Prediction of bird flu (H5N1) outbreaks in Taiwan by online auction: Experimental result

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Abstract

The ability of accurate epidemic prediction facilitates early preparation for the disease and minimizes losses due to any strikes. We devised a platform on the Web for users to exchange their information / opinion on possible avian flu outbreaks in Taiwan. The likelihood of the first human infection of bird flu in Taiwan in, say, December 2005 is securitized in the form of a futures contract. Incentives are introduced via tournament: users trade the futures in the market on our Web server in order to win the awards in the end of the tournament. We ran such a tournament during the period between December 2005 and February 2006. Results of the futures' prices correctly predicted no outbreaks of bird flu among the residents in Taiwan during the 3-month period, suggesting that the design of the futures exchange on the Web be a useful tool of event forecasting.

Keywords: avian influenza, futures exchange, market

1. Introduction

The 1918 influenza pandemic, by a highly virulent strain (H1N1) of the influenza virus, arose in Europe and killed 20 to 50 million people globewise in about a year between 1918 and 1919. The fast spread of the disease is most fearful: AIDS has killed 25 million in the first 25 years since it was first recognized in 1981 while the 1918 flu may have killed as many in its first 25 weeks. Other major flu pandemics in the 20th century are the one (H2N2) that began in China in 1957 and killed about 2 million people worldwide and the one (H3N2) that started in Hong Kong in 1968 and killed about 1 million people worldwide.

The 1957 and 1968 flu pandemics were known to be caused by human flu viruses that became deadly by acquiring two or three gene mutations from avian flu virus. They are of hybrid origins. A recent genetics study on the 1918 epidemic however revealed that the 1918 flu was of an entirely avian origin[1], explaining its virulence to human hosts which had not developed immunity. Recently, an H5N1 bird flu started ravaging the poultry in southeastern Asia in late-2003 and has killed at least 131 people worldwide, according to the WHO[2]. In the dawn of the 21st century when people are traveling and migrating across continents at a higher frequency and on a larger scale than ever before, the H5N1 bird flu therefore presents a threat should the virus mutates to a form that is transmissible among humans. Gauged on the magnitude of the devastation the epidemic may incur, we desire a method that can accurately predict the date when an outbreak occurs.

A survey in January 2006 estimated that the penetration rate of Internet users in Taiwan was 66%, 91% of which were broadband users[3]. It would be advantageous to consolidate the collective intelligence of the online users for an efficient epidemic surveillance. If we treat the probability of an epidemic outbreak as a variable, the value of it is undetermined due to the stochastic nature of the event occurrence. In economics, auctions are a way of determining the values of commodities or securities by sellers and bidders. If the market is big enough in the sense that representative traders are present, the prices determined via the auction are believed to be accurate or fair.

We were pressed by the urging concern of epidemic threat and thus developed a website[4] for the exchange of so-called "bird flu futures". The type of auction employed in the online exchange is the continuous double auction which is widely used in real world exchange houses worldwide. The prices of the futures contracts, by design, directly translate into the probability of bird flu outbreak so that when the price of bird flu Feb'06 reaches 90 per share, it means that the chance of a bird flu infection in Taiwan in the February of 2006 is 90%. When the price goes down to 5, the chance drops to 5%, …, and so on. A time-series data for the futures' price thus manifests public forecast of bird flu outbreaks in Taiwan.

We launched such an experiment on the Internet in December 2005 with four futures contracts: bird flu Dec'05, bird flu Jan'06, bird flu Feb'06 and no bird flu at all by Feb'06. About 40 players participated in the experiment. The four time-series corresponding to the four futures contracts correctly predicted no local human infection by the bird flu during the 3-month period of the experiment.

Event outcome predictions by online exchange were pioneered in predicting elections by the so-called political futures[5][6]. Our design is distinct in that, instead of predicting who will win the election, we predict when the deadly infections will (or will not) erupt. The second feature of our study is that the experiment was conducted in the form of tournament where players trade the futures contracts using fictitious money. This is to circumvent the difficulty and complications of dealing with flow of real money under the constraint of an academic research setting. Incentives are nevertheless shown to be important for the success of the experiment.

The report is organized as follows. The Bird Flu Futures section describes specs of the futures contracts. The Tournament section details the experiment on the Web server. We discuss and compare results of the experiments.

2. Bird Flu Futures

Four bird flu futures contracts are created for the trading in the exchange market on our Web server:

1. *birdflu_Dec05*: first human infection with bird flu in Taiwan in December 2005
2. *birdflu_Jan06*: first human infection with bird flu in Taiwan in January 2006
3. *birdflu_Feb06*: first human infection with bird flu in Taiwan in February 2006
4. *no_birdflu06*: no human infections with bird flu in Taiwan between Dec '05 and Feb '06

The liquidation price of a share of *birdflu_Dec05* will be 0 if no human is infected with bird flu in Taiwan in the month of December 2005. If a local infection should occur in December, the liquidation price of *birdflu_Dec05* will be 100, and those of the other contracts, i.e. *birdflu_Jan06*, *birdflu_Feb06* and *no_birdflu06* will all be 0, and we will end the experiment immediately. The same liquidation price and rule apply to *birdflu_Jan06* and *birdflu_Feb06*. If no human bird flu infections have occurred till the end of February 2006, the liquidation price of *no_birdflu06* will be 100 per share and those of the rest will be 0, and we end the experiment on February 28, 2006.

