribution of Average IWP as Percentage

Note: All the IWP have been multiplied by 100

	Outright-Winner Market			Top-10-Finish Market		
	Mean	**sd**	**N**	**Mean**	**sd**	**N**
Panel A: Pre-Event (Time: 29Apr2017 21:20:45 – 30Apr2017 08:00:00)						
	All Participating Countries			*All Participating Countries*		
Average IWP	3.77	8.57	2,184	-	-	0
	Best 5 Countries Only			*Ranked 5-15 Countries Only*		
Average IWP	8.47	4.99	260	-	-	0
Panel B: No-Event After the First Rehearsal						
	All Participating Countries			*All Participating Countries*		
Average IWP	3.75	9.58	39,470	30.54	26.05	33,205
	Best 5 Countries Only			*Ranked 5-15 Countries Only*		
Average IWP	8.47	7.27	5,015	43.17	24.15	8,500
Panel C: Rehearsals and Semi-Finals						
	All Participating Countries			*All Participating Countries*		
Average IWP	3.93	9.63	33,803	33.01	27.25	28,812
	Best 5 Countries Only			*Ranked 5-15 Countries Only*		
Average IWP	10.08	9.93	4,670	44.08	23.47	8,150
Panel D: Grand Final (Time: 13May2017 20:00:00 – 13May2017 23:34:54)						
	All Participating Countries			*All Participating Countries*		
Average IWP%	4.88	10.84	4,550	42.37	30.91	3,952
	Best 5 Countries Only			*Ranked 5-15 Countries Only*		
Average IWP%	17.44	17.79	875	46.85	23.77	1,520

Table 1 reports the descriptive statistics of the average implied win probabilities as percentage, $\overline{IWP}_{c,m,t}\%$, and standard deviations among the four different panels for outright-winner market and top-10-finish market. In general, the IWPs in top-10-finish market are about 10 times higher than the IWPs in outright-winner market. This is because top-10-finish market is betting on the best 10 countries whereas outright-winner market focus on the winner only. It is also reasonable that the average IWPs are increasing from Panel A to Panel D that some participating countries are eliminated during the semi-finals and therefore increases the average win probabilities. Compared to the average IWPs of all participating countries, the selected countries with higher level of managerial attention have higher IWPs. This indicates that betting brokers put more attentions on expensive or favourite bets.

3.2. Price Dispersion Measures

We use 4 different measures to calculate the level of price dispersion. The measures are standard deviation (SD), coefficient of variation (CV) of the IWPs, the difference between the highest and lowest IWPs (H-L), and the difference between 75 percentiles and 25 percentiles of the IWPs (p75/p25). Table 2 reports the summary statistics of the price dispersion measures for outright-winner market and top-10-finish market, respectively. We use the following equations to calculate these different measures:

Standard Deviation: $SD_{c,m,t} = \sqrt{\frac{\sum_b (IWP_{c,b,m,t} - \overline{IWP}_{c,mt})^2}{S_{c,m} - 1}}$

Coefficient of Variation: $CV_{c,m,t} = SD_{c,m,t} / \overline{IWP}_{c,m,t}$

Highest – Lowest Odds: $H - L_{c,m,t} = \max(IWP_{c,b,m,t}) - \min(IWP_{c,b,m,t})$

75 percentiles – 25 Percentiles: $p75/p25_{c,m,t} = \mathrm{p75}(IWP_{c,b,m,t}) - \mathrm{p25}(IWP_{c,b,m,t})$

Table 2 shows the summary statistics of the 4 different price dispersion measures among different periods for all participating countries and selected countries only in outright-winner market and top-10-finish market, respectively. As shown, though shocks come into markets for different periods at very different frequencies, the levels of price dispersions do not have huge difference among different periods. This illustrates that the level of price dispersion may be not affected by the frequency of shocks. In other words, the level of price dispersion would not be changing significantly with the process of asset fundamentals revealing. Comparing all

participating countries, the selected countries with higher managerial attentions have higher price dispersion except the measure coefficient of variation. Coefficient of variation is generalised by the mean level, so it could have different trend from other measures. This shows that higher level of managerial attention increases scale of the price setting among sellers.

Table 2. Summary of Different Measures of Price Dispersion

	Outright-Winner Market (Number of Brokers > 3)			Top-10-Finish Market (Number of Brokers > 3)		
	Mean	**sd**	**N**	**Mean**	**sd**	**N**
Note: Except coefficient of variation, all other measures have been multiplied by 100.						
Panel A: Pre-Event (Time: 29Apr2017 21:20:45 – 30Apr2017 08:00:00)						
	All Participating Countries			*All Participating Countries*		
Standard Deviation	0.61	0.53	2,184	-	-	0
Coefficient of Variation	0.27	0.10	2,184	-	-	0
Highest – Lowest	2.33	2.21	2,184	-	-	0
p75 - p25	0.66	0.64	2,184	-	-	0
	Best 5 Countries Only			*Ranked 5-15 Countries Only*		
Standard Deviation	1.29	0.63	260	-	-	0
Coefficient of Variation	0.16	0.05	260	-	-	0
Highest – Lowest	4.67	2.40	260	-	-	0
p75 - p25	1.29	1.23	260	-	-	0
Panel B: No-Event After the First Rehearsal						
	All Participating Countries			*All Participating Countries*		
Standard Deviation	0.56	0.50	39,428	1.23	1.11	29,942
Coefficient of Variation	0.32	0.15	39,428	0.06	0.05	29,942
Highest – Lowest	2.13	1.97	39,428	2.94	2.86	29,942
p75 - p25	0.59	0.62	39,428	1.44	1.55	29,942
	Best 5 Countries Only			*Ranked 5-15 Countries Only*		
Standard Deviation	1.16	0.59	5,010	1.53	1.25	7,430
Coefficient of Variation	0.20	0.15	5,010	0.05	0.04	7,430
Highest – Lowest	4.35	2.46	5,010	3.76	3.55	7,430
p75 - p25	1.13	0.91	5,010	1.82	1.64	7,430
Panel C: Rehearsals and Semi-Finals						
	All Participating Countries			*All Participating Countries*		
Standard Deviation	0.54	0.52	33,780	1.44	1.42	28,526
Coefficient of Variation	0.32	0.15	33,780	0.07	0.06	28,526
Highest – Lowest	2.07	2.04	33,780	3.65	4.00	28,526
p75 - p25	0.57	0.65	33,780	1.68	1.63	28,526
	Best 5 Countries Only			*Ranked 5-15 Countries Only*		
Standard Deviation	1.16	0.66	4,670	1.85	1.95	8,070
Coefficient of Variation	0.18	0.13	4,670	0.06	0.07	8,070
Highest – Lowest	4.38	2.68	4,670	4.94	5.81	8,070
p75 - p25	1.23	0.93	4,670	1.96	1.79	8,070
Panel D: Grand Final (Time: 13May2017 20:00:00 – 13May2017 23:34:54)						
	All Participating Countries			*All Participating Countries*		
Standard Deviation	0.75	1.45	4,280	1.20	1.20	3,224
Coefficient of Variation	0.29	0.16	4,280	0.05	0.05	3,224
Highest – Lowest	2.06	3.90	4,280	2.65	3.13	3,224
p75 - p25	1.01	2.32	4,280	1.43	1.32	3,224
	Best 5 Countries Only			*Ranked 5-15 Countries Only*		
Standard Deviation	2.21	2.55	873	1.46	1.62	1,240
Coefficient of Variation	0.24	0.25	873	0.04	0.06	1,240
Highest – Lowest	6.17	6.65	873	3.29	4.43	1,240
p75 - p25	2.93	4.28	873	1.62	1.52	1,240

3.3. Predictors of Price Dispersion

Broker Turnover Although the data set includes 23 brokers in total, brokers can freely enter, exit, and re-enter the market. Therefore, the number of brokers for a bet may vary over time. To capture the entry and exit effect, we use broker turnover to measure how many brokers are active in the markets. The broker turnover is defined as the number of active brokers at time t, $S_{c,m,t}$, over the number of brokers at the corresponding sub-period, $S_{c,m,p}$. Sub-period is the period between two different events. For example, the first sub-period is from the first observation to the first rehearsal and the second sub-period is from the beginning of first rehearsal to the end of first rehearsal, and so on. Eventually, the contest is divided into 35 sub-periods (see appendix Table A1). Thus, the barriers to entry is higher if the turnover is lower.

