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# **Supernudge: A transparent pricing proposal for sports betting**

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# Supernudge: A transparent pricing proposal for sports betting\*

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## Abstract

This paper documents a policy proposal that improves consumer welfare in the sports betting industry by changing the framing of betting odds. On the demand side the proposal increases price salience, particularly for multibets, and acts as a classic behavioral nudge. On the supply side, the same change in framing increases the dimension of the pricing vector and, therefore, introduces a new dimension of price competition. In particular, the policy change introduces price competition into the market for multibets, reduces the current extraordinarily high profit margin on multibets, reduces non-price competition, and decreases demand for advertising from sports betting firms.

**Keywords:** Sports betting, transparent pricing, nudges, market structure

**JEL Codes:** D47, D91, Z28

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# 1 Introduction

Sports betting has exploded in popularity in recent years, and has been accompanied by a flood of advertising.<sup>1</sup> This increase in gambling activity has also generated an increase in concern from both public health researchers and policy makers about the harms associated with sports betting (Abbott, 2020; Johnstone and Regan, 2020). In this paper we introduce a novel policy proposal that is intended to improve consumer welfare in sports betting markets.

The current marketplace for sports betting exhibits two undesirable characteristics: prices are opaque, and the dimension of the pricing space is smaller than the dimension of the product space. These two characteristics dampen the elasticity of demand and induce firms to engage in non-price competition (i.e. excessive advertising). These effects are most pronounced in markets for multibets, a form of compound gamble that is frequently promoted in advertising materials, which are also referred to as parlays in North America or accumulators in the UK.

We propose a transparent pricing policy that simultaneously achieves two goals. On the demand side, the proposal acts as a nudge (Thaler and Sunstein, 2008) that improves consumer welfare by making prices more salient. On the supply side, the proposal increases the dimension of the pricing space and thereby facilitates price competition across a broader range of markets. The proposal enables prices for multibets to be set independently of prices for bets on individual events and, in doing so, removes the incentive for non-price competition in multibet markets. The transparent pricing policy is an example of libertarian paternalism (Thaler and Sunstein, 2003) and stands in contrast to other sports betting policy proposals, such as restrictions or bans on advertising or product offerings.

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<sup>1</sup>For example, real per capita wagering in Australia has increased from AUD1422 in 2000–01 to AUD2430 in 2018-19 (Queensland Government Statistician’s Office, 2023), and over 1 million gambling ads were broadcast on free-to-air television and metropolitan radio in Australia in the year ending April 2023 (Australian Communications and Media Authority, 2023). Legal sports betting revenue in the US reached USD11.04 billion in 2023, with the total amount wagered exceeding USD121 billion (American Gaming Association, 2023), after a Federal law that effectively banned sports betting was struck down by the Supreme Court in 2018 (Holden, 2019). The total 2023 sports betting spend on TV advertising in the US was over USD600 million (American Gaming Association, 2024).

## 1.1 Betting odds and price salience

A customer seeking to place a sports bet observes only the payouts associated with outcomes, presented in the form of odds, and not the underlying price of placing a bet.<sup>2</sup> For example, consider a match between Team A and Team B (and assume that a draw is not a feasible outcome) where the odds are  $d_A = \$1.57$  for Team A and  $d_B = \$2.41$  for Team B. Consider also a match between Teams C and D, with odds of  $d_C = \$1.80$  and  $d_D = \$2.05$ . Determining which match is presenting better value odds is not trivial. The underlying price of the first match can be calculated via the expression  $1 - \frac{1}{\frac{1}{d_A} + \frac{1}{d_B}} \approx 0.049$ , indicating a cost of approximately 4.9% of the amount wagered.<sup>3</sup> A similar calculation indicates that the cost for the second match is only 4.2% of the amount wagered.

Prices in a betting market are opaque, unless a customer is both able and willing to conduct these sort of calculations. Comparisons of odds across firms, for a given match, are straightforward but price comparisons across matches are difficult. Comparisons across events with a differing number of outcomes are particularly difficult: compare a basketball game, where draws are not possible, where the odds for the two teams to win are \$2.55 and \$1.52 with the odds for a soccer match, where a draw is possible, where the teams have odds to win of \$2.30 and \$2.75 and the draw has odds of \$3.50. Which set of odds is more attractive?<sup>4</sup>

One component of the transparent pricing policy proposed here is that underlying prices should be published directly. Transparent pricing has two key advantages for consumers. First, it renders comparisons across different matches and events trivial. Second, it sets an expectation for loss rates. Price salience allows for customers to make better informed and, therefore, better choices.

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<sup>2</sup>We use decimal odds, which present the total return to winning for each dollar bet, throughout. That is, odds of \$1.85 indicate that the total payout for a successful bet will be \$1.85 for each dollar wagered (including the return of the \$1 that was originally wagered).

<sup>3</sup>See Section 3 for a derivation and discussion. The betting literature often refer to the odds on an individual outcome as the price for that outcome. Here, because our unit of analysis is a *betting market* (see Definition 1), we define the price to be a property of the aggregate odds across all feasible outcomes. That is, the price of a betting market is a measure of the overall attractiveness of the odds offered across all possible outcomes, and is independent of the relative attractiveness of betting on each outcome. Price is therefore unrelated to the existence, or otherwise, of any favourite longshot bias in the market.

<sup>4</sup>The basketball game has better odds. The basketball game has a price of 4.8%, and the soccer match has a price of 7.8%. We are implicitly assuming here that the bettor has no appreciable skill, or lack of skill, in selecting teams that are more likely to win than the odds suggest. We formalize this assumption in Section 3.

## 1.2 Prices: single bets and multibets

A multibet is a bet that is placed across multiple different independent events.<sup>5</sup> The customer selects a winning outcome from each event, and the multibet wins only if all of the selected outcomes occur. Each independent component of a multibet is referred to as a “leg”. A multibet can be constructed from the first two two matches described in the previous subsection by, for example, selecting Team A in the first leg and Team C in the second leg. The odds for a multibet are constructed by multiplying the odds of each underlying leg:  $\$1.57 \times \$1.80 = \$2.83$  in this example. That is, if Team A wins the first match *and* Team C wins the second match, then a \$1 multibet will return \$2.83.

The underlying price of a multibet is more difficult to intuit than that of a single bet. In our running example, the two underlying single bets have costs of 4.9% and 4.2%. A natural, but incorrect, intuition is that the price of the multibet should be similar to the price of the underlying single bets, perhaps lying between 4.2% and 4.9%. Instead, consider that a multibet is equivalent to a customer placing a bet on the first leg and then reinvesting any winnings from the first leg into a bet on the second leg.<sup>6</sup> This formulation suggests the correct intuition: a cost of 4.9% is paid on the first bet and then the winnings, net of this cost, are reinvested in a second bet with a cost of 4.2% and the multibet pays the cost of *both* single bets. The price of the multibet, in this example, is  $1 - (1 - 0.049)(1 - 0.042) = 0.089$  and, in general, the price of a multibet is increasing in the number of legs in the multibet. The price rises sharply in the number of legs; a five leg multibet with an underlying price of 5% for each leg imposes an expected loss of 22.6%.

The complexity of pricing a multibet is substantially greater than pricing a single bet. It is, perhaps, unsurprising that many sports betting advertisements explicitly advertise multibets: they have higher profit margins than single bets, but the higher price is not readily transparent to unsophisticated consumers.<sup>7</sup> It is economically relevant to note that, given the current market structure, competition does not ameliorate the high profit margins on multibets for two main reasons. First, as already noted, uninformed consumers are unaware of the high prices that they

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<sup>5</sup>See footnote 16 for a discussion of multibets over non-independent events.

