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REVIEW OF PREDICTION MARKET RESEARCH: GUIDELINES FOR INFORMATION SYSTEMS RESEARCH

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Abstract

This paper presents an analysis of prediction market (PM) research relevant to information systems. Prediction markets are (online) markets are usually not traded on existing exchanges but on future events. As an emerging research area, prediction markets have received considerable attention from several disciplines, including economics, politics, marketing, computer science, electronic commerce and etc. In information systems research, however, they have been largely ignored. This study reviewed 93 academic articles concerning prediction markets. The analysis reveals that an increasing volume of PM research has been conducted, and that research themes of these studies can be categorized into three groups, namely general introduction, theoretical work, and PM applications. Building upon this work, we argue for the importance of future prediction market research and suggest potential research targets for IS researchers.

Keywords: prediction market, collective intelligence, synthesis view, information systems.

1 INTRODUCTION

Prediction markets, also known as “information markets”, “idea futures”, and “decision markets”, are promising forecasting mechanisms, which are able to efficiently aggregate dispersed information from various traders (Berg et al. 2003b; Fang et al. 2007; Forsythe et al. 1994; Wolfers et al. 2004b) to predict the outcomes of future events. PMs have been found to be efficient at aggregating dispersed information, regardless of the geographic limits or the irrationality of some traders (Ashton et al. 1985; Berg et al. 2003a; Chen et al. 2004; Forsythe et al. 1994). Meanwhile, PMs are proved to be often more accurate than those traditional information aggregating methods, such as polls and surveys (Berg et al. 2003a; Chen et al. 2005; Erikson et al. 2006; Forsythe et al. 1994; Kou et al. 2004; Rhode et al. 2004). In less than fifteen years, research on PM has captured several disciplines’ attention, including economics, politics, computer science, and marketing. Up to 2006, sixteen PMs (Appendix A) were open to the general public (Cherry et al. 2006a), and most of them are very popular and functioning well.

Compared with the rapid development of interests of PMs both in academia and practice, relevant research in information systems (IS) has been surprisingly absent. Given that prediction markets are applications of information systems to create online markets for (often business) phenomena, they are a highly relevant target for IS research and an area where IS research should be able to contribute significantly. Thus, to promote an understanding of this emerging research field, this study seeks to answer questions concerning the current development of PM research, the role of IS research done and research opportunities for the future. To achieve this goal, the study reviewed 93 academic research papers in order to develop a holistic view of previous PM studies. Building upon this work, we argue for the importance of PM research in IS and provide guidelines for future research.

The remainder of the paper is organized as follows. In the next section, we describe the research methodology, followed by an analysis of previous PM studies. Then we conclude the paper with a discussion of study limitations and then provide several guidelines for IS researcher.

2 METHODOLOGY

Three steps were performed to search for prior studies in prediction markets. First, ProQuest was used to build our initial pool of PM studies. ProQuest is a world leader database in offering information worldwide to researchers. It is made of more than 9,000 publishers worldwide and is known widely for its strength and breadth in multi-disciplines, that is why we mainly used it to search related articles. Since the term “prediction market” is not globally accepted, other widely used, relevant descriptions such as: “information markets”, “decision markets”, “idea futures”, and “Iowa Electronic Markets” were also used as keywords for searching.

Second, several prominent IS journals and conferences were searched one by one in order to identify possible PM papers in IS discipline. These journals include MIS Quarterly, European Journal of Information Systems, Information Systems Journal, Information Systems Research, Journal of AIS, Journal of MIS, Journal of Strategic Information Systems and Journal of Information Technology, and four IS conferences: ICIS, HICSS, PACIS and ECIS were also chosen to search PM articles.

Third, searches in all the references of each found paper were performed so as to identify additional PM papers. Under this condition, paper were searched and added by Google Scholar (<http://scholar.google.com>). Google Scholar is labelled as coverage of a multidisciplinary field and argued by Walters that it can provide the most uniform publisher and data coverage compared with other seven databases. Meanwhile, Walters resulted that Google Scholar indexes the greatest number of 155 core article (93%) (2007).

After these steps, it resulted in total of 119 articles, which include both journal and conference papers. By examining the abstract of all these articles, we eliminated irrelevant ones to refine the initial pool. 26 articles were removed because they studied different research topics, even use the same terms. For examples, some articles discussed “information markets” concerned trades between buyers and sellers. As a result, a total of 93 academic papers were found, including 77 journal articles and 16 conference proceeding papers.