$$Turnover_{c,m,t} = S_{c,m,t}/S_{c,m,p}$$

Size of Changes After a shock, brokers increase (decrease) the prices reacting to higher (lower) chances of the participating countries to promotion. The lowest IWP and the second lowest IWP we can observe are $\frac{1}{751}$ and $\frac{1}{701}$ respectively. The difference between $\frac{1}{701}$ and $\frac{1}{751}$ is approximately 0.000095, thus we use $\chi_{c,b,m,t} = I\{|\Delta IWP_{c,b,m,t}| > 0.00009\}$ as the indicator function for a non-zero price change, and $\Pi_{c,m,t} = \sum_b \chi_{c,b,m,t}$ as the number of observed non-zero price changes for country c in market m at time t. Then, the absolute size of changes for participating country c in market m at time t is,

$$|\Delta IWP_{c,m,t}| = \frac{\sum_b |\Delta IWP_{c,b,m,t}| \cdot \chi_{c,b,m,t}}{\Pi_{c,m,t}}$$

Frequency We use the IWP changing frequency as a proxy of the level of price stickiness. High frequency of price changes indicates that brokers can easily change the prices, i.e. the level of price stickiness is low. The frequency is calculated for every 10 minutes. We compute the frequency of price changing per quote line as the number of non-zero price changes divided by the ratio of time gap between Δt and 10 minutes, where Δt is the time gap between two neighbouring observations and is observed in minutes. This measure is aggregate to good level. We denote the total number of price changes including zero changes per quote line as $D_{c,m,t}$. Therefore, the proportion of price changes across brokers can be written as $z_{c,m,t} =$

$\sum_b \chi_{c,b,m,t} / D_{c,m,t}$. Thus, we have the equation below,

$$f_{c,m,t} = z_{c,m,t} / (\frac{\Delta t}{10})$$

Proportion of Price Changes In this paper, the frequency of price changes is equivalent to the proportion of price changes for every 10 minutes. However, frequency cannot identify whether the price change is positive or negative. Therefore, we use proportion of price changes with positive or negative sign as an alternative measure of price changing frequency. We use $\Pi^{+}_{c,m,t}$ and $\Pi^{-}_{c,m,t}$ to denote the number of positive changes and negative changes per quote line, respectively. $\Delta IWP_{c,b,m,t}$ is the size of changes of participating country c of broker b in a given market m at time t. Thus, we count 1 positive change for every $\Delta IWP_{c,b,m,t} \cdot \chi_{c,b,m,t} > 0$ and 1 negative change for every $\Delta IWP_{c,b,m,t} \cdot \chi_{c,b,m,t} < 0$ per quote line. Therefore, the proportion of price changes for every 10 minutes can be expressed as, (we denote proportion of positive changes as $PP_{c,m,t}$ and proportion of negative changes as $PN_{c,m,t}$)

$$PP_{c,m,t} = \Pi^{+}_{c,m,t} \cdot (\frac{\Delta t}{10}) / D_{c,m,t}$$

$$PN_{c,m,t} = \Pi^{-}_{c,m,t} \cdot (\frac{\Delta t}{10}) / D_{c,m,t}$$

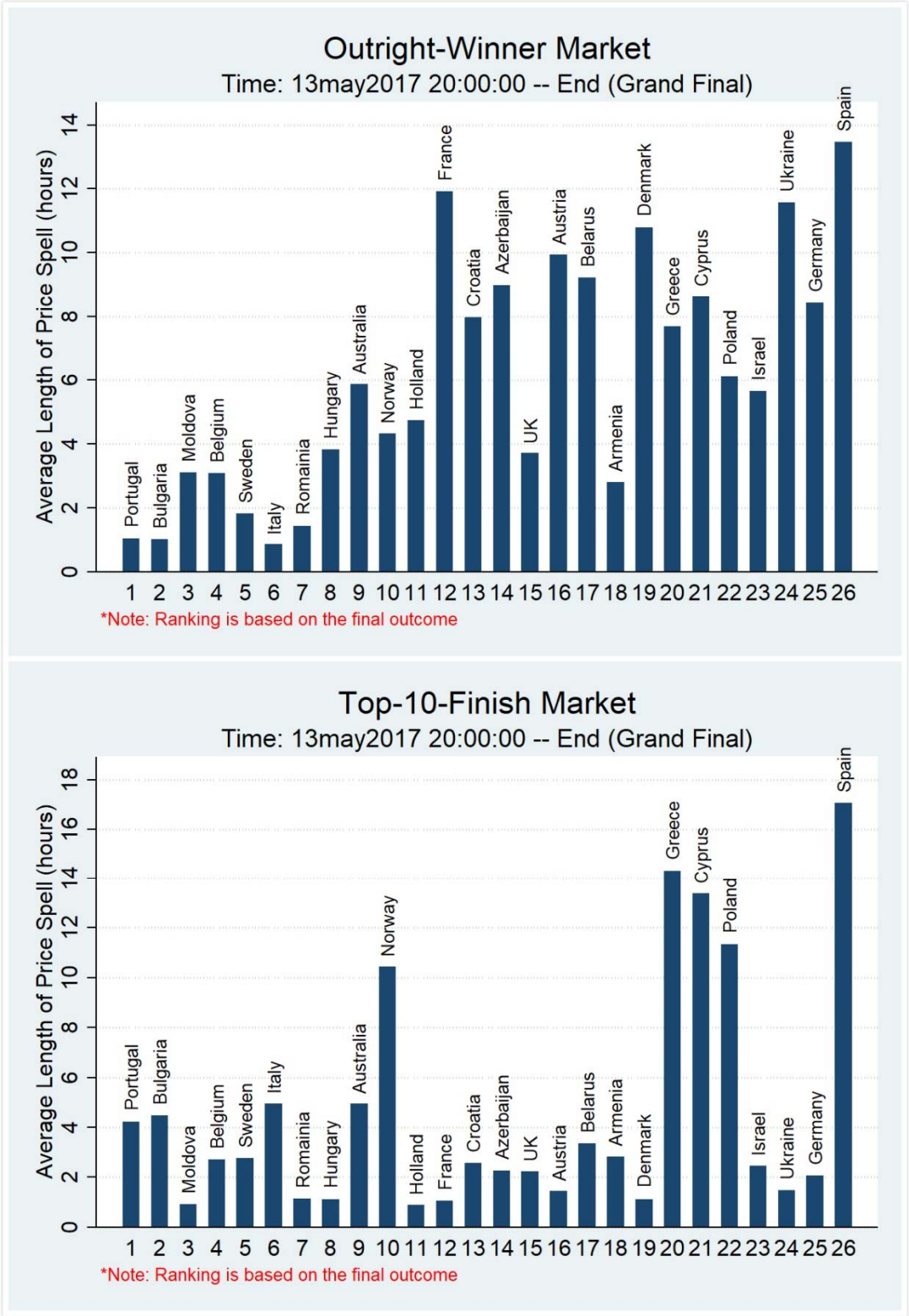
Length of Price Spells Notably, length of price spells means the time since last observed non-zero change. length of price spells is designed for measuring the life time of a price in the market, which is also a measure of the level of price rigidity. We define the length of price spells per quote line as below,

$$Length\ of\ Price\ Spells_{c,m,t} = \frac{1}{S_{c,mt}} \sum_b Length\ of\ Price\ Spells_{c,b,m,t}.$$

Figures 2 shows the length of price spells for the 26 final qualified countries during the grand final broadcasting period. In outright-winner market, the length is increasing with the increase of ranking. In top 10 finish market, the countries around 10 have the shortest length of price spells, the countries ranked 20 and above have relatively longest length of price spells. In other words, the degree of price rigidity is considerably smaller when the goods have higher level of

managerial attention.