<sup>6</sup>Incidentally, this provides the intuition for the pricing convention that the odds of a multibet are the product of the odds of the underlying bets.

<sup>7</sup>Markets in which consumers can purchase either a bundle of products or the individual components, known as mixed bundling markets, are typically characterized by the bundle being available at a discount relative to purchasing the components separately (Zhou, 2021). Multibets are a curiosity, where the bundle is markedly more expensive than the underlying components. A misapplication of the heuristic, that bundles are usually cheaper, may help explain why many consumers have difficulty recognizing the true cost of multibets.

are paying and, second, the only mechanism via which multibet prices can be lowered is by lowering prices for the underlying single bets, and therefore also lowering marginal revenue in the single bet markets.

We demonstrate, in Section 4, that equilibrium multibet prices can remain high in two simple models, one of perfect competition and one of a Hotelling (1929) style duopoly, with informed consumers placing single bets and uninformed consumers placing multibets, because there is only a single pricing lever that can be set across the two markets. Because price competition is not feasible in the market for multibets, firms resort to non-price competition (e.g. advertisements, other inducements, or social betting apps) to attract and retain customers in this profitable market segment.

### 1.3 Breaking the pricing connection

We have already identified that one key component of our transparent pricing proposal is that underlying prices should be published directly. The second key component of our proposal is that betting odds should be structured so that there are independent pricing levers across single bet and multibet markets. Doing so allows for competition on multibet prices that is independent of single bet markets and reduces multibet prices. The structure of the proposal is such that status quo pricing is still available to firms under the new proposal even though, in equilibrium, the proposal reduces multibet prices.

Consider, again, our initial example of Team A and Team B with odds of  $d_A = \$1.57$  and  $d_B = \$2.41$ , and an implicit price of 4.9%. If a bettor places a bet of \$100 on Team A, then they receive \$157 if Team A wins. We propose an alternative framing of these odds. The bookmaker charges an upfront commission of 4.9%, while offering odds of \$1.65 for Team A and \$2.54 for Team B. If a bettor places a bet of \$100 on Team A then the bookmaker takes a \$4.90 commission and places a wager of \$95.10 on Team A (at odds of \$1.65) such that the bettor receives  $\$95.10 * \$1.65 = \$157$  if Team A wins.<sup>8</sup> The odds of \$1.65 for Team A and \$2.54 for Team B are not chosen arbitrarily in this example: note that  $\frac{1}{1.65} + \frac{1}{2.54} = 1$ , indicating that these odds are *fair*, and that ratio of the fair odds is the same as the original odds ( $\frac{\$1.65}{\$2.54} = \frac{\$1.57}{\$2.41}$ ).<sup>9</sup>

In the status quo firms set the absolute odds for each outcome independently, and the price is defined implicitly. In our proposal, **firms set the *relative* odds for each outcome, subject to**

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<sup>8</sup>Calculations have been rounded throughout this section.

<sup>9</sup>We define odds to be *fair* if a consumer who randomly picks a team to bet on, in inverse proportion to the available odds, will in expectation neither win nor lose money.

**a constraint that the odds are fair, and also set an explicit commission for the market.**

In each case the firm has  $n$  degrees of freedom in a market with  $n$  outcomes, and the two pricing schemes are formally equivalent in the sense that any set of prices that can be set in one scheme can be set in the other. This result is proven, and the pricing proposal laid out explicitly, in Section 3.

In our proposal, odds in a multibet are still calculated as the product of the underlying odds. However, given that the underlying odds are constrained to be fair, with a price of  $p = 0$ , the multibet odds are fair, with a price of  $p = 0$ , by construction. Firms earn revenue from multibets by setting a commission, but there is no longer a fixed relationship between single bet commissions and multibet commissions. In fact, as we show in section Section 4, for multibets, equilibrium commissions under the proposal fall substantially.

Because the proposal allows prices to be set independently across single bets and multibets, the market for multibets is now exposed to price competition. This removes the current strong incentives for non-price competition over multibets and, therefore, will reduce the demand for advertising from sports betting firms.

## 1.4 Roadmap

The remainder of the paper expands on and formalizes the arguments made above. Section 2 provides a brief review of the literature on the effects of price transparency. Section 3 provides a derivation of the price of single bets and multibets and proves the formal equivalence of the status quo pricing structure and the proposed transparent pricing structure. Section 3.3 also provides a worked example of the transparent pricing proposal. Section 4 introduces two models of price setting in the betting industry, one of perfect competition and one of duopoly, and demonstrates that both multibet prices and advertising levels are reduced by our pricing proposal. Section 5 concludes.

The transparent pricing policy proposal is explicitly stated in Section 3.2, and proofs are gathered in the Appendix.

## 2 The effects of price transparency and nudges

The primary argument for price transparency is a straightforward theoretical one. Suppose that a consumer prefers to purchase a good if and only if it has a price less than  $p$ . Any force that compels the consumer to purchase when the price is greater than  $p$ , or to not purchase when the price is

less than  $p$ , reduces welfare. If a consumer is not able to accurately observe  $p$ , then the potential for such errors arises. In our current environment, introspection suggests that consumers may be failing to maximize utility when purchasing multibets. Take, for example, a price of  $p = 0.05$  with  $M = 5$ . How reasonable is the preference to place a multibet with a price of  $p_5 = 0.23$  over a single bet with price  $p = 0.05$ ?<sup>10</sup>

Nevertheless, it is still informative to consider some of the empirical literature on price transparency, focusing on survey articles to reflect broad trends in the literature. To the best of my knowledge, none of the prior literature considers gambling markets. Greenleaf et al. (2016) presents a broad literature review on partitioned pricing, the practice of breaking up a total price into smaller components while shrouding some of the components. Common examples of partitioned pricing include posting prices that exclude sales taxes, withholding shipping fees until the end of a transaction, and appending fees and surcharges. Greenleaf et al. (2016) document legislative action, some of which has been contentious, has been taken to limit or prevent partitioned pricing across a range of industries (airlines, hotels, ticket sales, and auction houses) across the US, UK, New Zealand, Japan and Australia. Greenleaf et al. (2016) summarize the effects of partitioned pricing and find that, relative to an all in pricing scheme, partitioned pricing can lower the overall *perceived* cost, increase consumer demand, decrease price elasticity and reduce perceptions of fairness. Or, in other words, transparent pricing can reduce consumer demand.

Vasas (2023) studies the literature on nudges in retail financial markets, and identifies 35 relevant papers, with a focus on evaluating the impact on consumer search and switching behavior. She finds only a small effect for purely informational nudges, an increase in search and switching behavior of approximately 2 percentage points, but a much larger effect, a 16 percentage point increase, for nudges that have a stronger degree of intervention. Vasas (2023) refers to these stronger nudges as “structural” nudges, and they include interventions that increase the ease and convenience of switching and nudges that change the structure of the decision making environment, such as moving from partitioned pricing to all in pricing. DellaVigna and Linos (2022) evaluate 126 randomized control trials that study nudges across a broad range of industries, and find that the average nudge intervention increases take-up by 8.7 percentage points for academic studies and 1.4 percentage points for studies by Nudge Units.<sup>11</sup> They consider six different categories of nudges finding the

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<sup>10</sup>While there are reasons that some consumers may intrinsically prefer multibets, including skewness of the payoff distribution and a cumulative joy of winning, these effects would have to be unusually strong to justify losing, in expectation, 23 cents out of every dollar bet. This is particularly true when considering that placing a single bet on a long-shot outcome would dominate the payoff distribution of typical multibets, and that the payoffs to multibets are usually not life changing sums of money (unlike, say, lotteries).

<sup>11</sup>Nudge Units have been setup by several Governments, including in the US, UK and Australia, to study and

largest effects for “choice design” and “framing and formatting” nudges, and finding a small *negative* effect for “personal motivation” nudges.

