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Department of Business Administration

UZH Business Working Paper Series

(ISSN 2296-0422)

Working Paper No. 342

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October 2014

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http://www.business.uzh.ch/forschung/wps.html

UZH Business Working Paper Series

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Abstract

Even though betting exchanges are considered to be the superior business model in the betting industry due to less operational risk and lower information costs, bookmakers continue to be successful. We explain the puzzling coexistence of these two market structures with the advantage of guaranteed liquidity in the bookmaker market. Using matched panel data of over 1.8 million bookmaker and betting exchange odds for 17,410 soccer matches played worldwide, we find that the bookmaker offers higher odds and bettor returns than the betting exchange when liquidity at the betting exchange is low.

JEL Classification: D40, L10, L83
Keywords: Market Structure, Liquidity, Betting Industry

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1 Introduction

Since the beginning of the 2000s, the betting industry has been characterized by the coexistence of quote-driven and order-driven markets. Similar to intermediary market makers in quote-driven financial markets, bookmakers operate on their own account and quote betting odds at which bettors can place their bets (Croxson & Reade, 2011). In the order-driven market, betting exchanges serve as a marketplace in which buy and sell orders are directly matched between bettors in a continuous double auction without intermediaries (De Jong & Rindi, 2009).

This coexistence of market structures is puzzling. Betting exchanges face less operational risk (Koning & van Velzen, 2009), have lower information costs (Davies, Pitt, Shapiro & Watson, 2005) and exhibit higher prediction accuracy in their odds (Smith, Paton & Vaughan Williams, 2006, 2009; Franck, Verbeek & Nüesch, 2010). Nevertheless, bookmakers continue to be successful. Bookmakers have not only managed to survive but have also generated considerable growth in net revenues. For example, *William Hill* and *Ladbrokes*, two major bookmakers in the United Kingdom, increased their net sportsbook revenues between 2008 and 2012 from £42 million to £166.7 million (+297%) and from £61.7 million to £77.8 million (+26%), respectively.

This paper explains the coexistence of both market structures with the liquidity advantage of the quote-driven bookmaker market. Liquidity provision is an important task of market makers in a quote-driven financial market (Demsetz, 1968). By guaranteeing market liquidity at the odds quoted, the market maker fills the gap that arises from the asynchronous order arrival of buyers and sellers. Hence, the market maker facilitates the rapidity of exchange by offering narrow bid-ask spreads. In order-driven markets, however, liquidity is provided by the flow of orders from market participants (De Jong & Rindi, 2009). An absence of a two-sided trading interest results in bid and ask prices that are far apart, which increases transaction costs. Therefore, order-driven markets are expected to perform poorly if liquidity is low (Demsetz, 1968).

De Jong, Nijman and Roell (1995) and Huang and Stoll (1996, 2001) compare pure quote- and order-driven financial markets and conclude that transaction costs are generally lower in order-driven markets. Madhavan and Sofianos (1998), Friederich and Payne (2007) and Venkataraman and Waisburd (2007) analyse hybrid financial markets in which elements from order- and quote-driven markets are combined. They find that market makers can improve the terms of trade when the liquidity offered by public limit orders is low.

This paper uses the betting industry to compare the quote- and the order-driven market structures. The betting industry offers the unique setting that identical betting contracts are traded on both market structures simultaneously, i.e., besides the market structure, everything else is equal. In related financial studies, differences in market structures are often accompanied by differences in underlying assets and/or differences in macroeconomic conditions across pure market structures (e.g., De Jong et al., 1995; Huang & Stoll, 1996, 2001) or by complex interactions within hybrid market structures (e.g., Madhavan & Sofianos, 1998; Friederich & Payne, 2007; Venkataraman & Waisburd, 2007).

Using matched panel data of over 1.8 million bookmaker and betting exchange odds for 17,410 soccer matches played worldwide, we find that bookmaker odds are higher than betting exchange odds if market liquidity at the betting exchange is low and that bookmaker odds are lower than betting exchange odds if market liquidity at the betting exchange is high. Bettors obtain higher odds and bettor returns when using the quote-driven bookmaker market if the cumulative trading volume at the betting exchange is less than £23.400 and/or if the quoted spread at the betting exchange is higher than 0.044 on average. However, as bettor returns are still negative on average, bookmakers are able to generate positive profits even when offering higher odds than the betting exchange.

The comparative advantage of the guaranteed liquidity in the quote-driven bookmaker market is found both in cross-sectional analyses that use across-match differences, in panel analyses that use within-match differences and in dynamic panel analyses that include a lagged dependent variable. While Croxson and Reade (2011) and Ozgit (2005) argue that betting exchanges generally offer higher odds and bettor returns than bookmakers, we show that the opposite is true in illiquid markets.

The liquidity advantage of the quote-driven bookmaker market rationalizes the decision of *Betfair* to start offering quoted odds in addition to the exchange-based odds as of February 2013 (Betfair, 2013a). Our findings also help to explain the recent shift in financial market structures from pure quote-driven or pure order-driven structures to hybrid structures that combine the advantages of both markets.

The remainder of this paper is organized as follows. In Section 2, we discuss the two market structures in more detail and review the relevant theoretical and empirical literature. In Section 3, we describe our data set containing bookmaker and betting exchange odds of soccer matches. Section 4 presents the empirical analysis of the guaranteed liquidity supply as a competitive advantage of the quote-driven bookmaker market compared to the order-driven betting exchange market. Section 5 concludes.