Figure 2. Length of Price Spells and Rankings of the Country



The first two row of each panel in Table 3 shows the number of brokers and broker turnover for all participating countries and the selected countries, respectively. The mean of number of brokers in live periods of both tables are smaller than the no event and rehearsals periods. For both markets, the broker turnovers are higher than 0.95 during the no-event and rehearsals and semi-finals periods. However, on average, only 15 percent of brokers in outright-winner market and 58 percent in top-10-finish market still trading during the grand final period. This indicates that it is easier to enter or re-enter the markets during the periods where markets are not intensive, but it is not easy for sellers to survive when markets are intensive.

The third rows and fourth rows report the absolute size of changes and price adjust frequency for every 10 minutes. The average size of changes and changing frequency for panel B and panel C are approximately equal to 0 and most of them are 0. This is that brokers do not adjust their price very frequent when sellers anticipate that no significant shocks are coming into the market. The average changing frequency increases to 0.19 in outright-winner market and 0.13 in top-10-finish market. This is because more shocks can be observed during the grand-final period, brokers tend to adjust the prices more frequent to react to the more frequent arrival shocks. In addition, the frequency is increased by 0.06 during the grand final period in outright-winner market, which indicates that higher level of managerial attention indeed increases the price changing frequency when markets are more intensive.

The last row in each panel of Table 3 reports the length of price spells. Although the it is decreasing sharply from no-event periods to grand final periods, we can still observe about 11 hours and 6 hours in outright-winner market and top-10-finish market, respectively. Compared with all participating countries, the selected countries with higher managerial attention have considerable shorter length of price spells. One may interpret this as suggesting managers put most of their attentions on the most uncertain bets and they do not care the bet that has an extremely high probability to win or loss. In other words, managerial attention helps to reduce the price rigidity.

Table 3. Summary Statistics of Variables

	Outright-Winner Market (S > 3)				Top-10-Finish Market (S > 3)			
Note: Frequency and Size of Changes are calculated every 10 mins; The Length of Price Spells are measured in days.								
Panel A: Pre-Event (Time: 29Apr2017 21:20:45 – 30Apr2017 08:00:00)								
	Mean	**sd**	**Median**	**N**	**Mean**	**sd**	**Median**	**N**
	All Participating Countries				*All Participating Countries*			
Number of Brokers (S)	18.61	0.52	19.00	2,184	-	-	-	0
Broker Turnover	0.98	0.03	1.00	2,184	-	-	-	0
Frequency	0.00	0.00	0.00	2,142	-	-	-	0
Size of Changes	0.00	0.00	0.00	2,142	-	-	-	0
Length of Price Spells	0.20	0.11	0.20	2,142	-	-	-	0
	Best 5 Countries				*Ranked 5-15 Countries Only*			
Number of Brokers (S)	18.65	0.48	19.00	260	-	-	-	0
Broker Turnover	0.98	0.03	1.00	260	-	-	-	0
Frequency	0.00	0.00	0.00	255	-	-	-	0
Size of Changes	0.00	0.00	0.00	255	-	-	-	0
Length of Price Spells	0.20	0.12	0.20	255	-	-	-	0
Panel B: No-Event After the First Rehearsal								
	All Participating Countries				*All Participating Countries*			
Number of Brokers (S)	18.08	2.64	18.00	39,428	5.95	1.60	6.00	29,942
Broker Turnover	0.95	0.09	1.00	39,428	0.99	0.03	1.00	29,942
Frequency	0.01	0.03	0.00	39,428	0.00	0.02	0.00	29,942
Size of Changes	0.00	0.00	0.00	39,428	0.00	0.00	0.00	29,942
Length of Price Spells	1.55	0.83	1.46	39,428	1.32	0.83	1.20	29,942
	Best 5 Countries				*Ranked 5-15 Countries Only*			
Number of Brokers (S)	17.92	2.74	17.00	5,010	6.06	1.68	6.00	7,430
Broker Turnover	0.94	0.10	1.00	5,010	0.99	0.03	1.00	7,430
Frequency	0.01	0.04	0.00	5,010	0.00	0.03	0.00	7,430
Size of Changes	0.00	0.00	0.00	5,010	0.00	0.00	0.00	7,430
Length of Price Spell	1.17	0.81	1.06	5,010	1.14	0.76	0.94	7,430
Panel C: Rehearsals and Semi-Finals								
	All Participating Countries				*All Participating Countries*			
Number of Brokers (S)	18.63	2.49	19.00	33,780	6.97	2.17	6.00	28,526
Broker Turnover	0.95	0.09	1.00	33,780	0.97	0.09	1.00	28,526
Frequency	0.01	0.05	0.00	33,780	0.01	0.05	0.00	28,526
Size of Changes	0.00	0.00	0.00	33,780	0.00	0.00	0.00	28,526
Length of Price Spells	1.29	0.82	1.16	33,780	0.96	0.77	0.77	28,526
	Best 5 Countries				*Ranked 5-15 Countries Only*			
Number of Brokers (S)	18.75	2.46	20.00	4,670	7.13	2.04	7.00	8,070
Broker Turnover	0.95	0.08	1.00	4,670	0.97	0.09	1.00	8,070
Frequency	0.02	0.07	0.00	4,670	0.01	0.07	0.00	8,070
Size of Changes	0.00	0.00	0.00	4,670	0.00	0.00	0.00	8,070
Length of Price Spells	0.93	0.78	0.69	4,670	0.77	0.70	0.49	8,070
Panel D: Grand Final (Time: 13May2017 20:00:00 – 13May2017 23:34:54)								
	All Participating Countries				*All Participating Countries*			
Number of Brokers (S)	7.76	2.71	7.00	4,280	4.66	1.41	4.00	3,224
Broker Turnover	0.41	0.14	0.37	4,280	0.58	0.18	0.50	3,224
Frequency	0.19	0.67	0.00	4,280	0.13	0.49	0.00	3,224
Size of Changes	0.00	0.03	0.00	4,280	0.00	0.02	0.00	3,224
Length of Price Spells	0.26	0.26	0.20	4,280	0.21	0.25	0.09	3,224
	Best 5 Countries				*Ranked 5-15 Countries Only*			
Number of Brokers (S)	7.77	2.59	7.00	873	4.66	1.41	4.00	1,240
Broker Turnover	0.41	0.14	0.37	873	0.58	0.18	0.50	1,240
Frequency	0.25	0.65	0.00	873	0.12	0.47	0.00	1,240
Size of Changes	0.01	0.05	0.00	873	0.00	0.02	0.00	1,240
Length of Price Spells	0.08	0.13	0.02	873	0.15	0.17	0.07	1,240

4. The Model and Results

4.1. The Model

This paper studies price setting behaviour in online betting market. We use fixed effects model to test the contributions of several predictors on price dispersion. However, standard techniques may fail take the spatial and temporal forms of cross-sectional correlation into account. Driscoll and Kraay (1998) introduce a nonparametric covariance matrix estimator for fixed-effects panel regression. The standard errors produced by this method are heteroscedasticity consistent and robust to the spatial and temporal forms.

$$Price\ Dispersion_{c,m,t} = \beta_{c,m} X_{c,m,t} + \alpha_{c,m} + \mu_{c,m,t}$$

Where,

- $\alpha_{c,m}$ (c = 1 … N, m = 1 … L) are the unknown intercepts for each specific good;

- $X_{c,m,t}$ are predictors of price dispersion;

- $\beta_{c,m}$ are the coefficients for the predictors;

- $\mu_{c,m,t}$ are the error terms.

4.2. Results and Discussions

Previous studies emphasise five broad sources of price dispersion. First, the level of market competition has impact on the level of price dispersion. The second source is search cost. Searching for the lowest price is costly for consumers. Third, sellers set prices at different times and frequencies in order to react arrival shocks that include new information of the product fundamental value, and demand and supply conditions (Nakamura et al 2011). Fourth, price discrimination causes price dispersion. Sellers set a good at different prices to different group of consumers (Kaplan and Menzio 2015). Fifth, managers of the business face costs of managerial attention (Ellison et al 2016). In the betting market, price discrimination is rarely observed. Thus, we run panel regressions with fixed effect to explore the importance of these sources on price dispersion.