Overall, the literature shows that the effects of nudges are typically small. The demand side of the price transparency proposal presented here is a “structural” nudge in the classification of Vasas (2023) and a “framing and formatting” nudge in the classification of DellaVigna and Linos (2022), and nudges in these categories typically exhibit stronger effects. On the supply side, however, the price transparency proposal has the potential to induce structural changes to the nature of competition in sports betting markets, and the supply side equilibrium effects are demonstrated in Section 4.

### 3 Defining price

This section formalizes the transparent pricing proposal in five steps. First, a formal definition of the price for a betting market is given. Second, we define what it means for a gambling market to be priced transparently, and prove the equivalence of transparently priced markets and traditionally priced markets. Third, we extend both of these concepts to multibets which, by definition, span multiple underlying betting markets. Fourth, we explicitly state the transparent pricing proposal. Finally, we provide an example of pricing in a transparent market.

Assume that there is an event with  $n$  possible mutually exclusive outcomes, or states,  $\{s_1, \dots, s_n\}$ .<sup>12</sup> Typically, a bookmaker offers a market, which consists of odds  $d_i$  for each dollar bet on state  $s_i$ , which we shall call a *standard market*.

**Definition 1.** A *standard market* with  $n$  outcomes is a set of odds  $d = \{d_1, \dots, d_n\}$ . If a consumer places a \$1 bet on outcome  $k$ , then the consumer’s payoff is  $d_k - 1$  if outcome  $k$  obtains and  $-1$  if outcome  $k$  does not occur.

Let  $q_i^*$  be the true (unobserved) probability of state  $s_i$  occurring, and  $B_i$  be a \$1 bet placed on state  $s_i$ . Then we can write the expected earnings for a consumer who bets \$1 on state  $s_i$  as

$$\mathbb{E}[B_i] = d_i q_i^* - 1$$

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implement nudges.

<sup>12</sup>We will sometimes abuse notation and refer to the state  $s_i$  and the  $i$ -th outcome interchangeably.

Given a set of odds, the implied probability that state  $s_i$  will occur is given by  $\frac{\frac{1}{d_i}}{\sum_{j=1}^n \frac{1}{d_j}}$ , and we denote this value by  $\bar{q}_i$ . Then we have

$$\begin{aligned}\mathbb{E}[B_i] &= d_i q_i^* - d \bar{q}_i + d_i \bar{q}_i - 1 \\ &= d_i (q_i^* - \bar{q}_i) - (1 - d_i \bar{q}_i) \\ &= \underbrace{d_i (q_i^* - \bar{q}_i)}_{\text{skill component}} - \underbrace{\left(1 - \frac{1}{\sum_{j=1}^n \frac{1}{d_j}}\right)}_{\text{price}}\end{aligned}$$

The expected return to the consumer has been decomposed into two components. The first is a skill component, dependent on the consumer's ability to select the outcome with the, relatively, most favorable odds. Notably, the skill component is expected to be zero in the case where the bookmaker sets relative odds accurately (so that  $q_i^* = \bar{q}_i$  for all  $i$ ); Hegarty and Whelan (2023) demonstrate that this will be the case in competitive betting markets. In markets with a favourite longshot bias a sophisticated consumer who takes advantage of the bias would earn a positive skill premium while an unsophisticated consumer who falls prey to the bias would earn a negative skill premium.<sup>13</sup> The existence of a favourite longshot bias is a property of the *relative* odds across outcomes.

The second component is the price of the bet, and the price captures the aggregate bias in the odds against the consumer.<sup>14</sup> The price of a market is independent of the outcome that the consumer chooses to bet on. Note that price can be altered, without changing the relative odds across outcomes, by scaling all odds up or down.

We now present a formal definition for the price of the market that is constructed to be independent of betting skill considerations. We say that a consumer bets into a market at random with weights  $w = \{w_1, \dots, w_n\}$  if they choose which outcome to bet on randomly and select outcome  $i$  with probability  $w_i$  and  $\sum_{i=1}^n w_i = 1$ .

**Definition 2.** The price of a standard market is the expected loss to a \$1 bet when the consumer bets into the market at random with weights  $w_i = \frac{1}{d_i}$  for all  $i$ .

The weights  $w_i = \frac{1}{d_i}$  are not arbitrary: a bookmaker who seeks to minimize the variance of their

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<sup>13</sup>The favourite longshot bias arises when  $q_i^* > \bar{q}_i$  for large values of  $q_i^*$  and  $q_i^* < \bar{q}_i$  for small values of  $q_i^*$ . See Ottaviana and Sørensen (2008) for an overview of the favourite longshot bias.

<sup>14</sup>The price is often referred to as the vigorish, juice, or hold, although the precise definitions of these terms can vary from source to source.

profits will set odds such that the expected flow of bets from consumers are inversely proportional to the odds (Cortis, 2015).

**Lemma 1.** The price of a standard market is  $p = 1 - \frac{1}{\sum_{j=1}^n \frac{1}{d_j}}$ .

This definition of price can be, alternatively, justified by two distinct arguments. First, a consumer can always place a set of bets which generates a risk-free payout of \$1 and cost a total of  $\sum_{j=1}^n \frac{1}{d_j} = \frac{1}{1-p}$ , which implies a loss of  $p\%$  of the total initial stake.<sup>15</sup> Therefore, we can interpret  $p$  as the cost of constructing a fully hedged portfolio within a given market. Second, if  $q_i^* = \bar{q}_i$  for all  $i$ , as would be the case in a competitive market (Hegarty and Whelan, 2023), then the expected loss from any bet on outcome  $i$  is a loss of  $p\%$  of the initial stake, implying that the price is equivalent to the expected loss from *any* bet into the market.

**Definition 3.** A market is *fair* if and only if  $p = 0$ , and a set of odds is *fair* if and only if the associated market is fair.

It follows immediately from Lemma 1 that a market has a price of  $p = 0$  if and only if  $\sum_{j=1}^n \frac{1}{d_j} = 1$ .

Now, we construct an alternative set of odds,  $d'$ , such that  $d'_i = d_i \sum_{j=1}^n \frac{1}{d_j}$  for all  $i$ . Note that, by construction,

$$\begin{aligned} \sum_{j=1}^n \frac{1}{d'_j} &= \sum_{j=1}^n \frac{1}{d_j \sum_{k=1}^n \frac{1}{d_k}} \\ &= \frac{\sum_{j=1}^n \frac{1}{d_j}}{\sum_{k=1}^n \frac{1}{d_k}} \\ &= 1 \end{aligned}$$

so that the alternative odds set a fair market. Furthermore,  $\bar{q}_i = \bar{q}'$  because each  $d_i$  has been scaled by the same amount. In other words, the alternate odds maintain the same implied probabilities over outcomes while setting the price of the gamble to zero.

**Definition 4.** For any set of odds,  $d$ , the *corresponding fair odds* are given by  $d'_i = d_i \sum_{j=1}^n \frac{1}{d_j}$  for all  $i$  and have a price  $p' = 0$ .

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<sup>15</sup>The consumer can generate this payout by placing a bet of value  $\frac{1}{d_i}$  on each outcome. This returns  $\frac{d_k}{d_k} = 1$  if outcome  $k$  obtains, and costs  $\sum_{j=1}^n \frac{1}{d_j} = \frac{1}{1-p}$ .

**Definition 5.** A *transparently priced market* consists of an upfront fee,  $f$ , and a set of *fair odds*,  $d$ . In a transparently priced market, each dollar bet is apportioned as follows:

- a fee of  $f$  is paid directly to the bookmaker, and
- a bet of value  $1 - f$  is placed in a market with (fair) odds,  $d$ .