3 LITERATURE ANALYSIS

3.1 Publication trend

The publication year of the 93 articles ranged from 1985 to 2007, which is a time span of more than 20 years. By calculating the number of papers for every two and four years respectively, we gained a clearer picture of the development of PM research over time (Figure 1 and Figure 2). As visible in Figure 1 below, the development can be divided into three periods. From the 1980s until approximately 1992, only a few studies were published each year. The early to late-90s (until 1998) witness an emergence of interest, likely coupled with the slow emergence of the Internet during that time. After the late 1990s, PMs begin to attract more research attention, resulting in fast publication growth. Figure 2 (aggregating over 4-year periods) shows an exponential publication growth trend. The trend significantly suggests that more publications can be expected in the following years. Nevertheless, we should note that the total number of PM study is still small, which indicates that PM research is still in its infancy.

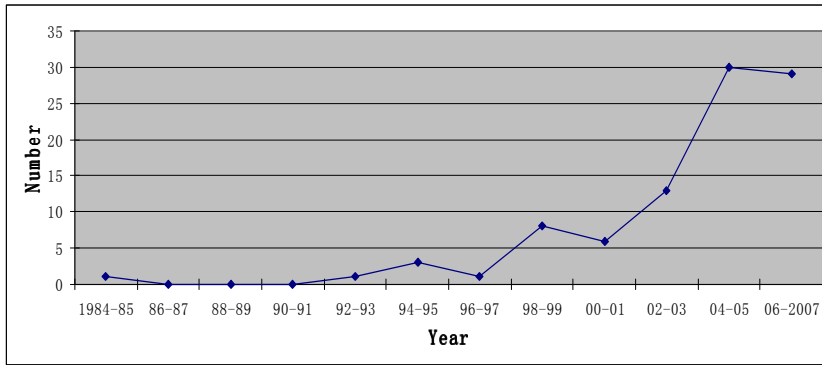


Figure 1. Publication trend (2-year intervals)

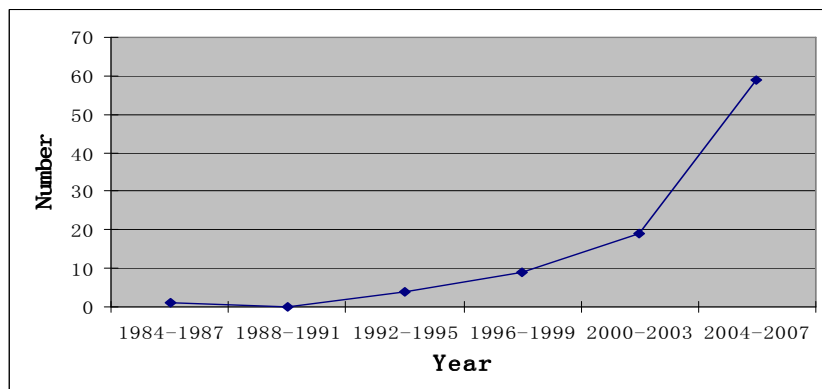


Figure 2. Publication trend (4-year intervals)

3.2 Publication outlet categories

As a next step in our analysis, we identified PM publication outlets, grouping them into seven categories, based on outlet name and outlet description (e.g., journal mission statement). We differentiated between business and economics, politics and law, information systems, prediction markets, electronic commerce, computer science and education. As Figure 3 shows, business & economics cover the largest number of studies and demonstrate the fastest growth in publications. Politics & law and information systems both show steady improvement as well. Among all the outlets, two were just established in recent years: *Electronic Markets* (Gruca et al. 2005; Rosenbloom et al. 2006; Servan-Schreiber et al. 2004) and the *Journal of Prediction Markets* (Hanson 2007). They seek to publish articles on every aspect of PM studies and applications.