As we focus on outright-winner market and top-10-finish market, we run regressions separately for each market. The regression results will full predictors for standard deviation are presented in Table 4. The results for other price dispersion measures are relegated into appendix

(Table B2- B4). Table 5 shows the results for the selected countries with higher managerial attention. However, we are unable to estimate the pre-event period (panel A) by using the nonparametric covariance matrix estimator, because the variance matrix for panel A is highly singular. Thus, we use fixed effect model with sandwich estimator in panel A and the results are relegated into appendix (Table B1).

In betting markets, we tend to find that the degree of price dispersion has different dynamics under different markets and levels of managerial attention. The signs of the estimated coefficients on some variables are different between outright-winner and top-10-finish market, such as ln number of brokers (measuring the competition level of the markets), broker turnover (measuring the difficulty of entry), and length of price spell (measuring the degree of price rigidity). If several conditions are achieved, the price dispersion could be minimised or even be eliminated.

As the special properties of gambling markets, search costs models, which indicate that a higher unit price gives higher returns on search and therefore encourages consumers to search the lowest price and leads to a lower price dispersion, are no longer suitable. We apply quadratic form of median IWP as the proxy of price level in both markets in which higher IWP means higher price. These two markets show similar magnitudes of the estimated coefficients on median IWP. As the signs of the median IWPs are all positive and the signs of the squared median IWP are all negative, the price dispersion would be minimised if the median IWP is extremely low or extremely high (maximised if the median IWP is between 0.25 to 0.60). In other words, higher uncertainty, i.e. moderate price level, is associated with higher price dispersion in gambling markets. This is reasonable as the higher the uncertainty the more difficult for brokers to estimate the win probability.

We find that the level of market competition has significant impact on the level of price dispersion. However, our results do not consistent with any previous studies. We use ln number of brokers as a proxy of market competition. These two markets show opposite results. In outright-winner market, a larger number of sellers is associated with a smaller price dispersion. However, the sign of the coefficients are positives in top-10-finish market. This indicates that competition decreases the price dispersion in outright-winner market and increases the price dispersion in top-10-finish market. This may due to the difference of the market structures?

Broker turnover – Berries to entry?

Consistent with the price stickiness model and menu costs model (Calvo 1983; Sheremirov 2015), our results show that higher proportion of price changes at a time tend to lower price dispersion. The menu costs are negligible in online betting markets. Thus, brokers should be

able to adjust the prices to react arrival shocks and changes in demand instantly. In other words, betting odds can easily catch up with the revealed fundamental values of the bets, which reduces the price dispersion. Absolute size of changes is an alternative proxy of price stickiness. Our results suggest that larger absolute size of price changes produces higher price dispersion. This estimation is consistent with the predictions of stick-price models that predict a negative relationship between proportion of price changes and size of changes.

Length of price spell – price rigidity?

We control the level of managerial attentions by dividing the markets into four panel in which the level of managerial attention is increasing from panel A to panel D. The costs of managerial attention are higher when the level of managerial is lower. In addition, we can also see the effects of managerial attention on price setting behaviour by comparing the difference between Table 4 and Table 5. Some rules can be found from our results. First, managerial attention does not impact the relationship between any proxies and the level of price dispersion. Second, proportion of IWP changes tend to be more significant and powerful when managerial attention is higher, as the magnitude of the coefficients are larger. Third, higher costs of managerial attention generally increase the prediction power of price level on price dispersion. One may interpret this result as suggesting that managers are easier to monitor and match their competitors' price when the costs of managerial attention is lower, which eliminate the predictor power of price level. These evidences suggest that price setting behaviour indeed highly depends on the level of managerial attention.

Overall, the regression results suggest that price dispersion can be affected by multiple sources. In online gambling market, the level of market competition, search costs, price stickiness, and managerial attentions are important factors to predict price dispersion. The results for other price dispersion measures are consistent. In addition, the estimate results are still consistent after removing seller fixed effects as shown in appendix C.

Table 4. Main Regressions of Price Dispersions for All Participating Countries

	Panel B: No Event (No rehearsal and no live periods)		Panel C: Rehearsals and Semi-Finals (All event periods except Grand Final)		Panel D: Grand Final (Grand final live period only)	
Market	Outright-Winner	Top-10-Finish	Outright-Winner	Top-10-Finish	Outright-Winner	Top-10-Finish
	(1)	(2)	(3)	(4)	(5)	(6)
	SD	SD	SD	SD	SD	SD
Median IWP	5.878***	2.408**	6.443***	0.614	-4.164	7.694***
	(10.129)	(2.818)	(19.426)	(1.574)	(-1.516)	(4.083)
Median IWP sq	-6.784***	-5.413***	-5.415***	-5.129***	7.928	-6.193**
	(-7.227)	(-7.257)	(-9.801)	(-10.870)	(1.880)	(-3.629)
ln Number of Brokers	-0.120*	0.622***	-0.179	0.692***	-1.245***	6.940***
	(-2.194)	(6.355)	(-1.860)	(9.628)	(-7.851)	(6.314)
Broker Turnover	0.417***	-2.231*	0.363*	-0.943***	1.750***	-7.542***
	(4.407)	(-2.448)	(2.287)	(-3.900)	(6.207)	(-5.024)
Proportion of Increased IWP	-0.440**	-1.900*	-0.648***	-0.567	-0.275***	-0.084
	(-2.858)	(-2.290)	(-5.054)	(-1.412)	(-5.906)	(-1.565)
Proportion of Decreased IWP	-0.260*	-0.795	-0.053	-0.593	-0.216**	-0.138*
	(-2.329)	(-0.775)	(-0.600)	(-1.484)	(-3.133)	(-2.148)
Absolute Size of IWP Changes	22.493*	75.951*	30.576**	39.911**	23.202***	10.266***
	(2.634)	(2.584)	(2.907)	(2.775)	(7.425)	(8.199)
Length of Price Spells	0.028***	-0.131***	0.048***	-0.168***	0.042	-0.877*
	(4.041)	(-7.797)	(5.523)	(-6.964)	(0.244)	(-2.756)
Δt	-0.006	0.046***	0.517*	-2.118***	-0.330	0.629
	(-0.360)	(5.922)	(2.178)	(-8.001)	(-0.334)	(0.545)
N	39404	29942	33780	28526	4280	3224
Within R-sq	0.130	0.083	0.267	0.158	0.329	0.117

Notes: This table presents nonparametric covariance matrix estimates with fixed effects (xtscc) of the main regressions of the price dispersion, standard deviation (SD), for all the 42 participating countries. Where Δt is the time gap between two neighbouring observations. The estimates of the regressions of other price dispersion measures are relegated to Appendix Table B1. The constant terms are included but not reported. *, **, and *** represent the 10, 5, and 1 percent significance level, respectively.

Table 5. Regressions of Price Dispersions for Selected Countries with Higher Managerial Attention

	Panel B: No Event (No rehearsal and no live periods)		Panel C: Rehearsals and Semi-Finals (All event periods except Grand Final)		Panel D: Grand Final (Grand final live period only)	
Market	Outright-Winner	Top-10-Finish	Outright-Winner	Top-10-Finish	Outright-Winner	Top-10-Finish
	(1)	(2)	(3)	(4)	(5)	(6)
	SD	SD	SD	SD	SD	SD
Median IWP	11.758***	22.160***	11.263***	10.652***	-9.154	-2.208
	(13.750)	(11.902)	(14.189)	(6.332)	(-1.577)	(-0.240)
Median IWP sq	-23.307***	-37.528***	-18.923***	-22.926***	11.624	10.958
	(-9.973)	(-18.876)	(-10.113)	(-11.494)	(1.798)	(0.976)
ln Number of Brokers	0.052	1.181***	-0.026	1.234***	-3.875*	7.459*
	(0.384)	(9.068)	(-0.163)	(9.741)	(-3.769)	(2.496)
Broker Turnover	0.357	-2.961**	0.333	-2.017***	5.942*	-7.089
	(2.009)	(-4.236)	(1.150)	(-7.977)	(3.348)	(-1.697)
Proportion of Increased IWP	-1.642*	-0.492	-1.402*	0.708	-0.772**	-0.068
	(-2.912)	(-0.618)	(-4.476)	(1.402)	(-5.228)	(-0.922)
Proportion of Decreased IWP	-0.676	-0.076	-0.214	-0.539	-0.681*	-0.046
	(-1.860)	(-0.090)	(-0.829)	(-1.094)	(-3.523)	(-0.356)
Absolute Size of IWP Changes	69.522*	18.612	58.791*	12.932	26.959**	9.283***
	(4.316)	(0.711)	(4.347)	(0.856)	(8.503)	(4.862)
Length of Price Spells	0.083**	-0.008	0.104**	-0.163**	-1.892	0.033
	(5.293)	(-0.202)	(5.534)	(-3.487)	(-1.862)	(0.041)
Δt	-0.002	0.068***	0.560	-6.211***	-2.194	0.485
	(-0.104)	(7.452)	(2.367)	(-13.398)	(-0.481)	(0.388)
N	5010	7430	4670	8070	873	1240
Within R-sq	0.233	0.412	0.340	0.425	0.384	0.167