Note that the contract, *no_birdflu06*, was introduced to ensure that the prices of the four contracts sum to 100, if the market is rational. This feature makes it easy for players to arbitrage whenever the market deviates from norm.

3. Tournament

The bird flu futures contracts defined above were issued and traded in an exchange market created on the Internet at http://socioecono.phys.sinica.edu.tw (Taipex). Everyone with access to Internet was free to join the experiment by registering at Taipex. An account was established at the Taipex server, coming with an amount of 3,000 fictitious dollars for the user to start with. Registration was free and anonymous.

Since the money was fictitious, we needed other incentives to motivate the participants. We decided to run the experiment as a tournament. In the end of the tournament, i.e. March 1, 2006, all the players were ranked according to the accumulated (fictitious) wealth in their accounts. The top three players were then identified and awarded winning certificates in honor of their comprehensive knowledge as well as excellent trading skills.

Trading went on as in a real world exchange. For example, market orders and limit orders for buying and selling shares of the futures contracts were possible via the graphical user interface at the Taipex website. A limit order could be cancelled before it expired. There was however no transaction fees. Account earned no interests since the tournament last only a short time (i.e. three months). A user was allowed to have multiple orders in different orderbooks, the operation of which is detailed in the appendix section. An account would be suspended if its balance became negative.

Product promotion is crucial to any business as evidenced by its proportion in corporate expenditure. Our experiment was no exception. We made the announcement of the tournament through posts to the Internet forums of the colleges bulletin board systems (BBS) throughout Taiwan.

4. Results

Though the Taipex website has existed[7], it is by no means a popular website. The number of participants started to climb only after the announcing posts appeared in the campus forums. Figure 1 shows how the number of registered users increases with the days after the tournament began. We had no other advertisements about the tournament than posting to the BBS in the beginning of the tournament. The figure shows that after an initial jump in the number of

users, the increase slowed down and the number stayed constant at 44 when the tournament ended.
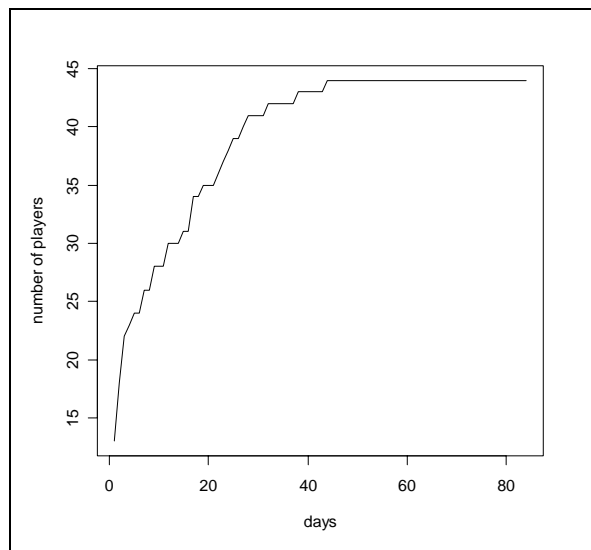

Fig. 1: Number of registered players as a function of time.

Figure 2 shows the four price time-series of the bird flu futures. Results of the prediction at the end of each month agreed to the fact that there occurred no human infections during the corresponding period. Shown in Fig. 3 is the accumulated trading volume for each contract as a function of time.

5. Discussion

The bird flu tournament followed immediately an experiment finished on December 3, 2005. That experiment was a trading tournament for the so-called political futures whose liquidation prices were designed to mirror the party-wise elected rates in the election of county magistrates and city mayors in Taiwan and Fujian province held on December 3, 2005. The two tournaments were different in two respects. First, the bird flu was on the prediction of whether, and if yes, when, an event would occur within a prescribed time span lasting for three months. The magistral election was however on predicting how the outcome of an event would unfold in one month till the predefined date when the election took place. Secondly, the magistral tournament awarded real cash together with winning certificates to the top players while the bird flu tournament awarded only winning certificates.

The results of the election prediction, Fig. 4, were good in the sense that the ranking of the proportions of the elected party seats among all the seats was correct. Whereas predictions by political futures exchange have been shown to work[5-7], it was not known whether futures like the bird flu in the current experiment would work. Results in Fig. 2 indicate that it worked. The non-cash incentives in the bird flu tournament however drew less players than those in the political futures tournaments which typically got about 400 registered players[6][7]. Winner certificates are considered helpful in graduate school applications, however.
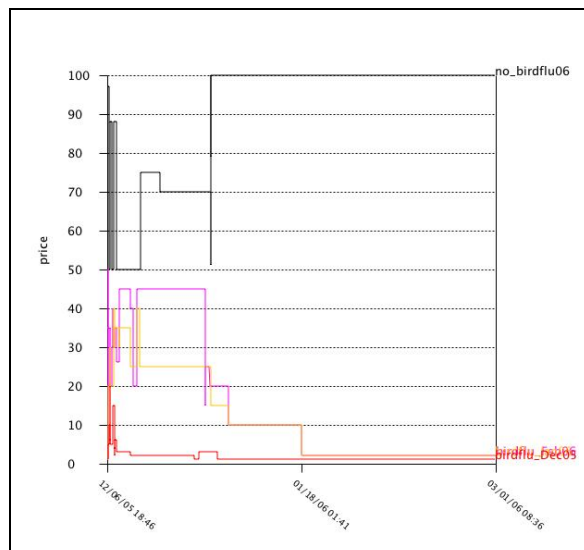

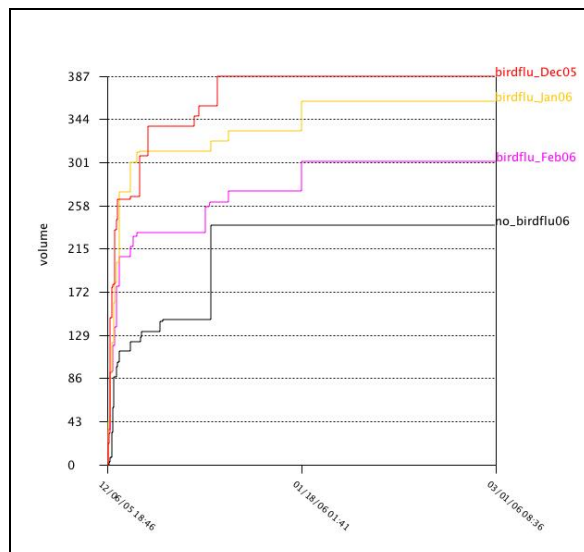Fig. 2: Price time-series of the bird flu futures contracts.

Fig. 3: Trading volume time-series of the bird flu futures contracts.

A look at the time series in Fig. 2 shows that the sum of the four prices was most of the time close to 100. If the price (i.e. probability) of a share of *no_birdflu06* is 100 and that of *birdflu_Feb06* per share is also 100, one of them must be wrongly priced.

The fact that price inconsistencies happened infrequently or last short, indicates that the players were rational or the market was efficient. The feature could be attributed to the fact that we posted the tournament announcement to the economics and finance BBS boards.
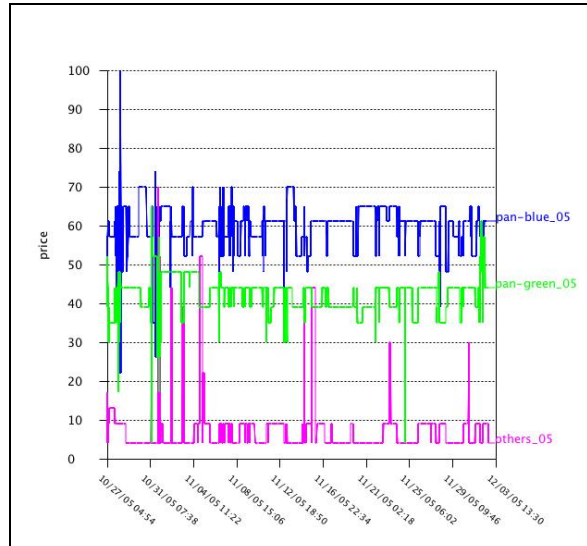

Fig. 4: Price time-series of the magistral futures contracts.

6. Appendix – continuous double auction

The trading price is determined in Taipex by an algorithm called *continuous double auction*, which is the standard mechanism in most financial exchanges. Outstanding ask orders are stored, in order of increasing limit, in a queue called orderbook for each futures contract. When a bid order is issued, it is checked with the lowest sale price in the orderbook of the asks. If the limit of the bid equals to or exceeds the lowest ask limit, a deal is made. The lowest ask limit sets the trade price and the trade volume is determined by the requested bid volume and the offer volume. If the offer exhausts, it is removed from the orderbook. The process iterates until the ask queue becomes empty or until all the bid volume is fulfilled. Unfulfilled or remaining bid volume stays in the bid queue, awaiting forthcoming ask orders. When an order expires, it is removed from the orderbook. For a market bid order, since no price limit is set, deals are made with the outstanding orders in the ask queue, starting from the top (lowest limit) of the orderbook. In short, the process ensures that most favorable actions are taken on behalf of the bidder. Similar algorithm/principle applies to an ask order.

7. References

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