There are natural parallels between a transparently priced market and the typical pricing structure of share brokers. A share broker will charge a percentage fee for executing a trade, and then invest the remaining money at market prices. Similarly, a bookmaker operating in a transparently priced market will charge a percentage fee,  $f$ , for executing a bet, and then invests the remaining money in a betting market with a price of zero. As might be expected, there is a close relationship between a *standard market* and a *transparently priced market*.

**Theorem 1.** *The following two markets are equivalent.*

1. A *standard market* with odds  $d$ .
2. A *transparently priced market* with corresponding fair odds,  $d'$ , and fee  $f = p = 1 - \frac{1}{\sum_{j=1}^n \frac{1}{d_j}}$ .

Theorem 1 states that any standard market can be exactly replicated as a transparently priced market. That is, the relative prices across the two markets are the same, including any favourite longshot bias if it exists, and the payoffs to both the bookmaker and all consumers are exactly the same. In this sense, the transparently priced market can be thought of as a reframing of the standard market.

Next, we consider the pricing structure of multibets in both standard markets and transparently priced markets.

### 3.1 Multibets

A *standard multibet market* consists of  $M$  independent *standard markets*, such that a consumer selects one outcome from each of the underlying markets to bet on. The consumer wins if all  $M$  selected outcomes obtain, and loses if any of the selected outcomes fails to obtain. We sometimes refer to each underlying standard markets as a *leg* of the multibet.

**Definition 6.** A *standard multibet market* is a set of independent standard markets,  $D = \{d^1, \dots, d^M\}$  where each  $d^l$  is a set of odds in standard market with  $d_k^l$  indicating the odds of the  $k$ -th outcome

in market  $l$ . If a consumer places a \$1 multibet on outcome  $k$  in each of the  $M$  markets, then the consumer's payoff is  $(\prod_{l=1}^M d_k^l) - 1$  if the  $k$ -th outcome obtains in all  $M$  markets and  $-1$  otherwise.

The payoff from a multibet is structured such that placing a multibet is equivalent to the consumer placing the  $M$  bets sequentially and reinvesting the winnings (if any) from each bet into the next. While it is feasible to conceive of a different payment structure for a multibet, this is payment structure that is currently used in multibet markets with independent underlying standard markets.<sup>16</sup>

**Lemma 2.** In a standard multibet market the price of a multibet,  $p_M$ , is given by

$$p_M = 1 - \prod_{l=1}^M (1 - p^l)$$

where  $p_l$  denotes the price of the  $l$ -th underlying standard market.

It follows immediately from Lemma 2 that the price of a multibet is increasing in the number of legs whenever the prices of the underlying standard markets are positive. (Cortis, 2015) also establishes that multibets have a larger profit margin than single bets.

**Definition 7.** A *standard multibet market with fair odds* is a standard multibet market where all of the underlying standard markets have fair odds.

**Corollary 1.** *The price of a standard multibet market with fair odds is  $p_M = 0$ .*

That is, a multibet market is fair whenever all of the underlying markets are fair. We now consider transparent pricing in a multibet market, with a transparently priced multibet market being defined analogously to a transparently priced (single bet) market.

**Definition 8.** A *transparently priced multibet market* consists of an upfront fee,  $f_M$ , and a standard multibet market with fair odds. In a transparently priced multibet market, each dollar bet is apportioned as follows:

- a fee of  $f_M$  is paid directly to the bookmaker, and

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<sup>16</sup>It is possible to extend the analysis here to cover the case of multibets with correlated underlying standard markets, at the cost of additional notation to handle the correlation between outcomes. We elect to focus on notational simplicity here. Correlated multibets are marketed as “same game multis” in Australia and can include, for example, betting on both the winner of a football match and the identity of the first goal scorer within the match.

- a bet of value  $1 - f_M$  is placed in a standard multibet market with fair odds.

**Lemma 3.** The price of a *transparently priced multibet market* is  $p_M = f_M$  and this price is independent of the number of legs in the multibet.

Finally, the equivalence between standard and transparently priced markets naturally extends into multibet markets.

**Theorem 2.** *The following two markets are equivalent.*

1. A standard multibet market with odds  $D = \{d^1, \dots, d^M\}$ .
2. A transparently priced market with corresponding fair odds,  $D = \{d'^1, \dots, d'^M\}$ , and fee  $f_M = p_M = 1 - \prod_{l=1}^M (1 - p^l)$ .

### 3.2 The transparent pricing proposal

The transparent pricing proposal being put forward in this paper is that all betting markets should be required by legislation to be transparently priced markets, and all multibet markets should be required by legislation to be transparently priced multibet markets.

**Proposal 1.** All single bet markets must be *transparently priced markets*, as in Definition 5, and all multibet markets must be transparently priced multibet markets, as in Definition 8.

Theorem 1 and Theorem 2 implies that the proposal is a nudge in the sense that any desired set of prices and odds that are available currently can be recreated in transparently priced markets. That is, for any standard market there exists an equivalent transparently priced market and for any standard multibet market there is an equivalent transparently priced multibet market. Thus, there is no barrier to a firm publishing standard odds alongside the transparently priced markets if they wish.

There is also a clear distinction in the relationship between standard markets and standard multibet markets, on the one hand, and transparently priced markets and transparently priced multibet markets, on the other. For any set of standard markets, the standard multibet market that is constructed from those standard markets must, by Lemma 2, have price  $p_M = 1 - \prod_{l=1}^M (1 - p^l)$ . This relationship no longer holds for transparently price markets. **A transparently priced multibet market is constructed using the same fair odds as the underlying transparently**

**priced markets, but the fees for each market can be set independently.** It is precisely this pricing independence that allows for an extra dimension of price competition when using transparently priced markets. We explore the implications of this pricing independence in the next section.

### 3.3 An example

We take, as an example, the four Australian Football League (AFL) games that were played on Saturday March 16th, 2024. These four games, and their odds as posted by Sportsbet the week before the games, are summarized in Table 1.

Home team	Away team	Home odds	Away odds
Essendon	Hawthorn	\$1.57	\$2.41
GWS	North Melbourne	\$1.10	\$7.00
Geelong	St Kilda	\$1.47	\$2.68
Gold Coast	Adelaide	\$1.80	\$2.05

Table 1: A summary of the four AFL games played on Saturday March 16th, 2024, with odds presented in the current standard format.

Table 2 shows the odds for the same games presented using the proposed transparent pricing format, as calculated using Theorem 1. It becomes clear, immediately, that the odds on the Gold Coast vs. Adelaide game are sharper than those of the other matches. Notice that a \$100 bet on Gold Coast would involve the bookmaker keeping \$4.20 as a commission and then placing the remaining \$95.80 on Gold Coast at odds of \$1.88. Thus, if Gold Coast wins, the consumer would receive  $\$95.80 \times \$1.88 = \$180.10$  which, up to a rounding error, is the same amount that the consumer would receive if the \$100 bet was placed at the standard odds of \$1.80. In all cases, the transfers from consumer to bookmaker are the same under the transparent pricing scheme as under the current odds format.