2 Quote-driven and Order-driven Markets

The organizational structure of a market comprises the trading rules for instruments (De Jong & Rindi, 2009). In the betting market, the instruments traded are bets. Similar to conventional assets and derivatives in financial markets, a bet is a state-contingent contractual claim on a future cash flow. This cash flow is determined by two parameters: (i) the outcome of the underlying event, such as a horse race, a soccer match or a political election, and (ii) the price of the contract, i.e., the posted odds (Sauer, 1998). Currently, the most common betting type is fixed-odds betting, where the cash flow of a successful bet is determined ex-ante. For example, if the decimal odds on the home team of a soccer match are 1.40, a one-dollar wager pays $1.40 and yields a return of 40% if the home team wins. Therefore, higher odds imply a higher bettor return in the case of success but an accordingly lower winning probability.

Financial markets are classified as either quote-driven, where trades must be fulfilled through intermediaries, or order-driven, where trading is based on the direct interaction of market participants (De Jong & Rindi, 2009). Similar to market makers in quote-driven financial markets, bookmakers in the betting industry serve as intermediaries between buyers (bettors willing to place a bet on a particular outcome) and sellers (bettors willing to place a bet on the opposite outcome). The bookmakers unilaterally determine the odds for a given betting contract at which they are willing to accept bets (Harris, 2003). In this market, the bookmakers guarantee sufficient liquidity. The odds quoted by the bookmakers already contain a commission (i.e., the 'overround') that compensates them for providing liquidity and bearing the risk of unfavourable outcomes. Examples of well-established bookmakers are *Bwin*, *Ladbrokes*, *Tipico* and *William Hill*.

Since 2000, betting exchanges have evolved in the betting industry. They operate as order-driven markets in which buyers and sellers trade directly with each other in a continuous double auction without the intermediation of market makers. In this market structure, bettors can provide or take liquidity. Bettors who provide liquidity post a limit order that indicates the terms at which they will trade. A transaction only takes place if there is a corresponding order on the opposite side of the market. Otherwise, the limit order is placed in the limit order book until it is either executed or cancelled. Bettors who take liquidity submit a market order that is immediately executed at the best odds available (Harris, 2003; De Jong & Rindi, 2009). Betting exchanges facilitate trading activity by providing an electronic platform on which supply and demand are matched and collect a commission on the net winnings of successful bets (Franck, Verbeek & Nüesch, 2013). Examples of larger betting exchanges are *Betfair*, *Betdaq* and *World Bet Exchange*.

Previous studies that compare the two market structures within the betting industry suggest that the betting exchange market is superior to the traditional bookmaking market in several ways. Koning and van Velzen (2009) argue that a fundamental advantage of betting exchanges is that they do not take any trading position. Because betting exchanges simply charge the winners a certain commission, a steady flow of income independent from the match outcomes is guaranteed. This exposes betting exchanges to minimal risk. In contrast, traditional bookmakers are continuously exposed to risk, as they can lose substantial amounts of money when they misjudge the probabilities or when they are over-exposed to an event that occurs (Davies et al., 2005). Furthermore, bookmakers need informed specialists who monitor the market and actively manage the odds. The information costs of bookmakers are therefore considerably higher than those of betting exchanges that simply provide a trading platform (Davies et al., 2005).

Empirical studies have found that prediction accuracy is higher in the order-driven betting exchange market than in the quote-driven bookmaker market (Smith et al., 2006, 2009; Franck et al., 2010). Moreover, Croxson and Reade (2011) and Ozgit (2005) show that bettors obtain higher net returns in the betting exchange market than in the bookmaker market. Given these advantages of the order-driven market, the ongoing success of the quote-driven bookmaker market is surprising.

In this paper, we investigate a distinct source of competitive advantage of the quote-driven market: the benefit that arises from the continuous provision of liquidity by the bookmaker. According to the theoretical work of Demsetz (1968), a key function of market makers in financial markets is the supply of immediacy by continuously quoting prices and by providing liquidity to the asynchronous arrival of orders from investors. The models of Garbade and Silber (1979) and Grossman and Miller (1988) show that the liquidity supply of market makers reduces temporal imbalances in order flow and increases the rapidity of exchange. By contrast, a lack of liquidity at the order-driven market leads to high bid quotations and low ask quotations, which increases both transaction and waiting costs.

De Jong et al. (1995) and Huang and Stoll (1996, 2001) compare pure quote- and order-driven financial markets and conclude that transaction costs are generally lower in order-driven markets. Other financial studies investigate hybrid markets in which liquidity is provided by market makers and by limit orders submitted by market participants simultaneously (De Jong & Rindi, 2009). Madhavan and Sofianos (1998) analyse market makers in the hybrid NYSE market. Because market makers participate more when bid-ask spreads are high, Madhavan and Sofianos (1998) conclude that the market maker is a liquidity provider of last resort. Friederich and Payne (2007) analyse the order flow in the London Stock Exchange (LSE) at which investors are free to choose between the order-driven or the quote-driven execution modes. Their results demonstrate that the liquidity supplied by intermediaries is increasingly utilized when execution risk is high due to large trades or high market volume. Furthermore, the authors show that the share of order flow migrates to the market maker segment when the bid-ask spreads of the limit order book are high. Venkataraman and Waisburd (2007) investigate firms that have chosen a designated market maker at the otherwise order-driven Paris Bourse. Their results suggest that the market maker resolves temporal imbalances in order flow by selectively providing liquidity when the public supply is insufficient. Thus, by maintaining a market presence, the market maker can improve the terms of trade offered by public limit orders.

However, comparative investigations of financial market structures are limited in two ways. First, comparisons of pure quote-driven and order-driven structures are often accompanied by differences in underlying assets and/or differences in macroeconomic conditions. Thus, a clear benchmark of market quality is missing (Madhavan, 2000). Second, hybrid structures combine both elements of order- and quote-driven markets with complex interactions and trading rules. For example, the liquidity supply of the market maker at the NYSE is constrained in a number of ways, and at the Paris Bourse, only large trades can be executed with the market maker (Friederich & Payne, 2007).

