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# The Quarterly Review of Economics and Finance

journal homepage: [www.elsevier.com/locate/qref](http://www.elsevier.com/locate/qref)



## How quickly is temporary market inefficiency removed?

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### ARTICLE INFO

#### Article history:

Received 17 July 2008

Received in revised form 15 January 2009

Accepted 16 April 2009

Available online 24 April 2009

#### JEL classification:

G14

#### Keywords:

Arbitrage

Market efficiency

Behavioral finance

### ABSTRACT

I provide evidence on the length of time it takes for arbitrageurs to exploit attractive investment opportunities. A unique data set from the Internet sports betting market allows me to focus on the speed of investor response in an environment that is not affected by the joint hypothesis problem. The market does not instantly converge to an efficient level after mispricing occurs, but the adjustment process is rapid. Arbitrageurs remove many of these opportunities within minutes of them being created and the majority are gone within an hour. Arbitrage opportunities that are more difficult to find last for longer.

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### 1. Introduction

Available information is fully reflected in prices in an efficient market (e.g., Fama, 1970), but in reality prices do not always react instantly to new information. Merton (1987, p. 485) states “the expected duration between the creation of this investment opportunity and its elimination by rational investor actions in the market place can be considerable.” Much research energy has been devoted to how quickly individuals respond to information which is unsurprising given the importance of the efficient market hypothesis to finance.

This literature involved two approaches, both of which have a weakness. The first strand considers the convergence of prices to efficient levels, but in order to do so the authors first need to identify what the efficient price level is. This requires the use of a benchmark model, which as Fama (1998) points out, effectively means that two tests are jointly being undertaken. The first is speed of price convergence and the second is ability of the benchmark model to correctly identify efficient price levels. The second

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strand of literature, which considers convergence to efficient price levels by considering the speed at which arbitrage opportunities are removed, overcomes this joint hypothesis problem, however another issue is encountered. Most arbitrage in financial markets is not free of impediments to arbitrage such as short-selling constraints (e.g., Shleifer & Vishny, 1997) so it is possible that mispricing persists for long periods due to these rather than a lack of effort by investors to remove them.

I consider how quickly prices converge to efficient levels (i.e. arbitrage opportunities are removed) in an environment which does not suffer from either of the weaknesses outlined above, the Internet sports betting market. Durham, Hertz, and Martin (2005) point out that sports betting markets are similar to financial markets in that they attract large volumes and information is widely available, but they also have several strengths as an empirical laboratory.<sup>1</sup> The particular advantages this paper is interested in are: numerous price (or odd) quotations on the same event by different decentralised market makers (bookmakers), diverse price quotations generating arbitrage opportunities, arbitrage opportunities being easily identified and valued based on odds that are perfect substitutes (i.e. no fundamental risk), the odds having a short life and a well defined termination point (i.e. no noise trader risk), the arbitrage transaction being executed with minimal cost via the Internet (i.e. low transactions costs), and the absence of short-selling constraints.

It is difficult to quantify exactly how many individuals are actively involved in sports betting arbitrage. However a quick search on the Internet<sup>2</sup> generates over 1.8 million links to websites discussing the concept, providing advice on how best to capture the profits on offer, and giving feedback on how much money individuals are making exploiting these arbitrage opportunities. Sports betting arbitrage forums such as [www.arbforum.co.uk](http://www.arbforum.co.uk) and <http://www.sportsarbitrageworld.com> have over 10,000 posts from individuals who appear to be actively engaged in this activity.

I show divergent price quotations on the same sporting event allow median arbitrage profits of just over 1.5% per trade to be made. Once created, these opportunities are quickly removed. Their median duration is 15 min and 75% of all opportunities are removed within 50 min. Arbitrage opportunities that are more difficult to find last for longer. These include opportunities involving three- rather than two-outcome sporting events and arbitrage opportunities created by bookmakers who do not typically post odds that create such an opportunity. The opportunity costs of checking these odds are larger than those of checking the odds of bookmakers who frequently create opportunities so it is rational for arbitrageurs to check these bookmaker websites less frequently.

My results provide further support for the Merton (1987) suggestion that attractive investment opportunities are not removed instantaneously. Investors take time to locate and exploit attractive investment opportunities even in a market setting where fundamental risk, noise trader risk, transactions costs, and short-selling constraints do not impede the capturing of arbitrage opportunities. My finding that arbitrage opportunities that are more difficult to find last for longer is also consistent with the propositions of Merton (1987). My results are not affected by the joint hypothesis problem that is inherent in most tests of the speed of convergence to market efficiency, as no model of efficient price levels is required. Sports betting markets are less liquid than financial markets and it is possible that credit concerns are more prevalent in sports betting markets. However, I propose that neither of these factors, which are discussed in detail later in the paper, affect my conclusions in a major way.

The remainder of the paper is organized as follows: Section 2 provides a discussion of relevant literature. The market setting, data set and methodology used to determine if an arbitrage opportunity exists is described in Section 3. The results are presented in Section 4. Section 5 concludes the paper.

## 2. Related literature

In an efficient market, prices quickly react to information and rapidly converge to efficient levels as rational individuals seek to exploit attractive investment opportunities. However, many researchers show that in reality mispricing persists for long periods of time. Lamont and Thaler (2003) find evidence

<sup>1</sup> Others have indicated there are similarities between bets and certain financial assets. For instance, Vecer, Ichiba, and Laudanovic (2006) shows bets and credit derivatives have many similar properties.

<sup>2</sup> The Google search for the term "sports arbitrage" was conducted on 27 September, 2007.

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