Consider, further, the case of multibets. Table 3 shows the odds for two different multibets that can be constructed from the four games in Table 1, with one multi selecting the four home sides and the other the four away sides. The effective price of the multibets is much larger, 17.8%, than the price for the underlying single bets and the transparent odds and fee have been calculated using Theorem 2.<sup>17</sup> Notice that the bookmaker could, if it desired, change the price of the multibets

<sup>17</sup>To illustrate, note that the transparent multibet odds are the product of the four home team transparent odds ( $\$5.56 = \$1.65 \times \$1.16 \times \$1.55 \times \$1.88$ ) and that the transparent fee can be calculated from the underlying single bet

Home team	Away team	Fee	Home odds	Away odds
Essendon	Hawthorn	4.9%	\$1.65	\$2.54
GWS	North Melbourne	4.9%	\$1.16	\$7.36
Geelong	St Kilda	5.1%	\$1.55	\$2.82
Gold Coast	Adelaide	4.2%	\$1.88	\$2.14

Table 2: The four AFL games played on Saturday March 16th, 2024, with odds presented in the proposed transparent pricing format.

by changing the fee charged for the multibets independently of any other pricing variable. This pricing independence is precisely the phenomena that allows for an additional dimension of price competition to drive multibet prices down when the transparent pricing proposal is implemented.

Bet	Standard odds	Transparent Fee	Transparent odds
Home team multi	\$4.57	17.8%	\$5.56
Away team multi	\$92.68	17.8%	\$112.72

Table 3: Two multibets constructed from the four AFL games played on Saturday March 16th, 2024, with odds presented both the standard and proposed transparent pricing formats.

## 4 Equilibrium

In this section we use two different models of equilibrium behavior in betting markets to investigate the effects of the transparent pricing proposal on the price of multibets and the demand for advertising from betting firms. The first model is a competitive market, and the second model is a Hotelling (1929) style duopoly market. In both settings we will consider two types of consumers, informed consumers and uninformed consumers. In the status quo, when facing a menu consisting of single bets and a multibet constructed from the single bets, an informed consumer will calculate the price of each bet and select the cheapest bet. An uninformed consumer, on the other hand, is assumed to always select the multibet in the status quo; unable, or unwilling, to calculate the price of a bet, the uninformed consumer prefers the larger payoffs that are associated with multibets. Under transparent pricing, both informed and uninformed consumers select the cheapest bet available: the uninformed consumer can now easily compare the price of different bets.

Given their inability to recognize prices in the status quo, uninformed consumers are primarily fees ( $0.178 = 1 - (1 - 0.049) \times (1 - 0.049) \times (1 - 0.051) \times (1 - 0.042)$ ).

recruited via advertising. Structuring the market in this manner is not an arbitrary modelling decision, but a reflection of the current state of the sports betting industry: the Australian Financial Review (Samlos, 2023) reported that SportsBet, the largest Australian sportsbetting firm, announced during an investor day in 2021 that it “had 3 million sports fans that it wanted to convert to sports betting.”<sup>18</sup> Consequently, sporting broadcasts in Australia, particularly from the two major football codes (the AFL and NRL), have been flooded with advertisements as SportsBet actively tries to realize this goal.<sup>19</sup>

#### 4.1 Competitive market

We begin by considering a representative firm in a competitive market where only informed consumers are present. Following Hegarty and Whelan (2023), in a competitive equilibrium the price of a single bet or, equivalently, the average rate of return to the firm will be equal to  $\theta$ , where  $\theta$  is a measure of the net normal profit rate. That is, we have

$$\theta = p$$

where  $\theta$  is the return, net of costs, required such that no new entrants seek to enter the market. Note that  $\theta$  implicitly prices in any regulatory barriers to entry, which may be substantial in some sports betting markets. Given this equality will hold for each betting market, we can define  $p$  to be *the* price for a bet on a single outcome. Given our definition of the price of a bet we restrict  $0 \leq p \leq 1$ .

Now, consider a market with both informed and uninformed consumers. For simplicity, we will assume that the only multibets that are offered are those with exactly  $M$  legs. Next, suppose that consumer demand for bets is such that some fraction  $q \in [0, 1]$  of all bets are placed by informed consumers and  $1 - q$  is placed by uninformed consumers. Then average revenue for the firm is given by

$$R = (1 - q)p_S + qp_M = (1 - q)p_S + q(1 - (1 - p_S)^M)$$

where  $p_S$  is the price for a single bet and  $p_M = 1 - (1 - p_S)^M$  is the price for a multibet. Note

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<sup>18</sup>For context, this is more than 11% of the Australian population in 2021.

<sup>19</sup>The motivation for this paper arose, in no small part, from the author becoming increasingly frustrated with the constant repetition of sports betting advertisements while he was trying to watch the AFL.

that

$$\frac{dR}{dp_S} = (1 - q) + q(M(1 - p_S)^{M-1}) > 0$$

so that, naturally, average revenue is increasing in prices.

In equilibrium, we must have

$$\theta = R = (1 - q)p_S + qp_M.$$

Note that  $p_S \leq p_M$  and  $0 \leq q \leq 1$  so that  $p_S < \theta < p_M$ .

Therefore, in equilibrium, the firm is earning less than equilibrium profits on single bets but making excess profits on multibets whenever  $q > 0$ . It is, of course, not possible to offer multibets without also offering the underlying single bets, and any mechanism that can generate new multibet customers is very profitable for the firm. This generates a demand for advertising and, specifically, the demand for advertising multibets from the firm. This motivates incorporating advertising into the model.

Suppose that a firm can recruit additional uninformed consumers via advertising. Let  $q' = q + a$  be the proportion of multibet customers after an advertising campaign that costs a proportion  $c(a)$  of revenue, with  $0 \leq a \leq 1 - q$ . We assume that  $c(a)$  is a convex function reflecting decreasing marginal returns to advertising, with  $c(0) = 0$  and  $c'(0) = 0$  and. Thus, average rate of return, net of advertising costs, is now given by

$$R = (1 - (q + a))p_S + (q + a)(1 - (1 - p_S)^M) - c(a)$$

There is clearly no equilibrium with  $a = 0$  because

$$\begin{aligned} \frac{dR}{da} &= -p_S + (1 - (1 - p_S)^M) - c'(a) \\ &= (1 - p_S) - (1 - p_S)^M - c'(a) \end{aligned}$$

and  $(1 - p_S) - (1 - p_S)^M > 0$  for  $0 < p_S < 1$ , which implies that  $\frac{dR}{da} > 0$  at  $a = 0$ .<sup>20</sup> Therefore,

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<sup>20</sup>If  $M$  is even, then  $(1 - p_S) - (1 - p_S)^M$  has roots at 0 and 1 and takes on positive values only for  $0 < p_S < 1$ . If  $M$  is odd, then  $(1 - p_S) - (1 - p_S)^M$  has roots at 0, 1 and 2 and takes on positive values for  $0 < p_S < 1$  and  $2 < p_S$ .

advertising must be positive in equilibrium. The equilibrium price,  $p^*$ , and advertising level,  $a^*$ , in this market can be characterized by the equations

$$(1 - (q + a^*))p^* + (q + a^*)(1 - (1 - p^*)^M) - c(a^*) = \theta \quad (1)$$

and

$$(1 - p^*) - (1 - p^*)^M - c'(a^*) = 0 \quad (2)$$

whenever  $(1 - p^*) - (1 - p^*)^M - c'(1 - q) < 0$ . Otherwise, the equilibrium involves sufficient advertising such that all consumers are uninformed, and equilibrium is characterized by  $a^* = 1 - q$  and  $(1 - (1 - p^*)^M) - c(a^*) = \theta$ .

Next, we consider a competitive market under the transparent pricing proposal. In this case, the fee for a single bet,  $f_S$ , and a multibet,  $f_M$ , can be set independently. Following the logic of competitive betting markets outlined in Hegarty and Whelan (2023) it must be that both  $f_S = \theta$  and  $f_M = \theta$ . Prices cannot fall below  $\theta$ , as firms would lose money and exit the market. Nor could prices rise above  $\theta$ , as the higher profits would attract excess entry that would drive prices down. There is no incentive to advertise to attract uninformed consumers under the transparent pricing proposal, as the profit rate from both uninformed and informed consumers are equal.

We summarize the key results derived above in the following proposition.