In the betting industry, by contrast, identical betting contracts are traded simultaneously on well-distinct market structures, which allows a proper comparison of market structures and a clean investigation of the liquidity advantage of the quote-driven market.

3 Sample and Data

Our data set consists of decimal betting odds from the bookmaker *Tipico* and the betting exchange *Betfair* on the *winner* betting contracts on *home win*, *draw* and *away win* of soccer matches. *Tipico* is one of the leading bookmakers in Europe. Through its on-line portal and more than 1,000 betting shops across Europe, the company offered odds on 1.76 million betting contracts and handled over 790 million bets from customers in 2012 (Tipico Co. Ltd., 2013). *Betfair* is the largest and most liquid betting exchange. In 2012, the betting exchange had over 4 million registered customers and processed more than 7 million transactions on an average day, which is more than the transactions of all European stock exchanges combined (Betfair, 2012).

The data cover 17,410 matches from over 400 leagues across more than 60 countries played between March 2012 and October 2012. Within each country, we observe matches from different divisions. For example, the data from England include matches from the *Premier League* (level 1), *Championship League* (level 2), *League One* (level 3), *League Two* (level 4), *Conference National* (level 5) and *Conference North/South* (level 6). Additionally, the data set also covers transnational tournaments such as the UEFA Champions League or Europa League, World Cup qualification matches and international friendlies. The lion's share of matches were played in European leagues, accounting for over 12,000 matches.

For each match and event, the data include the pre-play history of bookmaker and betting exchange odds, which were simultaneously recorded and thus have a time-stamp accurate to the second.[1] As an example, Figure 1 shows the decimal odds information

[1]The frequency at which the odds were collected depended on the time remaining until match start, ranging from every 3 hours between 72 and 48 hours before match start to every 5 minutes during the

available for the *home win* event bet from the match of *Chelsea FC* vs. *Newcastle United* played on May 2, 2012. The bookmaker changed his quoted odds only four times, whereas

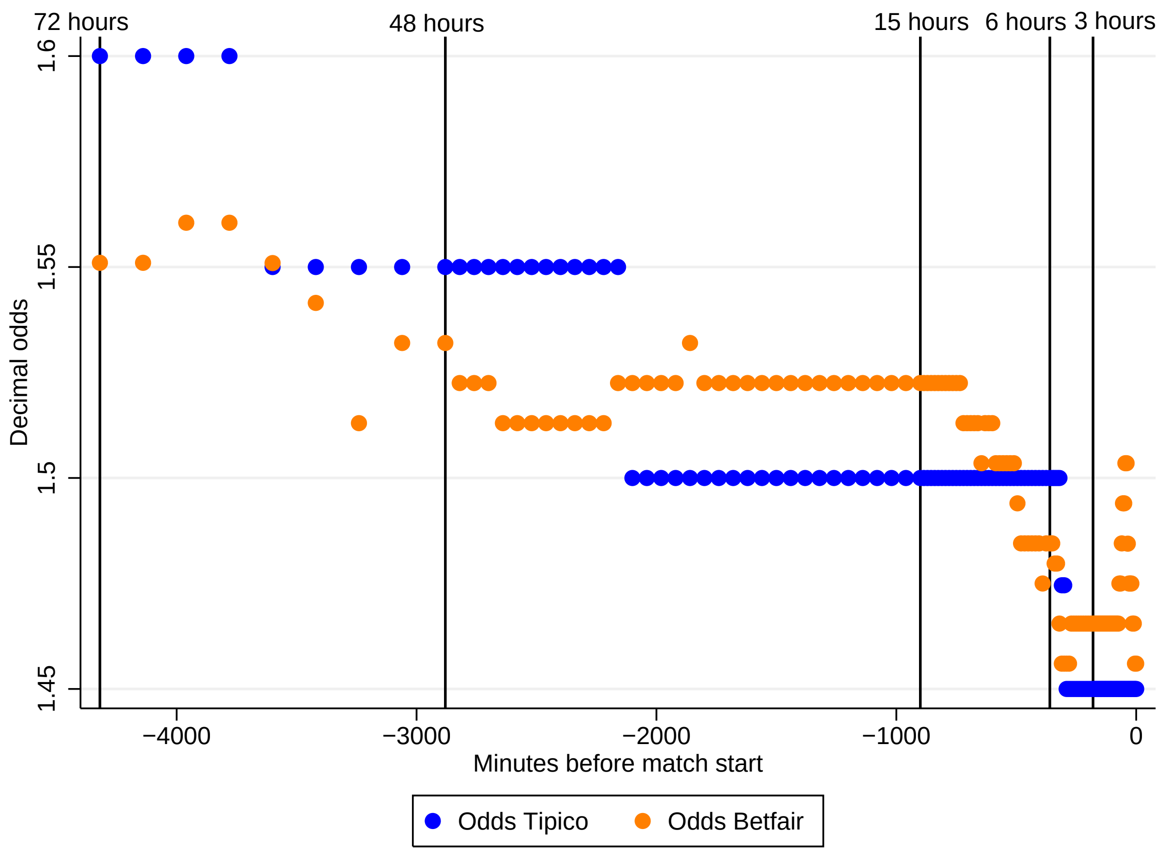


Figure 1: Example decimal odds on *home win* for Chelsea FC vs. Newcastle United, May 2, 2012

the odds available at *Betfair* exhibited a higher variation over time. This pattern is typical for many matches in our data set: while the bookmaker odds changed about twice on average, the betting exchange odds changed about 31 times on average.