Notes: This table presents nonparametric covariance matrix estimates with fixed effects (xtscc) of the main regressions of the price dispersion, standard deviation (SD), for Selected Countries with Higher Managerial Attention. In outright winner market, the selected countries are the best 5 countries. We selected the countries ranked 5 – 15 as the selected countries in top-10-finish market. Where Δt is the time gap between two neighbouring observations. The estimates of the regressions of other price dispersion measures are relegated to Appendix Table B1. The constant terms are included but not reported. *, **, and *** represent the 10, 5, and 1 percent significance level, respectively.

5. Conclusion

This paper documents price setting behaviour in online betting markets. Since the popularity of digital device, the price dispersion for online retail sectors has been linked to the role of tangible frictions, such as competition, low synchronisation of price changes, and price discrimination (Gorodnichenko et al., 2017; Dai et al 2014; Baye, Morgan & Scholten, 2004).

Using the unique high frequency dataset of the Eurovision Contest 2017 betting markets, which contains 42 participating countries 23 betting agencies and 19 markets, we find the presence of sizable and persistent price dispersion. In the environment with different levels of market intensity, we find that managerial attention indeed has strong impact on price setting behaviour.

During the periods with low information intensity and high costs of managerial attention, the price dispersion is significantly linked to price level. In the environment where the information intensity and managerial attention are high, the significance of price level disappear but the price changing frequency tends to be more significant and powerful to predict price dispersion. However, higher level of managerial attention does not help to reduce price dispersion.

We also find that the relationship between number of brokers and price dispersion can be either positive or negative, depending on the market structure. This finding is absent from previous studies (Gorodnichenko & Talavera, 2017; Stavins, 2001). More frequent price changes reduce price dispersion. The size of changes is positively associated with price dispersion. These are consistent with price stickiness models (Calvo 1983; Sheremirov 2015).

Furthermore, search costs models are not valid in betting markets that have some unique properties. Price dispersion tends to be minimised for the bets with extreme high or low IWPs. Hence, this is not consistent with any previous studies.

Specifically, it is possible that the price dispersion is very small under certain conditions in a market. We do observe no price dispersion 20 minutes before the final public voting in top-10-finish market. This implies that betting brokers can efficiently reach a consensus a short while before the realisation of final outcomes.

References

Baye, M. R., Morgan, J., & Scholten, P. (2004). Price Dispersion in the Small and in the Large: Evidence from An Internet Price Comparison Site. *The Journal of Industrial Economics, 52*(4), 463-496.

Benabou, R. (1988). Search, Price Setting and Inflation. *The Review of Economic Studies, 55*(3), 353-376.

Bergin, P. R., & Glick, R. (2007). Global Price Dispersion: Are Prices Converging or Diverging? *Journal of International Money and Finance, 26*(5), 703-729.

Borenstein, S., & Rose, N. L. (1994). Competition and Price Dispersion in the US Airline Industry. *Journal of Political Economy, 102*(4), 653-683.

Brown, A. (2014). Information Processing Constraints and Asset Mispricing. *The Economic Journal, 124*(575), 245-268.

Brown, A., & Yang, F. (2016). Limited Cognition and Clustered Asset Prices: Evidence from Betting Markets. *Journal of Financial Markets, 29*, 27-46.

Brown, A., & Yang, F. (2017). The Role of Speculative Trade in Market Efficiency: Evidence from a Betting Exchange. *Review of Finance, 21*(2), 583-603.

Brynjolfsson, E., & Smith, M. D. (2000). Frictionless Commerce? A Comparison of Internet and Conventional Retailers. *Management Science, 46*(4), 563-585.

Burdett, K., & Judd, K. L. (1983). Equilibrium Price Dispersion. *Econometrica: Journal of the Econometric Society, 51*(4), 955-969.

Calvo, G. A. (1983). Staggered Prices in a Utility-Maximizing Framework. *Journal of monetary Economics, 12*(3), 383-398.

Clay, K., Krishnan, R., & Wolff, E. (2001). Prices and Price Dispersion on the Web: Evidence from the Online Book Industry. *The Journal of Industrial Economics, 49*(4), 521-539.

Dahlby, B., & West, D. S. (1986). Price Dispersion in an Automobile Insurance Market. *Journal of Political Economy, 94*(2), 418-438.

Dai, M., Liu, Q., & Serfes, K. (2014). Is the Effect of Competition on Price Dispersion Nonmonotonic? Evidence from the Us Airline Industry. *Review of Economics and Statistics, 96*(1), 161-170.

Driscoll, J. C., & Kraay, A. C. (1998). Consistent Covariance Matrix Estimation with Spatially Dependent Panel Data. *The Review of Economics and Statistics, 80*(4), 549-560.

Ellison, S. F., Snyder, C. M., & Zhang, H. (2016). Costs of Managerial Attention and Activity as a Source of Sticky Prices: Structural Estimates from an Online Market. *Working Paper*.

Gorodnichenko, Y., & Talavera, O. (2017). Price Setting in Online Markets: Basic Facts, International Comparisons, and Cross-Border Integration. *The American Economic Review, 107*(1), 249-282.

Gorodnichenko, Y., Sheremirov, V., & Talavera, O. (2018). Price Setting in Online Markets:

Does It Click? *Journal of the European Economic Association, 00*(0), 1-48.

Kaplan, G., & Menzio, G. (2015). The Morphology of Price Dispersion. *International Economic Review, 56*(4), 1165-1206.

Morgan, J., Orzen, H., & Sefton, M. (2006). An Experimental Study of Price Dispersion. *Games and Economic Behavior, 54*(1), 134-158.

Nakamura, A. O., Nakamura, E., & Nakamura, L. I. (2011). Price Dynamics, Retail Chains and Inflation Measurement. *Journal of Econometrics, 161*(1), 47-55.

Reinganum, J. F. (1979). A Simple Model of Equilibrium Price Dispersion. *Journal of Political Economy, 87*(4), 851-858.

Salop, S. (1977). The Noisy Monopolist: Imperfect Information, Price Dispersion and Price Discrimination. *The Review of Economic Studies, 44*(3), 393-406.

Salop, S., & Stiglitz, J. (1977). Bargains and Ripoffs: A Model of Monopolistically Competitive Price Dispersion. *The Review of Economic Studies, 44*(3), 493-510.

Sheremirov, V. (2015). Price Dispersion and Inflation: New Facts and Theoretical Implications. *Federal Reserve Bank of Boston Working Paper*, 10-15.

Sheshinski, E., & Weiss, Y. (1977). Inflation and Costs of Price Adjustment. *The Review of Economic Studies, 44*(2), 287-303.

Stavins, J. (2001). Price Discrimination in the Airline Market: The Effect of Market Concentration. *The Review of Economics and Statistics, 83*(1), 200-202.