**Result 1.** *Under perfect competition*

1. *Advertising rates are lower under the transparent pricing proposal than under the status quo, and*
2. *The price of multibets are lower under the transparent pricing proposal than under the status quo.*

## 4.2 Oligopoly in the status quo

The conclusions of Result 1 are not critically dependent on the competitive market framework used in Section 4.1. To demonstrate this, we now derive the same conclusions from a duopoly model where firms compete for price-sensitive informed customers in the style of Hotelling (1929), but attract uninformed multibet consumers via advertising. In the status quo the uninformed consumers produce a larger profit per dollar bet, and this drives a large demand for advertising. Under the

transparent pricing proposal the marginal return from an additional uninformed consumer is equal to that of an additional informed consumer and advertising demand falls substantially, although in contrast to the competitive market advertising remains strictly positive in this case. The key results from the competitive model, that the profit rate from uninformed consumers and the demand for advertising both fall under the transparent pricing proposal, still hold.

The market for informed consumers is a market of product differentiation, in the style of Hotelling (1929). The dimension of differentiation is the user interface via which a consumer can place bets. While we abstract away from specific details, we imagine that factors including the ease-of-use of a betting app and the integration of betting services with associated products like tipping competitions or fantasy sports are all determinants of differentiation.<sup>21</sup> Consumers have differentiated preferences over these additional offerings; some consumers appreciate integration of various services, but others may find the additional services distracting and bothersome. Formally, a unit mass of consumers resides, uniformly distributed, along the interval  $[0, 1]$  and we index the interval by  $x$ . We assume a quadratic cost of taste function, so that a consumer who is located  $x$  units away from a firm experiences a cost of  $tx^2$  when purchasing from the firm, where  $t$  is a homogenous taste parameter. We assume two firms, one located at  $x = 0$  and the other at  $x = 1$ .<sup>22</sup>

Uninformed consumers exhibit distinct behavior. An uninformed customer would not, without external impetus, place any bets. Yet, an uninformed consumer may place a bet after being exposed to betting advertising. By assumption, the uninformed consumer is not able to calculate the price of a bet and, therefore, the uninformed consumers all place multibets (as multibets are featured in the advertising, being more profitable than single bets). The volume of uninformed consumers who place a bet is determined by their exposure to advertising, and by the odds provided by (i.e. the price of) the multibets.<sup>23</sup> The existence of uninformed consumers of this sort is non-standard, but it is not entirely ad-hoc.<sup>24</sup>

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<sup>21</sup>For example, in Australia, Sportsbet integrates with tipping in the Australian Football League by pre-filling a betting slip with your already chosen tips for upcoming games. In the United States, DraftKings and FanDuel integrate sports betting and fantasy sports competitions.

<sup>22</sup>It is readily shown that if firms choose a location endogenously then, in equilibrium, they will elect for maximal differentiation. See Tirole (1988, pp. 279–281) for example. For simplicity, we impose maximal differentiation exogenously.

<sup>23</sup>That uninformed consumers cannot calculate prices yet manage to have demand that is responsive to price may seem paradoxical. Even if a consumer cannot calculate price, they can still respond directly to the odds and be more likely to place a bet when odds are good. The inability to calculate prices prevents comparisons across different types of bets, however.

<sup>24</sup>It is more usual in the literature for consumers to be uninformed about the quality of a good, rather than the

### 4.2.1 Status quo demand functions and firm profits

A firm's total demand consists of a mass of informed customers who place single bets, and a mass of uninformed customers who place multibets. For simplicity, we assume that all single bets have the same price, and that all multibets consist of exactly  $M$  legs. We focus, first, on informed consumers.

An informed consumer, located at position  $x$  can elect not to place a bet, or place a \$1 bet with the firm located at 0 at a total cost of  $p_0 + tx^2$ , or \$1 bet with the firm located at 1 at a total cost of  $p_1 + t(1-x)^2$ , where we index firm specific variables by the firm's location. We assume that the consumer at location  $x$  will place a bet if  $\min\{p_0 + tx^2, p_1 + t(1-x)^2\} \leq \bar{v}$ , where  $\bar{v}$  is the consumer's reservation price.

The consumer at location  $\tilde{x}$  is indifferent between purchasing from firm 0 or firm 1 whenever  $p_0 + t\tilde{x}^2 = p_1 + t(1-\tilde{x})^2$  or when  $\tilde{x} = \frac{1}{2} + \frac{p_1 - p_0}{2t}$ . This point of indifference lies on the interior of the interval  $[0, 1]$ , and each firm is preferred by a strictly positive proportion of consumers, whenever  $|p_0 - p_1| < t$ . All consumers prefer to place a bet, rather than stay out of the market, when  $p_0 + t\tilde{x}^2 \leq \bar{v}$ , or when  $p_0 \leq \bar{v} - \frac{(t+p_1-p_0)^2}{4t}$  which reduces to  $p_0 \leq \bar{v} - \frac{t}{4}$  if  $p_0 = p_1$ . We shall assume that  $\bar{v}$  is sufficiently large to satisfy this condition.<sup>25</sup>

When both firms receive positive demand, the demand for firm 0 from informed consumers is

$$I_0(p_0, p_1) = \frac{1}{2} + \frac{p_1 - p_0}{2t}$$

and demand for firm 1 is

$$I_1(p_0, p_1) = \frac{1}{2} + \frac{p_0 - p_1}{2t}.$$

Demand from uninformed consumers,  $U(p_i, a_i)$ , is increasing in the level of advertising and decreasing in price. For simplicity we take demand to be linear in price, and that  $a_i$  scales the market size:  $U(p_i, a_i) = a_i(1-p_i)$ .  $U_i$  is independent of  $a_j$ , reflecting an underlying assumption that there is a large pool of potential uninformed customers such that a firm's demand is not affected by their rivals level of advertising.

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price. See Dranove and Jin (2010) for a survey. However, Samlos (2023) provides evidence that sports betting advertising targets casual sports fans, justifying the current assumption.

<sup>25</sup>Otherwise, we could rescale the mass of informed consumers so that only consumers who purchase are included.

A firm earns profits by selling single bets at price  $p$  to informed customers and selling multibets at price  $1 - (1 - p)^M$  to uninformed customers while facing a constant marginal cost of  $c$  and paying an advertising cost of  $b(a) = \frac{a^2}{2}$ . Thus, profits for each firm are given by:

$$\Pi_0(p_0, p_1, a_0) = \left(\frac{1}{2} + \frac{p_1 - p_0}{2t}\right)(p_0 - c) + a_0(1 - p_0)(1 - (1 - p_0)^M - c) - \frac{a_0^2}{2}$$

and

$$\Pi_1(p_0, p_1, a_1) = \left(\frac{1}{2} + \frac{p_0 - p_1}{2t}\right)(p_1 - c) + a_1(1 - p_1)(1 - (1 - p_1)^M - c) - \frac{a_1^2}{2}.$$

We illustrate the equilibrium by selecting reasonable values for the parameters  $t$ ,  $c$  and  $M$ . First, we assume that  $M = 5$ , so that all multibets in this market consist of 5 legs. Next, we assume that  $t = 0.02$  and  $c = 0.03$ , implying that marginal costs are 3% of the value of a bet and that the most that a consumer is willing to pay for a well designed betting app with an easy to use interface is 2% of the value of the bet. Note that when  $a_0 = a_1 = 0$ , equilibrium prices are  $p_0 = p_1 = t + c = 0.05$  (Tirole, 1988, p. 280).

The cross partial derivative  $\frac{\partial^2 \Pi_0}{\partial a_0 \partial p_0} = 6(1 - p_0)^5 - 0.97$  is positive for values of  $p_0 \leq 0.31$ , indicating that price and advertising are complements for reasonable price levels, and reflecting an intuition that the value of advertising is increasing in the value of uninformed consumers. As is the case in the standard Hotelling model,  $\frac{\partial^2 \Pi_0}{\partial p_0 \partial p_1}$  is also positive so that the pricing game is a game of strategic complements.

The first order conditions imply that, in any candidate equilibrium with prices  $p_0^*, p_1^*$  and advertising levels  $a_0^*, a_1^*$ , we have

$$a_0^* = (1 - p_0^*)(0.97 - (1 - p_0^*)^5) \quad \left(\frac{\partial \Pi_0}{\partial a_0}\right) \quad (3a)$$

$$a_1^* = (1 - p_1^*)(0.97 - (1 - p_1^*)^5) \quad \left(\frac{\partial \Pi_1}{\partial a_1}\right) \quad (3b)$$

$$0 = \frac{1}{2} + \frac{p_1^* - 2p_0^* + 0.03}{0.04} + 6a_0^*(1 - p_0^*)^5 - 0.97a_0^* \quad \left(\frac{\partial \Pi_0}{\partial p_0}\right) \quad (3c)$$

$$0 = \frac{1}{2} + \frac{p_0^* - 2p_1^* + 0.03}{0.04} + 6a_1^*(1 - p_1^*)^5 - 0.97a_1^* \quad \left(\frac{\partial \Pi_1}{\partial p_1}\right). \quad (3d)$$

Solving Equation 3, we find a candidate equilibrium at  $p_0^* = 0.085 = p_1^*$  and  $a_0^* = 0.300 = a_1^*$ . We confirm the equilibrium by checking the second order conditions, finding that  $\frac{\partial^2 \Pi_0}{\partial a_0 \partial a_0} < 0$  and

$$\frac{\partial^2 \Pi_0}{\partial a_0 \partial a_0} \frac{\partial^2 \Pi_0}{\partial p_0 \partial p_0} - \left[ \frac{\partial^2 \Pi_0}{\partial a_0 \partial p_0} \right]^2 > 0 \text{ at the critical point.}^{26}$$

#### 4.2.2 Transparent pricing demand functions and firm profits

When modeling the transparent pricing proposal, we will use the notation  $f_i^s$  and  $f_i^m$  to denote the fee charged by firm  $i$  for single bets and multibets, respectively. Given that the pricing is now transparent, it is immediate that if  $f_i^m > f_i^s$  then no consumer will purchase a multibet (and if  $f_i^m < f_i^s$  then no consumer will purchase a single bet). Thus, in equilibrium, all bets purchased from firm  $i$  will be purchased at a single price, and we denote this price by  $f_i$ .

Informed consumers are unaffected by the transparent pricing proposal. These consumers could already calculate the price of a bet in the status quo, and are thus indifferent between placing a bet at price  $p_i$  in the status quo or placing bet with fee  $f_i = p_i$ . Uninformed consumer are now able to select the betting product with the cheapest fee, and therefore can now purchase at price  $f_i$  instead of price  $(1 - (1 - p_i)^M)$  as before. Otherwise, we assume that uninformed consumer demand is unchanged. That is, we assume that  $U(p_i, a_i) = U(f_i, a_i)$ .

Profits for the firms under the new proposal is therefore given by:

$$\hat{\Pi}_0(f_0, f_1, a_0) = \left( \frac{1}{2} + \frac{f_1 - f_0}{2t} \right) (f_0 - c) + a_0(1 - f_0)(f_0 - c) - \frac{a_0^2}{2}$$

and

$$\hat{\Pi}_1(f_0, f_1, a_0) = \left( \frac{1}{2} + \frac{f_0 - f_1}{2t} \right) (f_1 - c) + a_1(1 - f_1)(f_1 - c) - \frac{a_1^2}{2}.$$

In this case the first-order conditions, using the same parametrization as before, for any candidate equilibrium are:

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<sup>26</sup>Calculations show that  $\frac{\partial^2 \Pi_0}{\partial a_0 \partial a_0} = -1$  and  $\frac{\partial^2 \Pi_0}{\partial p_0 \partial p_0} = -50 - 30a_0(1 - p_0)^4$ .

$$a_0^* = (1 - f_0^*)(f_0^* - 0.03) \quad \left(\frac{\partial \hat{\Pi}_0}{\partial a_0}\right) \quad (4a)$$

$$a_1^* = (1 - f_1^*)(f_1^* - 0.03) \quad \left(\frac{\partial \hat{\Pi}_1}{\partial a_1}\right) \quad (4b)$$

$$0 = \frac{1}{2} + \frac{f_1^* - 2f_0^* + 0.03}{0.04} + a_0^*(1 - 2f_0^* + 0.03) \quad \left(\frac{\partial \hat{\Pi}_0}{\partial p_0}\right) \quad (4c)$$

$$0 = \frac{1}{2} + \frac{f_0^* - 2f_1^* + 0.03}{0.04} + a_1^*(1 - 2f_1^* + 0.03) \quad \left(\frac{\partial \hat{\Pi}_1}{\partial p_1}\right). \quad (4d)$$

Solving Equation 4, we find a candidate equilibrium at  $f_0^* = 0.051 = f_1^*$  and  $a_0^* = 0.020 = a_1^*$ . We confirm the equilibrium by checking the second order conditions, finding that  $\frac{\partial^2 \hat{\Pi}_0}{\partial a_0 \partial a_0} < 0$  and  $\frac{\partial^2 \hat{\Pi}_0}{\partial a_0 \partial a_0} \frac{\partial^2 \hat{\Pi}_0}{\partial f_0 \partial p_0} - \left[\frac{\partial^2 \hat{\Pi}_0}{\partial a_0 \partial f_0}\right]^2 > 0$  at the critical point.<sup>27</sup>

### 4.3 The equilibrium effects of transparent pricing

The comparison of the status quo equilibrium with the transparent pricing equilibrium is stark. The level of advertising, which provides a measure of the market share of uninformed consumers, given that  $U(a, p) = a(1 - p)$ , falls from 0.3 to 0.02 in the transparent pricing equilibrium. The price paid by uninformed consumers also falls dramatically, from  $(1 - (1 - p)^5) = 0.357$  to  $f = 0.051$ , and the price paid by informed consumers falls from  $p = 0.085$  to  $f = 0.051$ . The results from our duopoly model therefore reinforce our key conclusions from the competitive equilibrium model.

**Result 2.** *In a price-setting duopoly*

1. *Advertising rates are lower under the transparent pricing proposal than under the status quo, and*
2. *The price of multibets are lower under the transparent pricing proposal than under the status quo.*

## 5 Conclusion

We have introduced a new transparent pricing policy proposal for sports betting markets. The policy proposal is structured such that the price of all bets is transparent, the demand for advertising

<sup>27</sup>Calculations show that  $\frac{\partial^2 \hat{\Pi}_0}{\partial a_0 \partial a_0} = -1$  and  $\frac{\partial^2 \hat{\Pi}_0}{\partial f_0 \partial f_0} = -50 - 2a_0$  and  $\frac{\partial^2 \hat{\Pi}_0}{\partial a_0 \partial f_0} = 0.97 - 2f_0$ .

from sports betting firms is reduced in equilibrium, and the price of multibets is reduced in equilibrium. The policy acts as a pure nudge on the demand side of the market, while simultaneously increasing the dimension of price competition on the supply side of the market. We expect the policy to improve consumer welfare in sports betting markets.

## A Proofs

*Proof of Lemma 1.* The expected return for a consumer who bets randomly into a market with weights  $w_i$  is given by:

$$\begin{aligned}
\frac{\sum_{i=1}^n w_i \mathbb{E}[B_i]}{\sum_{i=1}^n w_i} &= \frac{\sum_{i=1}^n w_i (d_i(q_i^* - \bar{q}_i) - (1 - \frac{1}{\sum_{j=1}^n \frac{1}{d_j}}))}{1} \\
&= \sum_{i=1}^n w_i d_i (q_i^* - \bar{q}_i) - \sum_{i=1}^n w_i (1 - \frac{1}{\sum_{j=1}^n \frac{1}{d_j}}) \\
&= \sum_{i=1}^n q_i^* - \sum_{i=1}^n \bar{q}_i - (1 - \frac{1}{\sum_{j=1}^n \frac{1}{d_j}}) \sum_{i=1}^n w_i \\
&= -(1 - \frac{1}{\sum_{j=1}^n \frac{1}{d_j}})
\end{aligned}$$

given that  $\sum_{i=1}^n q_i^* = 1$  by definition and  $w_i d_i = 1$ ,  $\sum_{i=1}^n w_i = 1$ , and  $\sum_{i=1}^n \bar{q}_i = 1$  by construction. □

*Proof of Theorem 1.* Write  $\mathbb{E}[B_i]$  to denote the expected return of a \$1 bet on outcome  $i$  in the standard market at odds  $d$ , and  $\mathbb{E}[B'_i]$  to denote the expected return of a \$1 bet on outcome  $i$  in a standard market at the corresponding fair odds  $d'$ . We have, for all  $i$ ,

$$\begin{aligned}
\mathbb{E}[B_i] &= d_i q_i^* - 1 \\
&= \frac{d'_i}{\sum_{j=1}^n \frac{1}{d_j}} q_i^* - 1 \\
&= \frac{1}{\sum_{j=1}^n \frac{1}{d_j}} [d'_i q_i^* - 1 + 1] - 1 \\
&= \frac{1}{\sum_{j=1}^n \frac{1}{d_j}} [\mathbb{E}[B'_i] + 1] - 1 \\
&= \frac{1}{\sum_{j=1}^n \frac{1}{d_j}} \mathbb{E}[B'_i] - (1 - \frac{1}{\sum_{j=1}^n \frac{1}{d_j}})
\end{aligned}$$

Next, consider the expected return of a \$1 bet in transparently priced market at odds  $d'$  and fee  $f$ , which we denote by  $\mathbb{E}[TB_i]$ . From the definition of a transparently priced market:

$$\begin{aligned}\mathbb{E}[TB_i] &= (1 - f)\mathbb{E}[B'_i] - f \\ &= \frac{1}{\sum_{j=1}^n \frac{1}{d_j}} \mathbb{E}[B'_i] - \left(1 - \frac{1}{\sum_{j=1}^n \frac{1}{d_j}}\right)\end{aligned}$$

Thus,  $\mathbb{E}[B_i] = \mathbb{E}[TB_i]$  for every  $i$ , and the consumer earns the same expected return from the standard market as the transparently priced market.  $\square$

*Proof of Lemma 2.* Suppose that the consumer selects the outcome for each underlying standard market randomly with weights  $w_i^l$ . The expected loss from the  $l$ -th leg of the multibet is  $p^l$ , from Lemma 1. Suppose that the consumer starts with a \$1 bet, and let  $r_k$  be the expected amount remaining after the  $k$ -th leg. After the first leg,  $r_1 = 1 - p^1$ .

Suppose that prior to the  $k$ -th leg, the consumer has an expected remaining bankroll of  $r_{k-1}$ . Then,  $r_k = r_{k-1}(1 - p^k)$ . Therefore,  $r_M = r_{M-1}(1 - p^M) = r_{M-2}(1 - p^M)(1 - p^{1-M}) = \prod_{l=1}^M (1 - p^l)$ . Finally, note that  $p_M = 1 - r_M$ .  $\square$

*Proof of Corollary 1.* Take  $p_l = 0$  for all  $l$  in Lemma 2.  $\square$

*Proof of Lemma 3.* From Corollary 1, the expected return from the  $1 - f_M$  that is randomly into the standard multibet market with fair odds is  $1 - f_M$ , and this value is independent of the number of legs in the market. Thus, the total expected return for the \$1 bet is  $1 - f_M$ , so that  $p = f_M$ , and is independent of the number of legs.  $\square$

*Proof of Theorem 2.* We prove the case of  $M = 2$ . The remaining cases follow naturally. Write  $\mathbb{E}[B_i^1]$  and  $\mathbb{E}[B_i^2]$  to denote the expected return of a \$1 bet on outcome  $i$  in the first and second standard markets, respectively, at odds  $d^1$  and  $d^2$ , and  $\mathbb{E}[B_i'^1]$  and  $\mathbb{E}[B_i'^2]$  to denote the expected return of a \$1 bet on outcome  $i$  in standard markets at the corresponding fair odds  $d'^1$  and  $d'^2$ . Further, write  $\mathbb{E}[B_{i,j}]$  to denote the payoff from placing a multibet on outcome  $i$  in the first market and outcome  $j$  in the second market. We have, for all  $i$  and  $j$ , that the expected return from placing

a multibet into the two markets is given by

$$\begin{aligned}
\mathbb{E}[B_{i,j}] &= \mathbb{E}[B_i^1]\mathbb{E}[B_j^2] = d_i^1 d_j^2 q^{*1} q^{*2} - 1 \\
&= \frac{d'1_i}{\sum_{k=1}^n \frac{1}{d_k^1}} \frac{d'2_i}{\sum_{k=1}^n \frac{1}{d_k^2}} q^{*1} q^{*2} - 1 \\
&= \frac{1}{\sum_{k=1}^n \frac{1}{d_k^1}} \frac{1}{\sum_{k=1}^n \frac{1}{d_k^2}} [d_i^1 d_i^2 q^{*1} q^{*2} - 1 + 1] - 1 \\
&= \frac{1}{\sum_{k=1}^n \frac{1}{d_k^1}} \frac{1}{\sum_{k=1}^n \frac{1}{d_k^2}} [\mathbb{E}[B_i^1]\mathbb{E}[B_i^2] + 1] - 1 \\
&= \frac{1}{\sum_{k=1}^n \frac{1}{d_k^1}} \frac{1}{\sum_{k=1}^n \frac{1}{d_k^2}} \mathbb{E}[B_i^1]\mathbb{E}[B_i^2] - \left(1 - \frac{1}{\sum_{k=1}^n \frac{1}{d_k^1}} \frac{1}{\sum_{k=1}^n \frac{1}{d_k^2}}\right)
\end{aligned}$$

Next, consider the expected return of a \$1 bet in transparently priced multibet market at odds  $d'$  and fee  $f$ , which we denote by  $\mathbb{E}[TB_{i,j}]$ . From the definition of a transparently priced market:

$$\begin{aligned}
\mathbb{E}[TB_{i,j}] &= (1 - f)\mathbb{E}[B_i^1]\mathbb{E}[B_i^2] - f \\
&= (1 - p^1)(1 - p^2)\mathbb{E}[B_i^1] - (1 - (1 - p^1)(1 - p^2)) \\
&= \frac{1}{\sum_{k=1}^n \frac{1}{d_k^1}} \frac{1}{\sum_{k=1}^n \frac{1}{d_k^2}} \mathbb{E}[B_i^1] - \left(1 - \frac{1}{\sum_{k=1}^n \frac{1}{d_k^1}} \frac{1}{\sum_{k=1}^n \frac{1}{d_k^2}}\right)
\end{aligned}$$

Thus,  $\mathbb{E}[B_{i,j}] = \mathbb{E}[TB_{i,j}]$  for every  $i$  and  $j$ , and the consumer earns the same expected return from the standard market as the transparently priced market.  $\square$

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