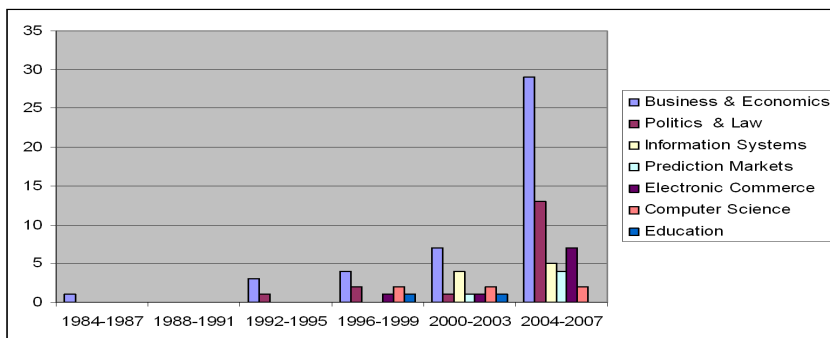


Figure 3. Publication by outlet category and time interval (4-year intervals)

In the business & economics category, we identified 44 papers, which cover 47%, nearly a half of the entire set (93) of identified PM articles. Research in this category usually adopt the *efficient market theory*, *market sorting rules* and *marginal trader hypothesis* to investigate explanations of PM success in anticipating future outcome, and to inspect PMs' efficient mechanisms for aggregating diverse information from distant traders (Berg et al. 2003a; Brüggelambert 2004; Feigenbaum et al. 2005; Hanson 2007; Malkiel 2003; Nikolova et al. 2007). Additionally, 17 articles were found in the politics and law category. They mainly discuss the application and legalization of PMs (Bell 2002; Einbinder 2006; Fowler 2006; Hanson 2006; Mccarthy 2007).

In the information systems category, we identified 9 articles, 6 in journals and 3 in conference proceedings. Five of the nine studies focused on applications, such as using PMs to support IT project management, while four articles paid attention to explain the accuracy of PMs and compared PMs with other traditional forecasting tools. It is difficult to clearly distinguish IS studies on PM only based on contents, which suggest that IS research currently still takes an undifferentiated view of the subject and has not yet evaluated PMs in the IS context.

Examining PM research according to specific publication outlets and publication dates, we found six articles were published in three conferences (ECIS ICIS and IRWIT)¹, as well as two IS journals, which are *Management Science* and *Information System Frontiers*, in the years from 2003 to 2007. In other words, only in recent years IS researchers have started to pay attention to PMs, have given this subject potentially less emphasis (suggested by 1/3 conference papers) and have been quantitatively under-represented compared to other fields (9 out of 92 articles). Moreover, considering the articles' context, few of them reflect true IS research characteristics, namely coverage of an information technology (IT) artifact. Orlikowski and Lacono (2001) propose the IT artefact as the "core subject matter" of the IS research field. Benbasat and Zmud (2003) define IT artifact as "the application of IT to enable or support some task(s) embedded within a structure(s) that itself is embedded within a context(s)" (p. 186), and design the IT artifact as the hardware and software. However, when we examined these 9 articles, it is hardly to find any one discussing the applications of IT in prediction markets.

IS articles have covered PM research from these three directions. Firstly, IS researchers paid attention to PM popularity and efficient mechanism. Chen et al. (2003, 2004) experimentally verified PMs can aggregate scatted information so that they can produce reliable forecasts of uncertain future events, which are more accurate than other traditional techniques, such as surveys and opinion polls (Chen et al. 2003; Chen et al. 2004). Spann and Skiera (2003) described forecast accuracy of PMs and offered a number of advantages compared to traditional forecasting methods.

Secondly, IS researchers proposed certain theoretical support and explanations about PM operation. Chen (2003; 2004) confirmed the rational expectations theory; while trader behaviours have been analyzed by Oliven and Rietz (2004). The feasibility and forecast accuracy of PM were analyzed and a new validity test for forecasting was proposed by Spann and Skiera (Spann et al. 2003). Additionally, based on PMs, a novel, multi-classifier combiner method for decision fusion, IMF (Information Market based Fusion), was presented by Perols and Chari (Perols et al. 2006).

Finally, the aim of four articles was to evaluate the potential uses of PM for business forecasting (Gruca et al. 2003; Herbert Remidez et al. 2007; Soukhoroukova et al. 2005; Spann et al. 2003). Spann and Skiera (2003) offered different design possibilities for PM forecasting applications in business. Field experiments of PMs were extended to the problem of forecasting the success of new products (Gruca et al. 2003), while using PMs to support the communication need within a distributed team environment in an IT project management (Herbert Remidez et al. 2007).