Appendix A

Table A1. Rehearsals and Broadcastings Timetable

Event	Date and Time (BST) (Year 2017)
1ST REHEARSAL FOR 1ST SEMI-FINAL	30apr 08:00:00 -- 30apr 17:20:00
1ST REHEARSAL FOR 1ST SEMI-FINAL	01may 08:00:00 -- 01may 17:20:00
1ST REHEARSAL FOR 2ND SEMI-FINAL	02may 08:00:00 -- 02may 17:20:00
1ST REHEARSAL FOR 2ND SEMI-FINAL	03may 08:00:00 -- 03may 17:20:00
2ND REHEARSAL FOR 1ST SEMI-FINAL	04may 08:00:00 -- 04may 17:35:00
2ND REHEARSAL FOR 1st & 2nd SEMI-FINAL	05may 08:00:00 -- 05may 13:00:00
1ST REHEARSAL FOR THE BIG FIVE + UKRAINE	05may 13:00:00 – 05may 19:50:00
2ND REHEARSAL FOR 2ND SEMI-FINAL	06may 08:00:00 -- 06may 15:45:00
2ND REHEARSALFOR THE BIG FIVE + UKRAINE	07may 08:00:00 -- 07may 15:00:00
1ST SEMI-FINAL - DRESS REHEARSAL 1 & 2	08may 10:00:00 -- 08may 16:30:00
1ST SEMI-FINAL - DRESS REHEARSAL 3	09may 11:00:00 -- 09may 20:00:00
***1ST SEMI-FINAL BROADCAST**	**09may 20:00:00 -- 09may 22:14:28**
2ND SEMI-FINAL - DRESS REHEARSAL 1& 2	10may 09:00:00 -- 09may 20:00:00
2ND SEMI-FINAL - DRESS REHEARSAL 3	11may 11:00:00 -- 11may 20:00:00
***2ND SEMI-FINAL BROADCAST**	**11may 20:00:00 -- 11may 22:15:00**
GRAND FINAL - DRESS REHEARSAL 1 & 2	12may 10:30:00 -- 12may 23:30:00
GRAND FINAL - DRESS REHEARSAL	13may 09:30:00 -- 13may 20:00:00
***GRAND FINAL BROADCAST**	**13may 20:00:00 – 13may 23:45:50**
FINAL RESULTS RELEASED	**13may 23:33:50**

Note: Each period and every period between 2 events is considered as an individual sub-period.

Table A2. Lists of Participating Countries

First Semi-Final Participating Countries					
Albania	Armenia*	Australia**	Azerbaijan*	Belgium**	Cyprus*
Czech	Finland	Georgia	Greece*	Iceland	Latvia
Moldova**	Montenegro	Poland*	Portugal***	Slovenia	Sweden**
Second Semi-Final Participating Countries					
Austria*	Belarus*	Bulgaria**	Croatia*	Denmark*	Estonia
Fyr Macedonia	Holland*	Hungary**	Ireland	Israel*	Lithuania
Malta	Norway**	Romania**	San Marino	Serbia	Switzerland
Big Five + Ukraine					
France*	Germany*	Spain*	UK*	Italy**	Ukraine*

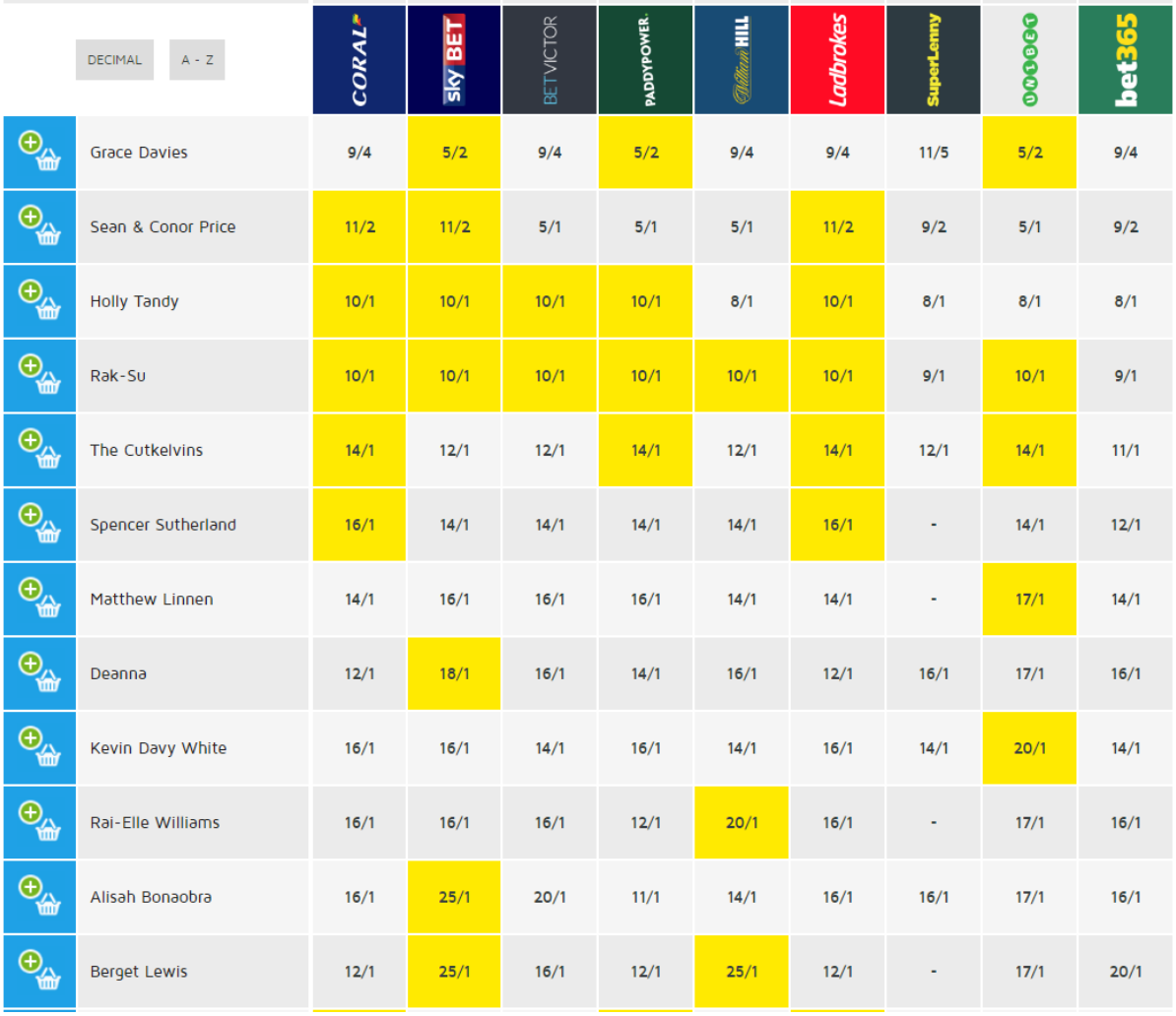
*Note: * Promoted to Grand Final; ** Final Top-10; *** Winner of the Contest*

Figure A1. Screenshot of Betting Odds Comparison Website

FRACTION A - Z	CORAL	sky BET	BETVICTOR	PADDYPOWER	William HILL	Ladbrokes	SuperLenny	888BET	bet365
Grace Davies	3.25	3.50	3.25	3.50	3.25	3.25	3.20	3.50	3.25
Sean & Conor Price	6.50	6.50	6.00	6.00	6.00	6.50	5.50	6.00	5.50
Holly Tandy	11.00	11.00	11.00	11.00	9.00	11.00	9.00	9.00	9.00
Rak-Su	11.00	11.00	11.00	11.00	11.00	11.00	10.00	11.00	10.00
The Cutkelvins	15.00	13.00	13.00	15.00	13.00	15.00	13.00	15.00	12.00
Spencer Sutherland	17.00	15.00	15.00	15.00	15.00	17.00	-	15.00	13.00
Matthew Linnen	15.00	17.00	17.00	17.00	15.00	15.00	-	18.00	15.00
Deanna	13.00	19.00	17.00	15.00	17.00	13.00	17.00	18.00	17.00
Kevin Davy White	17.00	17.00	15.00	17.00	15.00	17.00	15.00	21.00	15.00
Rai-Elle Williams	17.00	17.00	17.00	13.00	21.00	17.00	-	18.00	17.00
Alisah Bonaobra	17.00	26.00	21.00	12.00	15.00	17.00	17.00	18.00	17.00
Berget Lewis	13.00	26.00	17.00	13.00	26.00	13.00	-	18.00	21.00

Figure A1 shows a screenshot from easyodds.com. The first column contain a number of betting events in a game. Each row of the first column is defined as a unqiue good. The first row shows the betting agents. The numbers are the decimal odds. The odds in yellow backgroud are the cheapest prices.