In total, we observed 1,873,831 pairs of odds from the bookmaker and the betting exchange for each of the three events *home win*, *draw* and *away win*. The data set also contains the cumulative trading volume at the betting exchange for each match and time point of the odds collection.

final 3 hours before match start. Matches with a pre-play history of less than 1 hour have been deleted from the data set.

4 Empirical Analysis

As identical betting contracts are offered on both market structures simultaneously, we simply relate the odds of both market structures to each other. Thereby, higher odds are more attractive for bettors. For the ease of interpretation, we convert the odds into prices, which are the reciprocal of the odds (e.g., $p = \frac{1}{1.40} \approx 0.714$). These prices represent the amount of money a bettor has to invest in order to collect \$1 for a winning bet (Forrest & Simmons, 2008).

For each match i, event $e \in \{home\ win,\ draw,\ away\ win\}$ and time t before match start, the price offered by the bookmaker is defined as

$$p_{iet,BM} = \frac{1}{odds_{iet,BM}} \tag{1}$$

where $odds_{BM}$ refers to the decimal odds quoted by the bookmaker. The bookmaker odds already include a commission. Betting exchanges usually charge a commission on net winnings that is not included in the odds offered. Hence, the net price at the betting exchange is calculated as

$$p_{iet,BE} = \frac{1}{\left[\underbrace{(odds^{back}_{iet,BE} - 1)}_{\text{net winnings}} \cdot (1 - c)\right] + 1} \tag{2}$$

where $odds^{back}_{BE}$ refers to the best decimal back odds, i.e., the odds of a bet on a certain outcome available at the betting exchange, and c refers to the commission. The commission at *Betfair* varies between 2% and 5% on net winnings, contingent on the betting activity of a bettor. Thereby, the commission decreases the money a bettor has wagered in the past (Betfair, 2013b). In this paper, we employ the standard commission of 5% to compute an upper (lower) bound for the prices (net returns) from *Betfair*.[2]

[2]It is reasonable to assume that most of the bettors betting at *Betfair* pay 5% in commission, as a discount in the commission requires very high betting activity. According to the *Betfair* commission rule, a bettor has to wager at least \$112,500 per week in order to reach the 2% commission rate (Betfair, 2013b).

Liquidity is an important characteristic of well-functioning markets and permits the trading of large quantities quickly at low costs (Harris, 2003). While liquidity in the quote-driven market is guaranteed by the bookmaker,[3] liquidity in the order-driven market depends on the order flow from market participants (De Jong & Rindi, 2009).

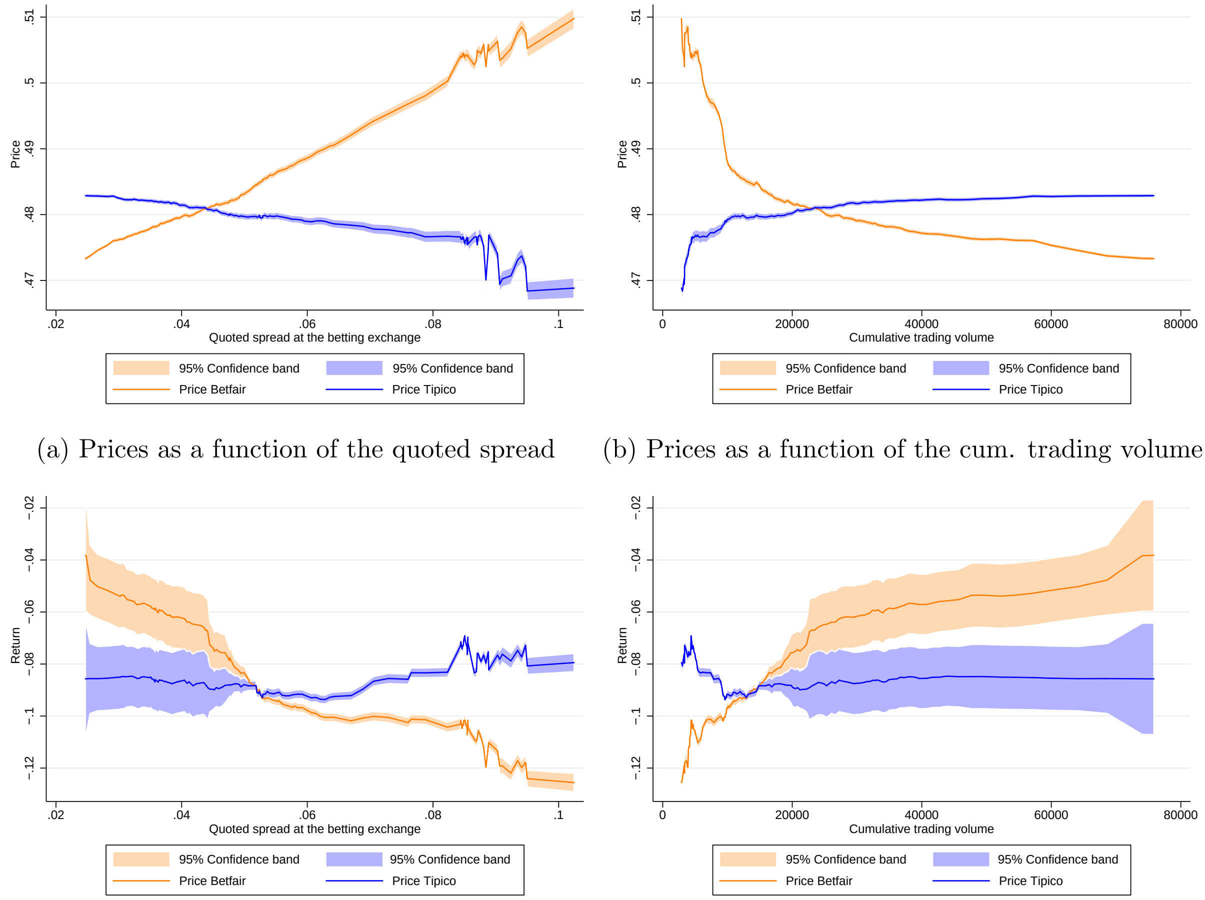
A common measure of liquidity in financial studies is the quoted spread (e.g., Amihud & Mendelson, 1986). The quoted spread is the difference between the lowest ask price and the highest bid price (Chordia, Roll & Subrahmanyam, 2008). A small quoted spread indicates high market liquidity because the transaction costs are lower. We calculate the quoted spread ($QSPR$) as

$$QSPR_{iet,BE} = \frac{1}{odds^{back}_{iet,BE}} - \frac{1}{odds^{lay}_{iet,BE}} \tag{3}$$

where $odds^{back}$ refers to the best ask price, and $odds^{lay}$ refers to the best bid price available at the betting exchange.

Figure 2a displays the average bookmaker and betting exchange prices as a function of the average quoted spread for *home win* events at the betting exchange, and Figure 2b displays the prices as a function of the cumulative trading volume for *home win* events at the betting exchange. Both figures show that liquidity at the betting exchange increases the average price at the bookmaker market and decreases the average price at the betting exchange. If the betting exchange market is illiquid (i.e., high quoted spread, low cumulative trading volume), the bookmaker market offers significantly lower prices than the betting exchange. However, if the betting exchange market is liquid (i.e., low quoted spread, high cumulative trading volume), the betting exchange offers significantly lower prices than the bookmaker market. If the quoted spread is 0.044 and the cumulative

[3]One might worry that liquidity at the bookmaker is restricted by maximum stake limits. Indeed, bookmakers limit the maximal winning amount per betting contract: day or week. For example, the maximum winning amount per bet is £500,000, £100,000 and €100,000 for the bookmakers *William Hill*, *Ladbrokes* and *Tipico*, respectively. For an average bettor, these limits are sufficiently high. According to the online betting survey from Merrion Stockbrokers (2010), over 95% of the bettors stake less than $250 on average, and 75% of the bettors stake less than $25 on average.



(a) Prices as a function of the quoted spread (b) Prices as a function of the cum. trading volume

(c) Returns as a function of the quoted spread (d) Returns as a function of the cum. trading volume

Figure 2: Prices and bettor returns as a function of liquidity measures

trading volume is £23.438 at the betting exchange, both markets offer the same prices on average. If liquidity at the betting exchange exceeds these threshold values, the betting exchange offers lower prices. Otherwise, the bookmaker market offers lower prices for bettors. Similarly, Figure 2c and Figure 2d show that bettor returns are significantly higher at the bookmaker market when liquidity is low at the betting exchange. However, as bettor returns are still negative on average, bookmakers are able to generate positive profits.

Taken together, Figure 2 indicates that the bookmaker and the betting exchange prices and bettor returns both but differently react to the liquidity at the betting exchange. The following econometric models examine the influence of liquidity at the betting exchange on the bookmaker and betting exchange prices and on bettor returns in more detail.

As a dependent variable, we use an indicator variable LOW_BM that equals 1 if the bookmaker offers a lower price than the betting exchange and 0 otherwise. Thus, when LOW_BM equals 1, the bookmaker market provides higher bettor returns if the event occurs. Our main independent variable is the liquidity at the betting exchange, measured by either the quoted spread ($QSPR$) or the log cumulative trading volume ($LnVOL$). As we have longitudinal data on matched bookmaker-betting exchange prices, we run four different regressions: (i) a pooled LPM, (ii) a LPM with one randomly chosen observation per match, (iii) a fixed-effects LPM, and (iv) an Arellano-Bond dynamic panel GMM model.[4]

The pooled LPM and the LPM with one randomly chosen observation per match analyse the relationship between liquidity and bookmakers versus betting exchange pricing using across-match variation, whereas the fixed-effects LPM and the Arellano-Bond model analyse this relationship using within-match variation. Because liquidity at the betting exchange tends to increase in the pre-play period and because incoming match-relevant information may differently influence the bookmakers and betting exchange's pricing, we include a full set of dummies for each hour in the pre-play period of a match as controls in all of our models. In the across-match analyses, we additionally include league dummies to control for unobserved league-level factors that may correlate with the liquidity at the betting exchange and differential pricing at the bookmaker and the betting exchange market. To take into account that the liquidity at the betting exchange at t could be influenced by the relative prices at $t-1$, the Arellano-Bond model additionally includes a lagged dependent variable as a control variable.

[4]Our results are robust to the use of (fixed-effects) logit models. We prefer the linear model as a main specification because observations with no within-group variation in the dependent variable are dropped from fixed-effects logit models, which changes the interpretation and the generalization of the results. In addition, unlike with linear models, pooled logit estimates cannot be directly compared with those from a fixed-effects model because including fixed effects in a non-linear model would change the estimates even if the fixed effects were independent of the variables of interest (Norton, 2012).

Table 1 shows the coefficient estimates and heteroskedasticity-consistent standard errors clustered at the match level in parentheses for *home win* bets. Panel A displays the across-match results and Panel B the within-match results. The results for *away win* and *draw* bets are virtually the same (see Table A.1 and Table A.2 in the Appendix).

The results in Panel A show that illiquidity at the betting exchange significantly increases the probability that the bookmaker price is lower than the betting exchange price. The bookmaker tends to offer lower prices in matches with a high quoted spread and a low cumulative trading volume. Whereas we pool all observations in Columns (1) and (2), we only use a randomly chosen observation per match in Columns (3) and (4). The magnitudes of the estimates are virtually the same, and all liquidity coefficients are still statistically significant at the 1% level. Thus, we find that when liquidity is low, bookmakers offer lower prices than betting exchanges.

Panel B of Table 1 shows the results of the within-match analyses that no longer use liquidity and price differences across matches to identify the effects. In the fixed-effects LPM models in Columns (1) and (2), we control for all time-constant match heterogeneity and test how the relative pricing at the bookmaker and the betting exchange market changes if liquidity changes. The results suggest that an increase in liquidity at the betting exchange reduces the probability that the bookmaker offers a lower price.

As the relative prices in the recent past are likely to influence the liquidity at the betting exchange, Columns (3) and (4) of Panel B show the estimates of an Arellano-Bond dynamic-panel GMM model that includes the lagged dependent variable as additional control variable. Here again, liquidity at the betting exchange market decreases the probability that the bookmaker offers a lower price than the betting exchange.

To investigate the liquidity advantage of the quote-driven market further, we use the net bettor returns from a one-unit wager placed at both the bookmaker market and the betting exchange market as a dependent variable. As independent variables, we include an indicator variable BM that equals 1 if the return corresponds to the bookmaker market

Table 1: Analysis of prices for *home win* events

Panel A: Across-match analysis

	Dependent variable: LOW_BM (1/0)			
	Pooled LPM		Random time point LPM	
	(1)	(2)	(3)	(4)
$QSPR$	0.964***		0.964***	
	(0.017)		(0.030)	
$LnVOL$		-0.046***		-0.046***
		(0.001)		(0.002)
Hourly dummies	Yes	Yes	Yes	Yes
League dummies	Yes	Yes	Yes	Yes
R^2	19.68%	18.91%	22.01%	21.21%
N	1,873,831	1,873,831	17,410	17,410
N of groups	17,410	17,410		

Panel B: Within-match analysis

	Dependent variable: LOW_BM (1/0)			
	Fixed-effects LPM		Arellano-Bond GMM	
	(1)	(2)	(3)	(4)
$QSPR$	0.808***		1.050***	
	(0.019)		(0.007)	
$LnVOL$		-0.043***		-0.020***
		(0.001)		(0.001)
LOW_BM_{t-1}			0.727***	0.791***
			(0.001)	(0.001)
Hourly dummies	Yes	Yes	Yes	Yes
R^2 overall	11.19%	12.12%		
Wald χ^2 (56)			$2.77{\cdot}10^6$***	$2.55{\cdot}10^6$***
N	1,873,831	1,873,831	1,839,011	1,839,011
N of groups	17,410	17,410	17,410	17,410

Notes: Panel A: Columns (1) and (2) report the coefficients estimated from a pooled LPM with heteroscedasticity-consistent standard errors clustered at the match level in parentheses. Columns (3) and (4) report the results from a pooled LPM with one randomly chosen observation per match. Panel B: Columns (1) and (2) report the coefficients estimated from a fixed-effects LPM with robust standard errors. Columns (3) and (4) report the results from a Arellano-Bond dynamic panel GMM model. In all models, *, **, and *** denote significance at the 10%, 5% and 1% levels, respectively.

and 0 if the return corresponds to the betting exchange market, the centred liquidity variables $QSPR_c$ or $LnVOL_c$, and the interaction terms $BM \times QSPR_c$ or $BM \times LnVOL_c$, respectively.[5] Here again, we use hourly dummies to control for time trends and league dummies to control for time-constant league heterogeneity.

Table 2 shows the coefficient estimates for *home win* events from a pooled LPM, a LPM with a randomly chosen pair of returns per match and a fixed-effects LPM.[6] The insignificant BM dummy shows that bettor returns are not generally lower at the

Table 2: Analysis of bettor returns for *home win* events

	Dependent variable: bettor return					
	Pooled OLS		Random time point OLS		Fixed-effects OLS	
	(1)	(2)	(3)	(4)	(5)	(6)
BM	-0.006 (0.006)	-0.006 (0.006)	-0.011 (0.012)	-0.011 (0.013)	-0.006 (0.006)	-0.006 (0.006)
$QSPR_c$	-0.656*** (0.052)		-0.739*** (0.083)		-0.602*** (0.029)	
$BM \times QSPR_c$	0.602*** (0.036)		0.584*** (0.062)		0.605*** (0.036)	
$LnVOL_c$		0.017*** (0.004)		0.018** (0.007)		0.010*** (0.001)
$BM \times LnVOL_c$		-0.013*** (0.007)		-0.015*** (0.004)		-0.013*** (0.001)
Hourly dummies	Yes	Yes	Yes	Yes	Yes	Yes
League dummies	Yes	Yes	Yes	Yes		
R^2	4.25%	4.17%	5.77%	5.68%	0.17%	0.06%
N	3,747,662	3,747,662	34,820	34,820	3,747,662	3,747,662
N of groups	17,410	17,410			17,410	17,410

Notes: Columns (1) and (2) report the coefficients estimated from a pooled OLS. Columns (3) and (4) report the results from a pooled OLS with one randomly chosen observation per match. Columns (5) and (6) report the coefficients estimated from a fixed-effects OLS. All standard errors reported in parentheses are heteroscedasticity-consistent and clustered at the match level. In all models, *, **, and *** denote significance at the 10%, 5% and 1% levels, respectively.

bookmaker market than at the betting exchange market. The significantly negative effect of the quoted spread ($QSPR_c$) and the significantly positive effect of cumulative trading volume ($LnVOL_c$) indicate that liquidity at the betting exchange increases bettor returns

[5] We mean-center the variables $QSPR$ and $LnVOL$ to get a meaningful interpretation of the coefficients when an interaction term is included (Wooldridge, 2012).

[6] Unfortunately, the estimation of an Arellano-Bond dynamic-panel GMM model is not suitable here, as we have two return observations per time unit.

in general. The main variable of interest in Table 2 is the interaction term. The interaction effects are significantly positive when using the quoted spread as an illiquidity measure and significantly negative when using the cumulative trading volume as an liquidity measure. Thus, bettor returns at the bookmaker market are higher than at the betting exchange market if liquidity at the betting exchange is low. This finding is consistent across all three regression specifications as well as for *away win* and *draw* bets (see Table A.3 and Table A.4 in the Appendix).

5 Conclusion

Due to less operational risk, lower information costs and higher prediction accuracy, betting exchanges are considered to be a superior business model to traditional bookmaking (e.g., Davies et al., 2005; Koning & van Velzen, 2009). Nevertheless, bookmakers continue to be successful. This paper argues that the liquidity advantage of the bookmaker market helps to explain the puzzling co-existence of bookmakers and betting exchanges in the betting industry.

Both across- and within-match analyses demonstrate that the liquidity at the betting exchange significantly influences the bookmaker's and the betting exchange's prices. We find that bookmaker odds are higher than those of the betting exchange if the cumulative trading volume at the betting exchange is less than £23,400 and/or the quoted spread at the betting exchange is higher than 0.044 on average. Our results imply that a lack of liquidity at the betting exchange causes large gaps between bid and ask prices and thus higher betting exchange prices than bookmaker prices. Analyses of bettor returns confirm that bettors obtain higher returns at the bookmaker market than at the betting exchange market if liquidity at the betting exchange is low. Thus, the guaranteed liquidity provision at the bookmaker market is particularly valuable in periods in which liquidity is low at the betting exchange. Altogether, our paper shows that the order-driven betting exchange structure is not generally superior to the quote-driven bookmaker structure, as the active management of the sportsbook offers a distinct liquidity advantage, which helps to explain the ongoing coexistence of the two market structures.

Of course, the liquidity advantage is only one explanation for the coexistence of the market structures in the betting industry. Another advantage of the bookmaker is rooted in his profit-maximizing response to incoming betting demand. When the incoming volume demand is asymmetrically distributed due to the sentimental preferences of bettors, bookmakers can increase their profits by distorting their odds (Levitt, 2004; Forrest & Simmons, 2008; Franck, Verbeek & Nüesch, 2011). Croxson and Reade (2011) hypothesize that bookmakers continue to be successful because bettors face learning costs when switching to the betting exchange structure. The exchange interface, with its limit order book, different odds and the options to back (i.e., betting on a certain outcome) or lay (i.e., betting against a certain outcome) a bet, may discourage bettors from switching the market structure. Bookmakers also offer incentives such as free bets to dissuade customers from leaving. Franck et al. (2013) show that bookmakers tend to offer higher odds than the betting exchange as an element of their promotional activities to attract new customers. Once bettors have opened an account, switching costs cause them to to stick with the given bookmaker, even under unfavourable conditions.

Our analysis sheds some light on the recent shift of financial markets into hybrid structures. The London Stock Exchange (LSE) and the Nasdaq market, for example, moved from quote-driven systems to a hybrid market structure, at which the order book is supplemented by market makers (Friederich & Payne, 2007). Furthermore, the New York Stock Exchange (NYSE) is characterized by elements of both market structures (Madhavan, 2000). Empirical financial studies suggest that market makers are particularly valuable in hybrid structures when liquidity at the order book is low (e.g., Madhavan & Sofianos, 1998; Friederich & Payne, 2007; Venkataraman & Waisburd, 2007). As such, the hybrid market structure combines the advantages of both the quote-driven and order-driven structures. This might be one of the reasons why *Betfair* has started a sportsbook offering quoted fixed odds in addition to the exchange-based odds as of February 2013 (Betfair, 2013a), essentially moving to a hybrid market structure.

A Appendix

Table A.1: Analysis of prices for *away win* events

Panel A: Across-match analysis

	Dependent variable: LOW_BM (1/0)			
	Pooled LPM		Random time point LPM	
	(1)	(2)	(3)	(4)
$QSPR$	0.939***		0.958***	
	(0.016)		(0.039)	
$LnVOL$		-0.052***		-0.054***
		(0.001)		(0.002)
Hourly dummies	Yes	Yes	Yes	Yes
League dummies	Yes	Yes	Yes	Yes
R^2	23.16%	23.34%	25.23%	25.58%
N	1,873,831	1,873,831	17,410	17,410
N of groups	17,410	17,410		

Panel B: Within-match analysis

	Dependent variable: LOW_BM (1/0)			
	Fixed-effects LPM		Arellano-Bond GMM	
	(1)	(2)	(3)	(4)
$QSPR$	0.794***		1.025***	
	(0.018)		(0.006)	
$LnVOL$		-0.049***		-0.026***
		(0.001)		(0.0005)
LOW_BM_{t-1}			0.714***	0.780***
			(0.001)	(0.001)
Hourly dummies	Yes	Yes	Yes	Yes
R^2 overall	11.50%	15.05%		
Wald χ^2 (56)			$2.71{\cdot}10^6$***	$2.48{\cdot}10^6$***
N	1,873,831	1,873,831	1,839,011	1,839,011
N of groups	17,410	17,410	17,410	17,410

Notes: Panel A: Columns (1) and (2) report the coefficients estimated from a pooled LPM with heteroscedasticity-consistent standard errors clustered at the match level in parentheses. Columns (3) and (4) report the results from a pooled LPM with one randomly chosen observation per match. Panel B: Columns (1) and (2) report the coefficients estimated from a fixed-effects LPM with robust standard errors. Columns (3) and (4) report the results from a Arellano-Bond dynamic panel GMM model. In all models, *, **, and *** denote significance at the 10%, 5% and 1% levels, respectively.

Table A.2: Analysis of prices for *draw* events

Panel A: Across-match analysis

	Dependent variable: LOW_BM (1/0)			
	Pooled LPM		Random time point LPM	
	(1)	(2)	(3)	(4)
$QSPR$	1.058*** (0.018)		1.166*** (0.034)	
$LnVOL$		-0.068*** (0.001)		-0.072*** (0.002)
Hourly dummies	Yes	Yes	Yes	Yes
League dummies	Yes	Yes	Yes	Yes
R^2	29.89%	32.41%	31.69%	34.39%
N	1,873,831	1,873,831	17,410	17,410
N of groups	17,410	17,410		

Panel B: Within-match analysis

	Dependent variable: LOW_BM (1/0)			
	Fixed-effects LPM		Arellano-Bond GMM	
	(1)	(2)	(3)	(4)
$QSPR$	0.844*** (0.020)		1.124*** (0.003)	
$LnVOL$		-0.064*** (0.001)		-0.009*** (0.001)
LOW_BM_{t-1}			0.705*** (0.001)	0.932*** (0.003)
Hourly dummies	Yes	Yes	Yes	Yes
R^2 overall	13.76%	20.60%		
Wald χ^2 (56)			$3.02{\cdot}10^6$***	696,763***
N	1,873,831	1,873,831	1,839,011	1,839,011
N of groups	17,410	17,410	17,410	17,410

Notes: Panel A: Columns (1) and (2) report the coefficients estimated from a pooled LPM with heteroscedasticity-consistent standard errors clustered at the match level in parentheses. Columns (3) and (4) report the results from a pooled LPM with one randomly chosen observation per match. Panel B: Columns (1) and (2) report the coefficients estimated from a fixed-effects LPM with robust standard errors. Columns (3) and (4) report the results from a Arellano-Bond dynamic panel GMM model. In all models, *, **, and *** denote significance at the 10%, 5% and 1% levels, respectively.

Table A.3: Analysis of returns for *away win* events

	Dependent variable: bettor return					
	Pooled OLS		Random time point OLS		Fixed-effects OLS	
	(1)	(2)	(3)	(4)	(5)	(6)
BM	-0.004** (0.002)	-0.004** (0.002)	-0.006** (0.003)	-0.005* (0.002)	-0.004** (0.002)	-0.004** (0.002)
$QSPR_c$	-0.750*** (0.045)		-0.747*** (0.069)		-0.819*** (0.040)	
$BM \times QSPR_c$	0.829*** (0.036)		0.824*** (0.055)		0.829*** (0.039)	
$LnVOL_c$		0.002*** (0.001)		0.009 (0.007)		0.015*** (0.001)
$BM \times LnVOL_c$		-0.017*** (0.0004)		-0.018*** (0.001)		-0.017*** (0.001)
Hourly dummies	Yes	Yes	Yes	Yes	Yes	Yes
League dummies	Yes	Yes	Yes	Yes		
R^2	2.78%	2.69%	3.33%	3.22%	0.15%	0.03%
N	3,747,662	3,747,662	34,820	34,820	3,747,662	3,747,662
N of groups	17,410	17,410			17,410	17,410

Notes: Columns (1) and (2) report the coefficients estimated from a pooled OLS. Columns (3) and (4) report the results from a pooled OLS with one randomly chosen observation per match. Columns (5) and (6) report the coefficients estimated from a fixed-effects OLS. All standard errors reported in parentheses are heteroscedasticity-consistent and clustered at the match level. In all models, *, **, and *** denote significance at the 10%, 5% and 1% levels, respectively.

Table A.4: Analysis of returns for *draw win* events

	Dependent variable: bettor return					
	Pooled OLS		Random time point OLS		Fixed-effects OLS	
	(1)	(2)	(3)	(4)	(5)	(6)
BM	0.001 (0.001)	0.001 (0.002)	-0.002 (0.002)	-0.002 (0.002)	0.001 (0.001)	0.001 (0.001)
$QSPR_c$	-0.870*** (0.049)		-0.890*** (0.076)		-0.829*** (0.036)	
$BM \times QSPR_c$	0.847*** (0.039)		0.819*** (0.054)		0.847*** (0.039)	
$LnVOL_c$		0.013*** (0.0005)		0.022*** (0.006)		0.015*** (0.001)
$BM \times LnVOL_c$		-0.016*** (0.0004)		-0.017*** (0.001)		-0.016*** (0.001)
Hourly dummies	Yes	Yes	Yes	Yes	Yes	Yes
League dummies	Yes	Yes	Yes	Yes		
R^2	3.01%	2.88%	3.54%	3.43%	0.22%	0.06%
N	3,747,662	3,747,662	34,820	34,820	3,747,662	3,747,662
N of groups	17,410	17,410			17,410	17,410

Notes: Columns (1) and (2) report the coefficients estimated from a pooled OLS. Columns (3) and (4) report the results from a pooled OLS with one randomly chosen observation per match. Columns (5) and (6) report the coefficients estimated from a fixed-effects OLS. All standard errors reported in parentheses are heteroscedasticity-consistent and clustered at the match level. In all models, *, **, and *** denote significance at the 10%, 5% and 1% levels, respectively.

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