¹ ICIS: International Conference on Information Systems, ECIS: European Conference on Information Systems, IRWIT: International Research Workshop on Information Technology

3.3 Research themes

Based on PMs research character, PMs' publications were divided into four broad themes, differentiating between general description, use and applications, theoretical work, and legality and regulation (Tziralis 2007). Actually, legality and regulation is subsidiary theme of PM applications, however, considering its fundamental effect on PM's development, legality and regulation theme was highlighted as one independent theme here. A summary of publications by theme over time is shown in Figure 4.

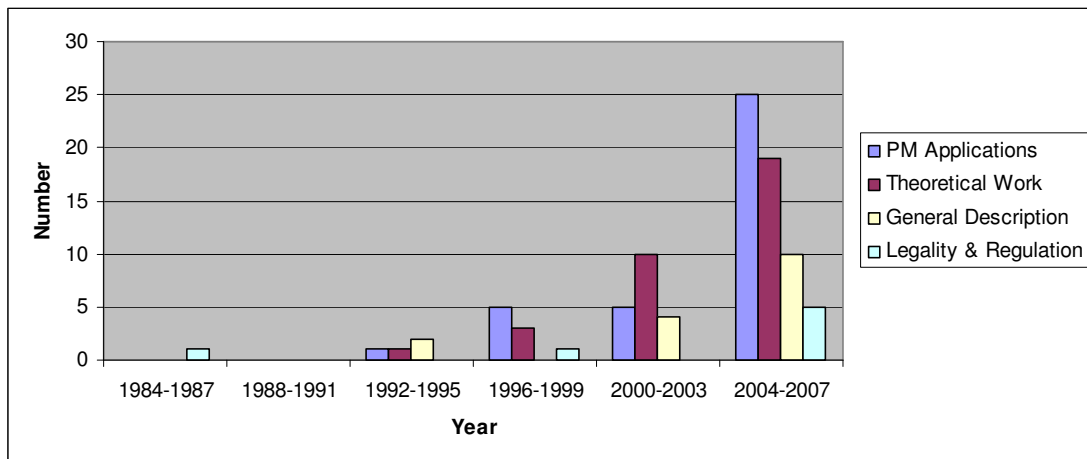


Figure 4. Research theme development over time

3.3.1 General description

Early research focused on the general description of PMs and introduction of this new information aggregation tool. Numerous studies of this kind exist (Cherry et al. 2006a; Dahan et al. 2002; Hahn et al. 2005a; Infotopia 2006; LaComb et al. 2007; Passmore et al. 2005a; Soukhoroukova et al. 2006; Spann et al. 2003). Research work in this theme provided fundamental information about PMs and defined different types of PMs.

The definition of PM has not reached a consensus in academic literature. The paper "Prediction Markets", written by Wolfers and Zitzewitz (2004a), is broadly adopted and widely cited. They define "Prediction markets", also known as "information markets" or "events future" as markets where participants trade in contracts whose payoff depends on unknown events. This definition focuses on basic aspects of PMs. Aiming at different purposes, different definitions emerge which highlight different characteristics of PMs. In the economic literature for instance, definitions mostly emphasize the pricing mechanism, depicting PMs as using prices to present the future events happening probability (Manski 2006); while articles on politics mainly focus on use in elections and thus the application of PMs. PMs are thus defined as futures exchanges on the outcome of elections. Elsewhere they are also referred to as *vote share markets* (Hansen et al. 2004).

As for the types of PM, there are two criteria frequently used to group PMs. One is based on the contracts and the other is considering *how to pay* for the contracts; using play money or real money. In a PM, payoffs are tied to the outcomes of future events. Different contract types regulate how payoffs are linked to the outcome of events. The literature differentiates between "winner-take-all", "index" contracts, and "spread" betting (Wolfers et al. 2004b). How to pay for the contracts is another important standard to categorize PMs: real-money markets versus play-money markets. If traders use real money to buy and sell contracts, they risk losing money. Under this condition, PM trading is often considered as gambling (Bell 2002). When "play money" is used in PMs, the activity is frequently

referred to as a game (Alster 2003; Debnath et al. 2003; Mangold et al. 2005; Mccarthy 2007; Pennock et al. 2001). However, whether the prediction market can be defined as a gambling or a game when using the real/ play money is still under discussion and have not come to consensus in academic research.

3.3.2 *Theoretical work*

The literature in this category describe PMs' theoretical nature, such as the market modeling, information aggregation convergence and equilibrium, as well as other theoretical issues (Tziralis 2007). Most articles appearing in economics journals have this focus.

Research on market modeling has covered various aspects of PM modelling, framework design and analysis (Bergfjord 2006; Chen et al. 2006; Fortnow et al. 2003; Hanson 2003; Hughes 2006; Kazumori 2004; Pennock 2004; Pennock et al. 2001). Focusing on information aggregation convergence and equilibrium, researchers have studied the convergence and equilibrium properties of the information aggregation process in PMs (Berg et al. 2003a; Chen et al. 2001; Feigenbaum et al. 2005; Hansen et al. 2004; Hanson 2002; Hauser et al. 2005; Pennock et al. 1997).

Other theoretical issues include offering theories to explain PM mechanisms and price efficiency (Oliven et al. 2004). Price is an essential criterion to assess whether a market is efficient. In order to explain estimation accuracy and attempt to explain this market's efficiency, many researchers examine PM prices effectiveness (Ashton et al. 1985; Bean 2005; Berg et al. 2003a; Forsythe et al. 1995; Forsythe et al. 1999; Gjerstad 2005; Knight 2007; Manski 2006; Wijnhoven 2001).

3.3.3 *PM applications*

This category comprises papers which describe all applications of PMs. Most papers discuss practical applications of PMs, such as the most famous one "Iowa Electronic Markets" and etc. Meanwhile there are some papers experimentally verify certain application of PMs.

Many researchers describe different applications of PMs in different countries. The early works mostly focused on political stock markets applications. One of the most famous ones is the Iowa Electronic Markets (IEM), which was initiated in 1988 and originally designed to predict the outcome of US presidential elections (Forsythe et al. 1992). In addition to the Iowa Electronic Markets (Berg et al. 2006a; Berg et al. 2006b; Forsythe et al. 1994; Forsythe et al. 1999; Gruca 2000), other election markets were also described and analyzed in different countries, like the Passauer Wahlbörse, as early as 1990 in Germany (Beckmann et al. 1996), as well as others in Canada (Antweiler et al. 1998; Forsythe et al. 1995; Forsythe et al. 1998), and Sweden (Bohm et al. 1999). Recently, the use and application of PM extend from political election to many other areas (Elberse 2005): such as sports (Debnath et al. 2003; Mangold et al. 2005), entertainments (Gruca 2000; Rosenbloom et al. 2006), educations (Passmore et al. 2005b; Simkins 1999), and other business forecasting (Guo et al. 2006; Ho et al. 2007; Polgreen et al. 2007; Polk et al. 2003; Soukhoroukova et al. 2005).

3.3.4 *Legality and regulation*

Most political and law articles emphasize legal issues related to PM (Abramovicz 1999; Abramowicz 2004; Bell 2002; Cherry et al. 2006b; Hahn et al. 2006; Mccarthy 2007). In "Gambling for the Good, Trading for the Future: The Legality of Markets in Science Claims" (Bell 2002), Bell stated that PMs could effectively open a shortcut to the future, giving answers more quickly, accurately, and inexpensively than other forecasting methods. However, U.S. law does not clearly approve of this kind of market, especially when real money is used. Actually, in practice, legal issues are a key factor that has limited the further development of PMs (Abramowicz 2006). How to break through these limitations are urgent unsolved research gaps for any discipline researchers.

4 CONCLUSION AND DISCUSSION

PMs are an emergent phenomenon that has received wide attention from many fields, such as economics and politics, computer science, marketing, electronic commerce and etc. Meanwhile, they have been applied in a number of situations, such as elections, entertainments and even used by organizations internally for operations and marketing forecasting. Despite the growing interest elsewhere, there has been no comprehensive effort to broadly embrace PM research within the IS context, with only 9 articles categorized as IS research, none of them focusing strongly on the IS artifacts. One may argue that this literature survey cannot claim to be exhaustive, and thus the results may not provide an “entire” picture of the impact of IS research. However, based on its methodology (multiple keyword searches, reference search), it does identify a comprehensive list of articles. Table 1 illustrates the relative breadth, mapping publication outlet categories against publication themes identified earlier. Table 1 also highlights relatively “under-researched” areas, based on gaps and low article counts.

Theme	Publication Outlet Category							Total
	Business & Economics	Politics & Law	IS	PMs	Electronic Commerce	Computer Science	Education	
Use & Application	16	6	5	3	3	1	2	36
Theoretical Work	20	2	2	2	4	4	0	34
General Description	5	7	2	0	2	1	0	17
Legality & Regulation	3	2	0	0	0	0	0	5
Total	44	17	9	5	9	6	2	92

Table 1. Number of papers by publication category and research theme

Accurate predictions are essential to both individuals and organizations, and the ability to quickly gather, aggregate information is a key asset for today’s competition (Butler et al. 2005). PM, which has an efficient mechanism of aggregating diverse related information from dispersed individuals, is highly promising. Its success has been proved by many practical application examples as well as theoretically. Nowadays, PMs’ applications in industry and in the public Webs are rapidly increasing. Furthermore, at the core of prediction markets is an IS artifacts, the electronic market, and an associated data mining mechanism. Hence, considering the practical value of PMs, they definitely provide ideal research opportunities for IS researchers. Numerous research questions arise, especially with respect to information aggregation (information access and data mining), PM efficiency (knowledge management), and market feedback (communication).

First, PMs aggregate information from all participants, requiring that participants have relevant information about the issue in question (Fang et al. 2007; Hahn et al. 2005b; Hahn et al. 2005c; Herbert Remidez et al. 2007; Plott 2000). Furthermore, the information relevant to forecasts is often dispersed across different traders, frequently in different geographic areas. IS researchers may therefore provide insights on how to take the most advantage of new technologies to bring more “informative traders” together to create the best conditions for accurate estimates.

Second, PM efficiency is often explained based on the market’s ability to incentivize traders to participate and to reveal their inside information via a betting mechanism (Kambil et al. 2002; Leigh et al. 2006; Williams 2005). What and how to attract participants into these markets? How can we arouse traders’ enthusiasm of participating in PM by using specific information technologies? Analyzing trader behaviour in PM and the role of IT artifact in it is another key issue for IS research.

Third, the market provides feedback to participants through market prices. This feedback is immediately reflected by the price and hence it is a quick prediction of the impact of that information on future market situations (Green et al. 2007; Knight 2007; Veldkamp 2006; Wolfers et al. 2006). PMs have special information aggregation and demonstration mechanisms, whereby the information is immediately revealed by the price. At present, other aggregation methods such as number of hits, “digs”, or presence in a “search cloud”, are used to communicate popularity information. Using prices or their translation into probabilities is a useful area for exploration as a communication medium. IS researcher has already examined the use of PMs to improve project communication (Herbert Remidez et al. 2007). Therefore, using PMs to facilitate distributed information communication should be a worthwhile research target for more IS researchers.

Academic researches on PM are still in the early stages, especially for the information systems discipline. IS researchers have great opportunity to shed light on the applicability of prediction markets due to their understanding of the underlying IT artifact, the electronic market and the information aggregation mechanism. Future research that would enable improvement in the functionality of prediction markets would provide meaningful insights both to research and practice.

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Appendix A: Current Information Markets

Current PMs	Websites
Austrian Political Stock Markets	http://zwickl.ibab.tuwien.ac.at/apsm
Blogshares	www.blogshares.com
Celebdaq	www.bbc.co.uk/celebdaq/
Election Stock Market	http://esm.ubc.ca
Foresight Exchange	www.ideosphere.com
Hollywood Stock Exchange	http://www.hsx.com/
Influenza Prediction Market	http://iemweb.biz.uiowa.edu/OUTBREAK/flu_quotes.html
Innovation Futures	www.innovationfutures.com/bk/index.html
InTrade	http://www.intrade.com/
Iowa Electronic Markets (IEM)	http://www.biz.uiowa.edu/iem/
Long Bets- Accountable Predictions	http://www.longbets.org/
News Futures	www.us.newsfutures.com/index.html
Political Stock Exchange	http://www.PoliticalStockExchange.com/
TradeSports	http://www.tradesports.com/
Wahlstreet	http://www.wahlstreet.de/