Figure A2. Odds in the decimal form



DECIMAL	A - Z	CORAL	sky BET	BETVICTOR	PADDYPOWER	HILL	Ladbrokes	SuperLenny	888sport	bet365
Grace Davies		9/4	5/2	9/4	5/2	9/4	9/4	11/5	5/2	9/4
Sean & Conor Price		11/2	11/2	5/1	5/1	5/1	11/2	9/2	5/1	9/2
Holly Tandy		10/1	10/1	10/1	10/1	8/1	10/1	8/1	8/1	8/1
Rak-Su		10/1	10/1	10/1	10/1	10/1	10/1	9/1	10/1	9/1
The Cutkelvins		14/1	12/1	12/1	14/1	12/1	14/1	12/1	14/1	11/1
Spencer Sutherland		16/1	14/1	14/1	14/1	14/1	16/1	-	14/1	12/1
Matthew Linnen		14/1	16/1	16/1	16/1	14/1	14/1	-	17/1	14/1
Deanna		12/1	18/1	16/1	14/1	16/1	12/1	16/1	17/1	16/1
Kevin Davy White		16/1	16/1	14/1	16/1	14/1	16/1	14/1	20/1	14/1
Rai-Elle Williams		16/1	16/1	16/1	12/1	20/1	16/1	-	17/1	16/1
Alisah Bonaobra		16/1	25/1	20/1	11/1	14/1	16/1	16/1	17/1	16/1
Berget Lewis		12/1	25/1	16/1	12/1	25/1	12/1	-	17/1	20/1

Figure A2 shows the fractions form odds that are equalivent to the decimal odds in Figure A1.

Table A3. Quartile Changes of Price Level Ranking of Brokers

Caption: Each broker has a rank of its price level at each observed time. We classify the price level to 4 levels. For example, if the price offered by broker B is top 25% cheap at t-1 and becomes to 2nd quartile cheap in the outright winner market, then this broker belongs to the first row of second column in the outright-winner market. The sum of each row is equal to 100%.

Outright-Winer Market

		Price Level of Brokers at t				
		1st quartile	2nd quartile	3rd quartile	4th quartile	N
Price Level of Brokers at t-1	1st quartile	98.86%	0.99%	0.09%	0.06%	610,521
	2nd quartile	1.81%	96.64%	1.47%	0.08%	318,636
	3rd quartile	0.28%	1.63%	96.80%	1.28%	262,804
	4th quartile	0.18%	0.17%	1.43%	98.22%	223,738

Top-10-Finish Market

		Price Level of Brokers at t				
		1st quartile	2nd quartile	3rd quartile	4th quartile	N
Price Level of Brokers at t-1	1st quartile	99.47%	0.43%	0.09%	0.01%	212,849
	2nd quartile	0.99%	97.90%	1.06%	0.05%	78,599
	3rd quartile	0.42%	0.94%	98.09%	0.56%	73,489
	4th quartile	0.36%	0.16%	1.07%	98.41%	36,646

As shown in Table A3, most brokers set prices within the cheapest quartiles. The expensive brokers tend to be expensive, and cheap brokers tend to offer cheap prices.

Table A4. Direction of Odds Changes

Outright-Winner Market
Time: 29Apr2017 -- 13may2017 (Number of Brokers > 3)

		Percentage of Brokers who Decrease Odds at t			
		0	*0-25%*	*25%-50%*	*> 50%*
Percentage of Brokers who Increase Odds at t	*0*	91.53%	3.18%	0.07%	0.01%
	0-25%	4.61%	0.39%	0.02%	0.00%
	25%-50%	0.07%	0.04%	0.08%	0.00%
	> 50%	0.00%	0.00%	0.00%	0.00%

Top-10-Finish Market
Time: 29Apr2017 -- 13may2017 (Number of Brokers > 3)

		Percentage of Brokers who Decrease Odds at t			
		0	*0-25%*	*25%-50%*	*50%-75%*
Percentage of Brokers who Increase Odds at t	*0*	97.78%	0.86%	0.09%	0.01%
	0-25%	1.14%	0.01%	0.00%	0.00%
	25%-50%	0.09%	0.00%	0.00%	0.00%
	> 50%	0.00%	0.00%	0.00%	0.00%

Table A4 shows the percentage of price changes at time t across brokers. As shown, brokers tend to do not change their prices often. Even if they change prices, the changing directions are same at the most of times. Only no more than 1% observations have different changing directions.

Appendix B

Table B1: Predictors of Price Dispersion at Per-Event Period

	Panel A: Pre-Event Period (The period before the very first rehearsal)	
Market	Outright-Winner	Top-10-Finish
	(1)	(2)
	SD	SD
Median IWP	-5.978*	-
	(-2.625)	-
Median IWP sq	92.908**	-
	(3.480)	-
ln Number of Brokers	1.036	-
	(1.220)	-
Broker Turnover	-1.275	-
	(-1.416)	-
Proportion of Increased IWP	0.016	-
	(0.376)	-
Proportion of Decreased IWP	-0.009	-
	(-1.031)	-
Absolute Size of ln IWP Changes	0.473	-
	(0.463)	-
Length of price spells	-0.003**	-
	(-2.826)	-
Δt	0.001**	-
	(2.832)	-
N	2142	0
R-sq	0.345	-

Notes: The table presents estimates of the regression (xtreg) of the standard deviation of implied win probability (IWP) during the pre-event period. The constant terms are included but not reported. The regression uses the sandwich estimator of variance. * and ** represent the 10 and 5percent significance level, respectively.

Table B2. Predictors of Other Price Dispersion Measures at No-Event Periods

	Panel B: No Event (No rehearsal and no live periods)					
Market	Outright-Winner			Top-10-Finish		
	(1)	(2)	(3)	(4)	(5)	(6)
	CV	H - L	p75 - p25	CV	H - L	p75 - p25
Median IWP	-1.424***	14.932***	5.656***	-0.226***	7.271***	0.808
	(-23.529)	(5.945)	(5.732)	(-8.320)	(3.791)	(0.547)
Median IWP sq	1.613***	-15.149***	-5.701***	0.005	-17.275***	0.331
	(21.301)	(-4.043)	(-3.709)	(0.250)	(-10.080)	(0.191)
ln Number of Brokers	0.173***	0.315	-0.276**	0.036***	2.691***	1.149***
	(15.278)	(1.580)	(-3.259)	(8.474)	(12.194)	(10.783)
Broker Turnover	-0.265***	1.344***	0.567***	-0.098**	-4.218*	-3.794*
	(-16.497)	(3.990)	(3.758)	(-3.079)	(-2.581)	(-2.031)
Proportion of Increased IWP	-0.147**	-1.542*	-0.609**	-0.053	-4.406	-1.858*
	(-3.337)	(-2.558)	(-2.736)	(-1.696)	(-1.620)	(-2.573)
Proportion of Decreased IWP	0.049	-1.109*	-0.541**	-0.016	-1.052	0.485
	(1.698)	(-2.581)	(-3.260)	(-0.490)	(-0.333)	(0.401)
Absolute Size of IWP Changes	6.244***	56.823*	61.181**	1.663	173.909	77.609***
	(4.620)	(2.039)	(3.237)	(1.677)	(1.781)	(4.100)
Length of Price Spells	0.010***	0.125***	-0.001	-0.009***	-0.428***	-0.116***
	(4.109)	(4.640)	(-0.104)	(-8.946)	(-11.606)	(-4.524)
Δt	-0.001	-0.015	-0.032**	0.001**	0.155***	-0.038**
	(-0.269)	(-0.238)	(-2.708)	(3.208)	(9.199)	(-3.314)
N	39404	39404	39404	29942	29942	29942
Within R-sq	0.160	0.092	0.042	0.167	0.155	0.076

Notes:

Table B3. Predictors of Other Price Dispersion Measures at No-Event Periods

Panel C: Rehearsals and Semi-Finals

(All event periods except Grand Final)

Market	Outright-Winner			Top-10-Finish		
	(1)	(2)	(3)	(4)	(5)	(6)
	CV	H - L	p75 - p25	CV	H - L	p75 - p25
Median IWP	-1.399***	23.036***	6.564***	-0.351***	2.371*	1.366
	(-32.459)	(14.932)	(11.389)	(-19.877)	(2.159)	(1.547)
Median IWP sq	1.654***	-18.786***	-3.454**	0.077***	-14.626***	-2.443**
	(35.929)	(-8.192)	(-3.141)	(4.668)	(-11.490)	(-2.976)
ln Number of Brokers	0.186***	-0.161	-0.143	0.043***	2.833***	1.038***
	(8.444)	(-0.451)	(-1.085)	(15.453)	(14.175)	(10.900)
Broker Turnover	-0.239***	1.486*	0.116	-0.063***	-1.463*	-2.534***
	(-5.545)	(2.538)	(0.551)	(-9.154)	(-2.055)	(-10.110)
Proportion of Increased IWP	-0.117***	-2.457***	-0.868***	-0.012	-1.572	-0.538
	(-3.802)	(-5.324)	(-3.658)	(-1.058)	(-1.241)	(-1.195)
Proportion of Decreased IWP	-0.006	-0.024	0.062	-0.012	-1.833	0.141
	(-0.291)	(-0.067)	(0.327)	(-1.015)	(-1.437)	(0.379)
Absolute Size of IWP Changes	7.044***	84.076*	67.477**	1.065**	115.931*	36.267*
	(5.471)	(2.321)	(3.238)	(2.830)	(2.616)	(2.289)
Length of Price Spells	0.004	0.217***	0.025*	-0.009***	-0.512***	-0.166***
	(1.696)	(6.535)	(2.105)	(-8.991)	(-7.712)	(-5.000)
Δt	-0.115**	2.024*	0.567	-0.086***	-5.344***	-1.515**
	(-3.053)	(2.257)	(1.793)	(-8.112)	(-7.548)	(-3.344)
N	33780	33780	33780	28526	28526	28526
Within R-sq	0.134	0.211	0.135	0.305	0.194	0.091

Notes:

Table B4. Predictors of Other Price Dispersion Measures at No-Event Periods

Panel C: Grand Final

(Grand final live period only)

Market	Outright-Winner			Top-10-Finish		
	(1)	(2)	(3)	(4)	(5)	(6)
	CV	H - L	p75 - p25	CV	H - L	p75 - p25
Median IWP	-2.567***	-16.097	7.340*	0.015	9.216*	22.799**
	(-4.786)	(-2.016)	(2.298)	(0.173)	(2.119)	(3.321)
Median IWP sq	2.336***	30.893*	-9.568	-0.011	-8.361*	-17.610**
	(4.737)	(2.544)	(-1.978)	(-0.146)	(-2.110)	(-3.323)
ln Number of Brokers	-1.177***	-2.047***	-1.695***	0.270***	13.996***	6.799
	(-9.345)	(-4.750)	(-4.202)	(8.578)	(7.763)	(1.310)
Broker Turnover	1.993***	3.595***	2.019**	-0.286***	-12.921***	-6.790
	(7.722)	(4.289)	(3.238)	(-6.819)	(-5.382)	(-0.941)
Proportion of Increased IWP	-0.034**	-0.659***	-0.413***	-0.001	-0.141	-0.091
	(-3.722)	(-5.764)	(-3.771)	(-1.096)	(-1.220)	(-1.225)
Proportion of Decreased IWP	-0.010	-0.469*	-0.345**	-0.000	-0.220	-0.184
	(-0.917)	(-2.606)	(-2.861)	(-0.177)	(-1.410)	(-1.433)
Absolute Size of IWP Changes	0.721***	53.904***	38.237***	0.237***	20.654***	14.131***
	(10.536)	(8.194)	(4.487)	(9.915)	(7.245)	(9.287)
Length of price spells	0.126**	-0.271	0.022	-0.045**	-2.003*	-1.365**
	(3.354)	(-0.636)	(0.077)	(-3.065)	(-2.753)	(-3.667)
Δt	0.399	-0.690	0.092	0.017	1.732	0.301
	(1.074)	(-0.250)	(0.078)	(0.470)	(0.648)	(0.140)
N	4280	4280	4280	3224	3224	3224
Within R-sq	0.328	0.305	0.248	0.127	0.147	0.171

Notes:

Appendix C

Seller Fixed Effects

Brynjolfsson & Smith (2000) suggests that the remain important sources of price dispersion in online markets are the reputation of sellers and trusts between sellers and consumers. These sources are likely to affect the price dispersion in online betting markets because of the differences between betting agencies. Therefore, we run the following regression to remove the seller fixed effects,

$$IWP^{*}_{c,b,m,t} = \alpha_{c,m} + \gamma_b + \varepsilon_{c,b,m,t}$$

where,

- $IWP^{*}_{c,b,m,t}$ is predicted IWP of a bet (good);
- $\alpha_{c,m}$ is fixed effects of the bet;
- γ_b is the seller fixed effects;
- $\varepsilon_{c,b,m,t}$ is the residual.

Then, we report the price dispersion for the residual based on the predicted prices. The regression results are shown in Table C. The results are consistent with previous conclusions.

Table C1. Regressions of Price Dispersions After Broker Fixed Effects Removed for All Participating Countries

	Panel B: No Event (No rehearsal and no live periods)		Panel C: Rehearsals and Semi-Finals (All event periods except Grand Final)		Panel D: Grand Final (Grand final live period only)	
Market	Outright-Winner	Top-10-Finish	Outright-Winner	Top-10-Finish	Outright-Winner	Top-10-Finish
	(1)	(2)	(3)	(4)	(5)	(6)
	SD	SD	SD	SD	SD	SD
Median IWP*	2.829***	-2.678***	3.251***	-4.296***	1.516	0.087
	(13.071)	(-7.194)	(15.721)	(-16.872)	(1.221)	(0.088)
Median IWP* sq	-21.751***	-10.686	-9.906***	29.602***	4.124*	11.820
	(-3.688)	(-1.473)	(-6.310)	(8.567)	(2.195)	(2.054)
ln Number of Brokers	-0.105*	0.712***	-0.036	0.853***	-1.922***	6.697***
	(-2.088)	(6.393)	(-0.522)	(15.811)	(-11.637)	(6.757)
Broker Turnover	0.370***	-2.251*	0.128	-1.117***	2.936***	-6.907***
	(4.905)	(-2.623)	(1.125)	(-4.586)	(7.822)	(-5.121)
Proportion of Increased IWP*	-0.419**	-2.081*	-0.597***	-0.632	-0.283***	-0.073
	(-2.995)	(-2.362)	(-4.992)	(-1.668)	(-6.039)	(-1.513)
Proportion of Decreased IWP*	-0.217*	-0.574	-0.067	-0.521	-0.216**	-0.146*
	(-2.072)	(-0.524)	(-0.678)	(-1.445)	(-3.194)	(-2.765)
Absolute Size of IWP* Changes	46.377***	74.662*	44.042***	41.192**	23.287***	10.178***
	(4.187)	(2.402)	(3.927)	(3.029)	(7.587)	(7.740)
Length of Price Spells	0.003	-0.132***	0.004	-0.139***	0.124	-0.601
	(0.693)	(-7.014)	(0.956)	(-6.790)	(0.737)	(-1.799)
Δt	0.005	0.047***	0.172*	0.129	0.047	0.731
	(0.869)	(4.301)	(2.047)	(0.416)	(0.044)	(0.625)
N	39404	29942	33780	28526	4280	3224
Within R-sq	0.106	0.104	0.232	0.222	0.331	0.150

Notes: