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When games meet reality: is Zynga overvalued?

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On December 16, 2011, Zynga, the well-known social network game development company, went public. This event followed other recent initial public offerings (IPOs) in the world of social networking companies, including Groupon and LinkedIn, among others. With a valuation close to US$7 billion at the time it went public, Zynga became one of the biggest web IPOs since Google. The recent enthusiasm for social networking companies raises the question of whether they are overvalued. Indeed, in the few months since its IPO, Zynga has shown significant variability: its market capitalization going from US$5.6 billion to US$10.2 billion, hinting at possible irrational behavior from the market. To bring substance to the debate, we propose a two-tiered approach to compute the intrinsic value of Zynga. First, we introduce a new model to forecast its user base, based on the individual dynamics of its major games. Next, we model the revenues per user using a logistic function, a standard model for growth in competition. This allows us to bracket the valuation of Zynga using three different scenarios: US$3.4 billion, US$4.0 billion and US$4.8 billion in the base case, high-growth and extreme-growth scenarios, respectively. This suggests that Zynga has been overpriced ever since its IPO. Finally, we propose an investment strategy (dated April 19, 2012 on the arXiv), which is based on our diagnosis of a bubble for Zynga and how this herding/bubbly sentiment can be expected to play together with two important coming events: the quarterly financial result announcement around April 26, 2012, and the end of a first lock-up period around April 30, 2012. In the long term, our analysis indicates that Zynga's price should decrease significantly. The paper ends with a postmortem analysis added on May 24, 2012, just before going to press, showing that we successfully predicted the downward trend of Zynga. Between April 27 and May 24, 2012, Zynga's price dropped 25%.

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1 INTRODUCTION

After the recent initial public offerings (IPOs) of some of the major social networking companies – such as Groupon, LinkedIn and Pandora – Zynga went public on December 16, 2011. In November 2011, the estimated value of this social network game developing company was as high as US$14 billion (Reuters (2011)). However, after the underperformance of the IPO market, this number was scaled down. Indeed, 100 million shares of class A common stock were sold at US$10 per share, the top end of the indicative US$8.5–US$10 range (Zynga (2012a,c)). With a total of 699 million shares outstanding, the market capitalization of the company at IPO was US$7 billion. After dropping to US$5.6 billion on January 9, 2012, its minimum since the IPO, and peaking at US$10.2 billion on February 14, 2012, the market capitalization of Zynga was around US$9 billion on February 26 (Bloomberg (2012)). The efficient market hypothesis suggests that such large price changes should reflect significant variations in the fundamentals of the company that lead to the reassessment of its value by investors and analysts (Fama (1970)). As such, one could question the economic justification for such a change in price in the space of only a few months.

In addition, during the IPO process, no specifics were given by the underwriters, the S1 filing, the media or the investment banking sell-side analysts on the methodology used to obtain the US$7 billion valuation. The aim of this paper is to determine Zynga's fundamental value and put its current valuation into perspective. For this purpose, we extend to Zynga the methodology proposed by Cauwels and Sornette (2012) for the valuation of Facebook and Groupon, by introducing a semibootstrap approach to forecast Zynga's user base.

The pricing of IPOs, and companies in general, has been extensively studied. Ibbotson and Ritter (1995) and Ritter and Welch (2002), among others, reviewed well-known stylized facts when companies go public. We can cite the underpricing of new issues, ie, the fact that underwriters underprice the IPO, leading to high returns on the first day of trading, or the long-term underperformance of the underpriced IPOs compared with their "fairly" priced counterparts. During the dot-com bubble, the rapid rise of the Internet sector contrasting with the modest growth of the "old economy" raised a lot of interest. Bartov *et al* (2002) showed that there were differences in the valuation of Internet and non-Internet firms. Notably, for the latter, profits were rewarded (positively correlated with the share value) and losses were not (as is usually the case). However, the reverse was true for Internet companies, where losses were rewarded and profits were not. This somewhat paradoxical situation arose from the perception that losses were not the result of poor company management, but rather that they were investments that would later pay off. Hand (2001) and Demers and Lev (2001) further showed that web traffic was an important factor in the market value of the Internet company. Indeed, in the case of web-traffic-intensive companies, while

losses were being rewarded before the peak of the bubble and profits were not, the situation reversed after the peak of the bubble: profits became rewarded and losses were no longer rewarded. This phenomenon was not observed for Internet companies without web traffic.

We should note that the studies mentioned so far try to explain the market price of companies using different explanatory variables (such as revenues, type of company, amount of web traffic, difference between IPO price and first day closing price, etc), making the implicit assumption that the market is efficient and reflects the intrinsic value of the company. While, in the long run, this may be a good approximation, this is not true for shorter timescales (during a bubble, typically). As such, these methods (often based on linear relationships between the market price and the explanatory variables) are not meant to reveal the fundamental value of a company or make long-term predictions.

Ofek and Richardson (2002) tackled the problem from a different angle. They assumed that, in the long run, the price-to-earnings ratio of the Internet companies would converge with that of their "old economy" counterparts, and computed the growth in earnings necessary to achieve that. They found unrealistic growth rates making an argument against market rationality. Schwartz and Moon (2000) used a real-option approach to value Amazon, with the company having the option to go bankrupt (thereby limiting their losses). Their model relies on the future growth rate of revenues and uses the discounted cashflows method. It has the advantage of coming up with a valuation for the company but it is very sensitive to variations in its parameters. Gupta *et al* (2004) extended a methodology developed by Kim *et al* (1995) to value Amazon, Ameritrade, eBay and E*TRADE (all Internet companies). Their model uses the discounted cashflows analysis where the future revenues are computed based on the prediction of the company's user base combined with an estimation of the revenues generated by each user in time. They obtain robust valuations of the Internet companies, allowing for a quantitative assessment of the discrepancy between the market capitalization of the companies and their fundamental values. Adopting a similar approach, Cauwels and Sornette (2012) show that Facebook and Groupon are overvalued. The main insight of the aforementioned works is to recognize that, for companies deriving their value directly from their users, such a simple approach can give a much better estimate of the intrinsic value of a company than the methods employed previously.

This paper adds to the existing literature by extending the methodology of Cauwels and Sornette (2012) to Zynga, a company where the user dynamics are very different from, and more complicated than, the ones observed in Facebook, Groupon, Amazon, etc. Indeed, the evolution of Zynga's user base is a result of the individual dynamics of each of its individual games and therefore cannot be modeled by a single function. Moreover, we find that the revenues per user have entered a saturation phase. This

limits Zynga's ability to increase its revenues much further, as their user base is already in a quasi-stationary phase. Finally, we find that Zynga has been greatly overvalued since its IPO, and we give a short-timescale prediction about its price dynamics by combining our fundamental analysis with the effect consisting of a price drop subsequent to the end of the lock-up period.

This paper is organized as follows. Section 2 gives a brief summary of the methodology used to value Zynga. Section 3 describes the dynamics of the number of daily active users (DAUs) of Zynga. Section 4 analyzes the financial data relevant to the valuation of the company. Section 5 gives its estimated market capitalization. Section 6 analyzes the evolution of Zynga so far in light of its valuation. Section 7 discusses possible strategies for arbitraging the overvalued stock of Zynga. Section 8 concludes.

2 VALUATION METHODOLOGY

The majority of the revenue of a social networking company is inherently linked to its user base. The more users it has, the more income it can generate through advertising. From this premise, the basic idea of the method proposed by Cauwels and Sornette (2012) is to separate the problem into three parts.

(1) First, we will forecast Zynga's user base. This part of the analysis is based on hard data and modeling. Because Zynga uses Facebook as a platform, and one does not need to register to have access to its games (a Facebook account is sufficient), there is no such thing as a measure of total registered users (U). These registered users were used by Cauwels and Sornette (2012) in their valuation of Facebook and Groupon. Because it takes an effort to unregister, the number of registered users is an almost monotonically increasing quantity. As such, Cauwels and Sornette (2012) were able to model and forecast Facebook and Groupon's user dynamics with a logistic growth model:

$$\frac{\mathrm{d}U}{\mathrm{d}t} = gU\left(1 - \frac{U}{K}\right) \tag{2.1}$$

Here, g is the constant growth rate and K is the carrying capacity (this is the largest possible number of users). This is a standard model for growth in competition. When $U \ll K$, U grows exponentially since $\mathrm{d}U/\mathrm{d}t \approx gU$ (this is the unlimited growth paradigm) until reaching saturation when $U = K$ (and $\mathrm{d}U/\mathrm{d}t = 0$). This model is a good description of what happens in most social networks: the number of users starts growing exponentially and eventually saturates because of competition/constrained environment. For Zynga, a different approach had to be worked out. Here, the analysis is based on the number of DAUs: a more dynamic measure. The number of DAUs can fluctuate and as such cannot be modeled with a logistic function. Moreover, Zynga's users form an aggregate from over sixty different games. Therefore, to understand the

dynamics of Zynga's user base, we had to examine the user dynamics of its individual games. Figure 1 on the next page gives the total number of Zynga users and the DAUs of two of its most popular games. We decided to model each of its top twenty games individually, as this approach accounts for more than 98% of the recent total number of Zynga users. We will elaborate further on the specifics of this analysis in Section 3.

(2) The second part of the methodology is based on what we consider "soft" data. This part uses the financial data available in Zynga (2011). This will be used to estimate the revenues that are generated per DAU in a certain time period. It also reveals information on the profitability of the company. Due to the limited amount of published financial information, we will have to rely on our intuition and good sense to give our best estimate of the future revenues per user generated by the company. This is why we call this the soft data part. This will be elaborated on further in Section 4.

(3) The third part combines the two previous parts to value the company. Using an estimate of the future DAUs and of the revenues each of them will generate (r), it is possible to compute the future revenues of the company. These are converted into profits using a best-estimate profit margin (p_{margin}), and are discounted using an appropriate risk-adjusted return d. The net present value of the company is then the sum of the discounted future profits (or cashflows):

$$\text{valuation} = \sum_{t=1}^{\text{end}} \frac{r(t)\,\text{DAU}(t)\,p_{\text{margin}}}{(1+d)^t} = \sum_{t=1}^{\text{end}} \frac{\text{profits}(t)}{(1+d)^t} \tag{2.2}$$

From this, we optimistically assume that all profits are distributed to the shareholders.

3 HARD DATA

3.1 General approach

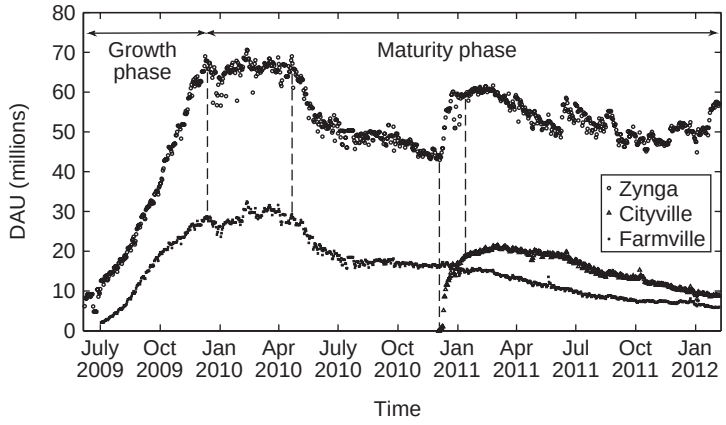
We will take the following steps to forecast Zynga's DAUs.

(1) We will use a functional form of the DAUs of each of the top twenty games to forecast the future DAUs evolution of the company. This is done as follows:

- the data that is available is used as it is;
- this is extended into the future by extrapolating the DAU-decay process with an appropriate tail function.

(2) Because Zynga relies on the creation of new games in order to maintain or even increase its user base, it is important to quantify its rate of innovation. This is done by using $p(\Delta t)$ as the probability distribution of the time between the implementation of two consecutive new games (restricted to the top twenty).

FIGURE 1 Number of daily active users as a function of time for Zynga and two of its most popular games: Cityville and Farmville.



After an initial growth period, Zynga entered a quasi-stable maturity phase in January 2010. A typical feature of the games can be seen in Cityville and Farmville: after an initial rapid rise, the DAUs of the games enter a slower decay phase. The dashed black lines show that the total DAUs of Zynga depend strongly on the performance of the underlying games. Note that, even though Zynga has existed since mid-2007, we do not have DAU data since it was formed. Data source: www.appdata.com/devs/10-zynga.

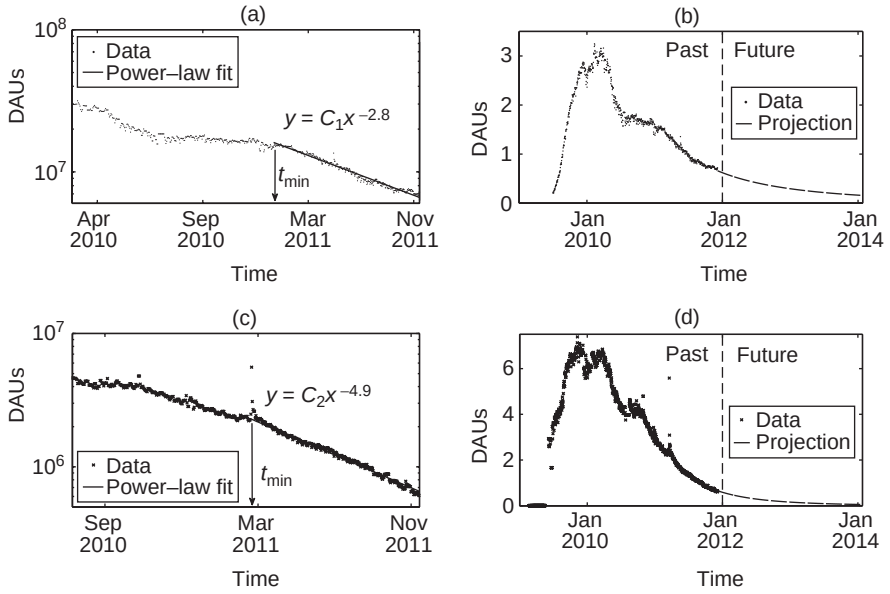
(3) Finally, a future scenario is simulated as follows. For the next twenty years, each Δt days, Δt being a random variable taken from $p(\Delta t)$, a game is randomly chosen from our pool of top twenty games. The DAUs of Zynga over time is then simply the sum of the simulated games. We compute 1000 different scenarios.

3.2 The tails of the DAU decay process

The functional form of the DAUs of each game is composed of the actual observed data and a tail that simulates the future decay process. We will use a power law, $f(t) \propto t^{-\gamma}$, for that purpose. This results in a slow decay process and as such will not give rise to any unnecessary devaluation of the company by underestimating its future user base. Figure 2 on the facing page shows the power law fits (part (a)) and the extension of the user dynamics into the future (part (b)) for the games Farmville and Mafia Wars.

Such a power law is a reasonable prior, given the large evidence of such time dependence in many human activities (Sornette (2005)), which includes the rate of book sales (Sornette *et al* (2004) and Deschatres and Sornette (2005)), the dynamics of video views on YouTube (Crane and Sornette (2008)), the dynamics of visitations of a major news portal (Dezso *et al* (2006)), the decay of popularity of Internet blog posts

FIGURE 2 Tails and daily active user dynamics for Farmville and Mafia Wars.



(a) Tails of Farmville. (b) DAU dynamics of Farmville. (c) Tails of Mafia Wars. (d) DAU dynamics of Mafia Wars. It can be seen that a power law is a good fit for the tails from t_{min} onwards. Data source: www.appdata.com/devs/10-zynga.

(Leskovec *et al* (2007)), the rate of donations following the tsunami that occurred on December 26, 2004 (Crane *et al* (2010)), and so on.

3.3 Innovating process

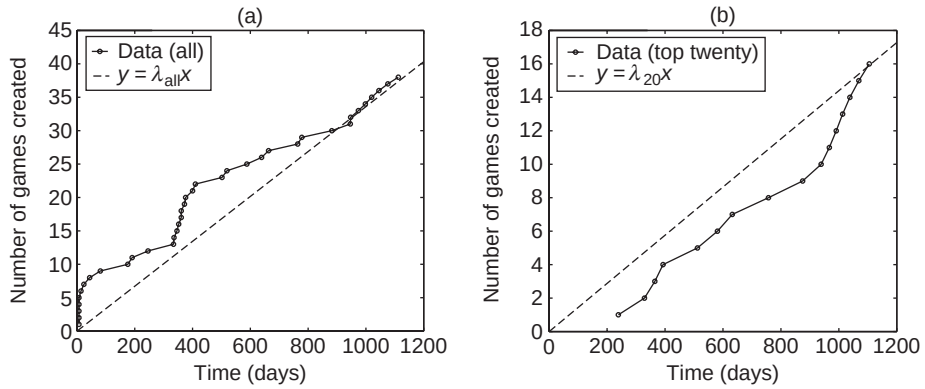
To be able to realistically simulate Zynga's rate of innovation, it is important to understand the generating process underlying the creation of new games. The simplest process that can be used for that purpose is the Poisson process. To understand its meaning, consider its discrete counterpart, the Bernoulli process. It has a very intuitive meaning and can be thought of as follows. At each time step, a game is introduced with a probability of p (and no game is introduced with a probability of $1-p$). For a large enough number of time steps and a small enough p, the Bernoulli process converges to the Poisson process. The Poisson process has the following three important properties:

(1) it has a constant innovation rate;

(2) it has independent interevent durations;

(3) the interevent durations have an exponential distribution $p(\Delta t) = \mathrm{e}^{-\lambda \Delta t}$.

FIGURE 3 Newly created games as a function of time.



(a) Number of newly created games as a function of time for all the games. The empirical innovation rate is at most equal to the theoretical rate coming from the Poisson process (dashed line). The parameter λ_{all} is obtained by using maximum likelihood (assuming a Poisson process). (b) Number of newly created games as a function of time for the top twenty. The empirical innovation rate seems to be higher for the last games than λ_{20}, the theoretical rate from the Poisson process. This is most likely due to insufficient statistics, this phenomenon being absent when all games are taken into account.

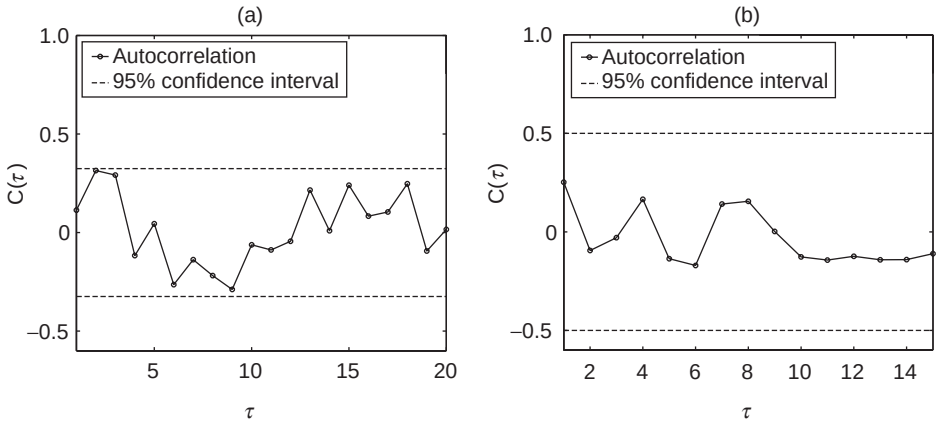
To assess whether this is a suitable process to model the innovation rate, we measured the time between the introduction of two consecutive new games, $\Delta t_{(1,2)}, \Delta t_{(2,3)}, \ldots, \Delta t_{(n-1,n)}$, and tested for the three properties mentioned above.

3.3.1 Innovation rate

To test whether the innovation rate is constant, different approaches can be adopted. One possibility is to test for the stationarity of the DAUs of Zynga since it entered its maturation phase. Stationarity in the number of users would imply a constant innovation rate. Indeed, Figure 1 on page 124 suggests that the user dynamics of Zynga are stationary, its number of DAUs being between 43 million and 70 million users since the end of the growth phase. However, due to the short time span of the data, it is hard to implement rigorous statistical tests such as unit-root tests. Instead, we adopt a different approach. If the rate of creation of new games is constant, then the number of new games created as a function of time should lie around a straight line with slope λ, the intensity of the Poisson process. Figure 3 shows $N(t)$, the number of created games up to time t.

As we can see from Figure 3, the constant innovation rate is a good approximation. Our main concern was to discard the possibility of an important increase in the frequency of creation of new games toward the end of the time period, which would

FIGURE 4 Autocorrelation functions for interevent times.



(a) Autocorrelation function for the interevent times of all the games. The confidence interval (CI) indicates the critical correlation needed to reject the hypothesis that the interevent times are independent. It is computed as $CI_{0.95} = \pm(2/\sqrt{N})$, N being the sample size (Chatfield (2004)). (b) Autocorrelation function for the interevent time of the top twenty games. In both cases, the independence hypothesis cannot be rejected.

have led to an underestimation of the number of new games created in the future and, hence, of the future number of users. When all games are taken into account, the innovation rate is at most equal to the one coming from the Poisson process. As such, the Poisson process with constant intensity would not lead to an underestimation of the value of the company.

3.3.2 Independence of interevent times

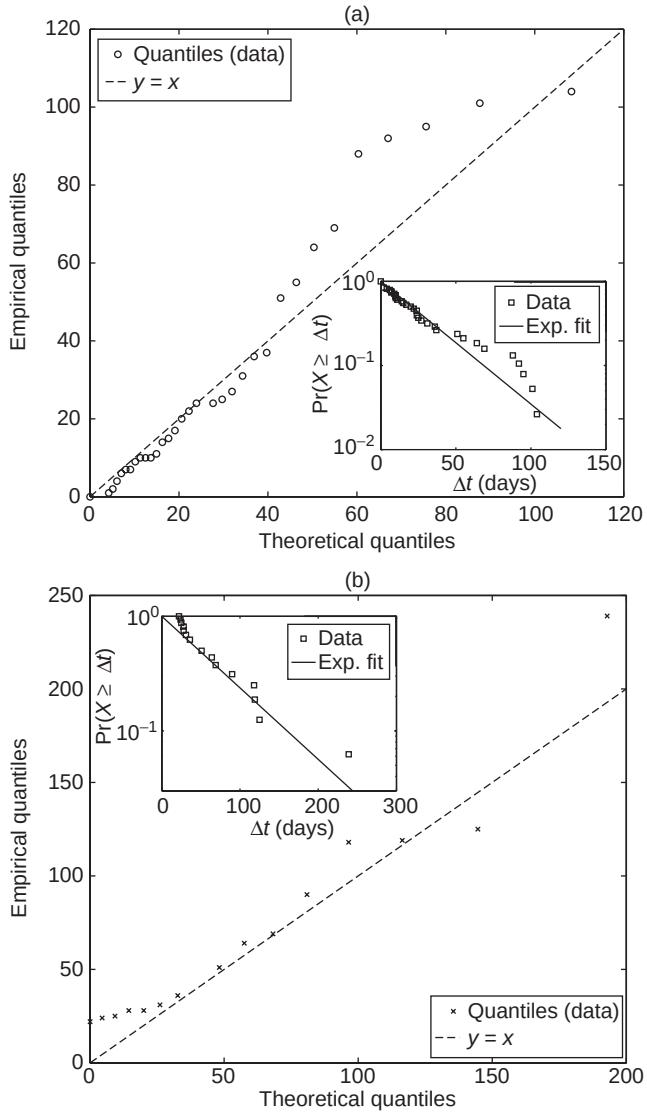
To test for the independence of the measured Δt, we study the autocorrelation function $C(\tau)$, the correlation between $\Delta t_{(i,i+1)}$ and $\Delta t_{(i+\tau,i+\tau+1)}$. The result is given in Figure 4.

As can be seen, $C(\tau) = 0$ is within the confidence interval for $\tau > 0$ in both cases, so the independence hypothesis cannot be rejected.

3.3.3 Distribution of interevent times

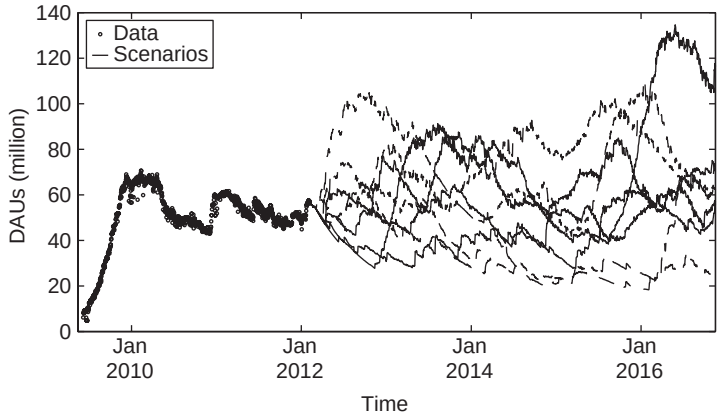
To test for the distribution of interevent times, we use a Q–Q plot. The Q–Q plot is a graphical method for comparing two distributions by plotting their quantiles against each other. If the obtained pattern lies on a straight line, the distributions are equal. In our case, the two distributions to be compared are the empirical one (from data)

FIGURE 5 Q–Q plots.



(a) Q–Q plot of the distribution of time intervals Δt between the introduction of new games, for all the games. The theoretical (assuming a Poisson process) and data quantiles (circles) agree well, as can be seen from the proximity to the dashed black line ($y = x$). The subpanel shows the cumulative distribution function of the data (squares) and the exponential fit (black line) on which the quantiles were built. (b) Q–Q plot of Δt for the top twenty games. We can see a deviation for small values of Δt between exponential theoretical and data quantiles. This can be attributed to insufficient statistics.

FIGURE 6 Eight different scenarios of the daily active user evolution of Zynga for the next four years.



The company is valued for each of these scenarios (Section 5). This will give a range for its expected market capitalization.

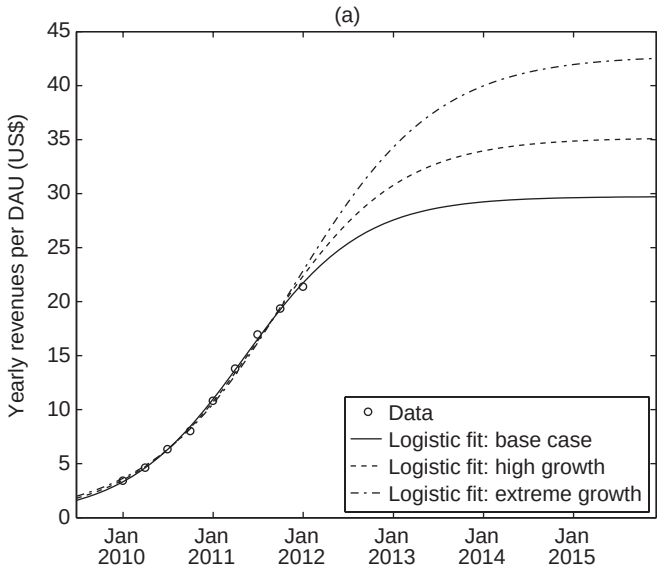
and the theoretical one (an exponential with parameters obtained from a maximum likelihood fit to the data). The results of this analysis are presented in Figure 5 on the facing page.

As we can see, in both cases the Q–Q plots show a reasonable agreement between the empirical and the exponential distribution given the number of data points, so that the exponential distribution for the interevent times (Δt) cannot be rejected. The innovation process will thus be modeled as a Poisson process.

3.4 Predicting the future DAUs of Zynga

Starting from the present and going forward through the next twenty years, a top-twenty game is randomly sampled every Δt days, with Δt drawn from its theoretical exponential distribution $p(\Delta t)$. For each of these sampled games, the DAU number is calculated using its functional form. Summing the DAUs of all of these games, the user's dynamics of Zynga are computed. This process is repeated 1000 times, giving 1000 different scenarios. As can be seen from Figure 6, the evolution of the user base between scenarios can be quite different. That is the reason why a wide range of scenarios is needed. The valuation of the company is computed for each of those scenarios (using (2.2)). This will give a probabilistic forecast of the market capitalization of Zynga.

FIGURE 7 Historical evolution of revenues per daily active user: (a) yearly revenue per daily active user over time. [Figure continues on next page.]



A logistic fit (2.1) is proposed with $K \approx$ US$30, US$35 and US$43 for the base case, high-growth and extreme-growth scenarios. Data source: Zynga (2011, 2012a).

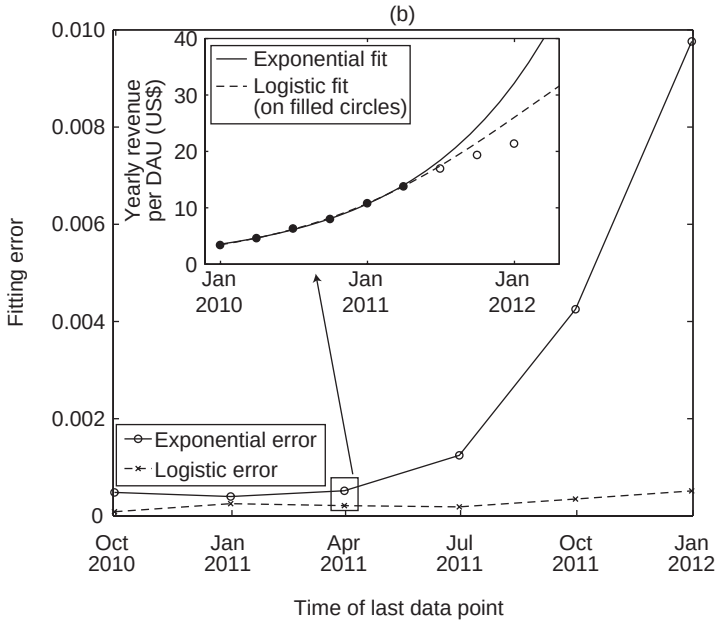
4 SOFT DATA

The next step in calculating Zynga's value is to estimate the revenues per DAU per year. We base our analysis on Zynga (2011) complemented by Zynga (2012a), to add results from the last quarter of 2011. The yearly revenues are given each quarter as a running sum of the four previous quarterly revenues:

$$R_i = R^{\mathrm{q}}_{i-3} + R^{\mathrm{q}}_{i-2} + R^{\mathrm{q}}_{i-1} + R^{\mathrm{q}}_i \tag{4.1}$$

Here, R_i and R^{q}_i are, respectively, the yearly and quarterly revenues at quarter i with $i \in (4, \mathrm{last})$. The yearly revenues per DAU at each quarter, r_i, are then obtained by dividing R_i by $\langle \mathrm{DAU}_i \rangle_{\mathrm{year}}$, the realized DAUs at time i averaged over the preceding year. Figure 7 gives the historical evolution of the revenues per DAU. Initially, this followed an exponential growth process. However, as can be clearly seen in part (b), this growth saturates and the process follows the trajectory of a logistic function. This implies that the revenues per DAU will reach a ceiling. As such, different logistic functions are fitted to the data set. Each of these corresponds to a different scenario: a base case, a high-growth scenario and an extreme-growth scenario (as defined in

FIGURE 7 Continued: (b) fitting error of the exponential versus logistic function.



Each point is obtained by performing the logistic and exponential regressions on data taking more and more data points into account, starting from a minimum of four (as shown in the subpanel where only filled circles are fitted). We can see that the logistic starts performing significantly better than the exponential from July 2011. Data source: Zynga (2011, 2012a).

Cauwels and Sornette (2012)). These scenarios are exhibited in part (a) of Figure 7 on the facing page.

From the creation of Zynga until April 2011, both the exponential and the logistic fits perform similarly. Indeed, when $r_i \ll K$, when the revenues per user are far away from saturation, the logistic function can be approximated by an exponential. April 2011 is a turning point in the sense that the growth in revenue per user slows down, hence the deviation from the exponential (growth at constant rate). This saturation in r_i is easy to explain. There have to be constraints on how much money can be extracted from a user. Under spatial constraints (there is a limited number of advertisements that can be displayed on a webpage), time constraints (there are only so many advertisements that can be shown per day) and, ultimately, economic constraints (there is only so much money a user can spend on games or an advertiser is willing to spend), the revenues per DAU are bound to saturate. Using this logistic description for the revenues per DAU, a valuation of Zynga is given for each of the three growth hypotheses.

TABLE 1 Revenue, net income and profit margin of Zynga.

Year	Revenue (US$ million)	Net income (US$ million)	Profit margin (%)
2008	19.41	−22.12	−114
2009	121.47	−52.82	−43
2010	597.46	90.60	15
2011	1065.65	−404.32	−38

Data source: Zynga (2011, 2012a,b).

5 VALUATION

Combining (using (2.2)) the hard part of the analysis with the soft part, ie, the number of users over time and the revenues each of them generates per year, the value of the company can be calculated.

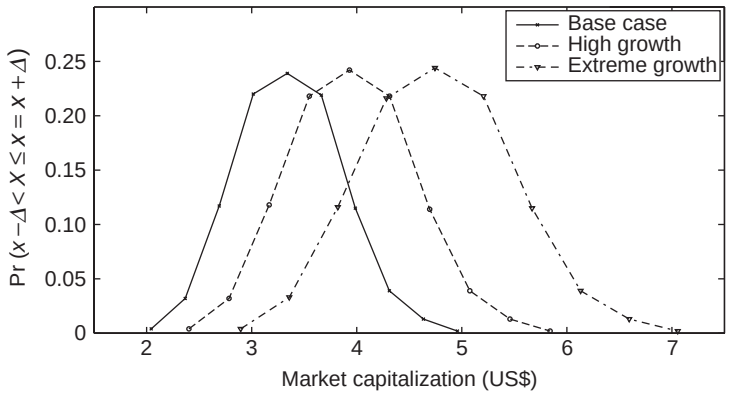
We will use a profit margin of 15%. This is Zynga's profit margin for the fiscal year 2010. As can be seen from Table 1, this is an optimistic assumption since it was the highest profit margin to this point, with 2010 being the only profitable year for Zynga in its history. We also assume that all profits are distributed to the shareholders and use a discount factor of 5% as in Cauwels and Sornette (2012). We computed the company's valuation for all 1000 different scenarios using (2.2). The results are shown in Figure 8 on the facing page and Table 2 on the facing page.

We obtain a valuation of US$3.4 billion for our base case scenario, well below the approximate US$7 billion value at IPO or the US$9 billion value at the end of March 2012. Even the unlikely extreme-growth scenario could not justify any of the valuations we have seen in the market so far.

6 HISTORIC EVOLUTION

At the time of the IPO, on December 15, 2011, Zynga was valued at US$7 billion. Right after the IPO, on December 27, Forró *et al* (2011) pointed to an overvaluation of Zynga (which was estimated at US$4.2 billion in our base case scenario). Zynga then published its earnings for the fourth quarter of 2011. These figures increased the accuracy of our valuation since they contributed to reducing the difference between the three scenarios for the revenues per user. By April 2012, it had traded on the stock market for four months. The big question was whether the share price of Zynga moved in the direction of its fundamental value. As we can see in Figure 9 on page 135, it was quite the contrary: after an initial depreciation of the share value reaching a minimum of US$7.97 on January 9 (still above our extreme-case scenario), a moderate run-up in

FIGURE 8 Distribution of the market capitalization of Zynga according to the base case, high-growth and extreme-growth scenarios.



This shows that the US$7 billion valuation at IPO or the US$9 billion valuation of March 2012 is beyond even the extreme-revenue case.

TABLE 2 Valuation and share value of Zynga in the base case, high-growth and extreme-growth scenarios.

Scenario	Valuation (US$)	95% confidence interval	Share value (US$)	95% confidence interval
Base case	3.4 billion	[2.4 billion; 4.4 billion]	4.8	[3.5; 6.2]
High growth	4.0 billion	[2.9 billion; 5.1 billion]	5.7	[4.1; 7.3]
Extreme growth	4.8 billion	[3.5 billion; 6.2 billion]	6.8	[4.9; 8.9]

price followed, until February 1, 2012, the date of the S1 filing from Facebook. After that, without any solid economic justification, Zynga skyrocketed to a maximum of US$14.55/share, corresponding to a US$10.2 billion valuation, on February 14. However, after the release of the fourth-quarter results, the company lost more than 15% in a single day, regaining a part of this loss on the following days and peaking again at US$14.62 on March 2, 2012. On March 28, insiders of Zynga (including its CEO, Mark Pincus) sold 43 million shares in a secondary offering (see Section 7.2.1) over the counter for US$12/share (Zynga (2012c)). Zynga's shares subsequently experienced a 6% drop in one day. By the end of April 18, the publication date of our trading strategy (see Section 7), Zynga closed at US$10. More details about Zynga's price trajectory are given in Table 3 on the next page and Figure 9 on page 135.

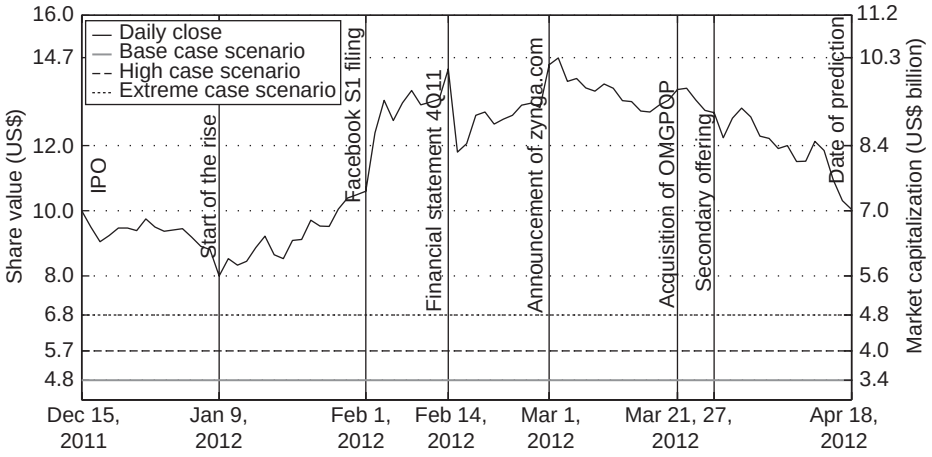
TABLE 3 Important events in Zynga's price history up to April 18, 2012 (the date of our prediction).

Date	Share price (US$)	Event
12/15/2011	10.00	Zynga goes through its IPO
01/09/2012	8.00	Zynga closes at its lowest level for the next four months
02/01/2012	10.60	Facebook publishes its S1 filing; this fuels Zynga's bubble
02/14/2012	14.35	Zynga unveils its financial results for the fourth quarter of 2011; the next day, Zynga's share price experiences an 18% drop, its biggest drop so far, at time of writing
03/01/2012	14.48	Zynga announces that it will launch zynga.com (Takahashi (2012)), a platform independent from Facebook; the news is followed by a small increase in share price
03/21/2012	13.72	Zynga acquires OMGPOP, another social gaming company, for over US$200 million (Cutler (2012))
03/27/2012	13.01	Inside investors of Zynga (including its CEO, Mark Pincus) sell 43 million shares at US$12/piece in a secondary offering; this is followed by a significant 6% drop in share price
04/18/2012	10.04	We publish our short-term prediction on the arXiv

The highly volatile, news-driven behavior of Zynga's stock price can be quantified using the implied volatility measure. In option pricing, the value of an option depends upon, among other things, the volatility of the underlying asset. Knowing the price at which an option is traded, one can reverse-engineer the implied volatility: the volatility needed to obtain the market value of the option given a pricing model. This standard measure has the upside of being forward-looking: contrary to the historic volatility, the implied volatility is not computed from past known returns. As such, implied volatility is a good proxy for the mindset of the market. Figure 10 on the facing page compares the implied volatility priced by the market for options written on Zynga with that of Google and Apple.

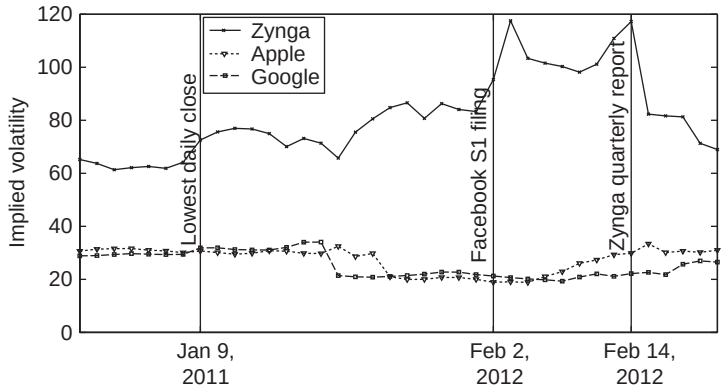
We can observe a big difference between the two groups. While Apple and Google have a standard stable implied volatility, there is much more uncertainty surrounding Zynga in the eyes of the market, given its high and unstable volatility. What this

FIGURE 9 Share value of Zynga over time.



The base case, high-growth and extreme-growth scenarios are represented (horizontal lines) as well as important dates for the stock price (vertical black lines). Data source: Yahoo Finance (2012).

FIGURE 10 Implied volatility of Zynga, Apple and Google.



Zynga has a much higher and less stable volatility than Apple or Google. Data source: Bloomberg.

tells us is that, until now, the market players have had a hard time putting a value on Zynga. This perception is reinforced by the following event. On February 15, 2012, the day after the biggest drop in Zynga's share price since its IPO, most investment

banks (with some exceptions) downgraded Zynga's stock rating, readjusting their price target. Some notable examples of actual price targets per share are (Best Stock Watch (2012))

- Barclays Capital (US$11),
- BMO Capital Markets (US$10),
- Evercore Partners (US$10),
- JP Morgan Chase (US$15),
- Merrill Lynch (US$13.5),
- Sterne Agee (US$7).

Compared with our analysis (see Table 2 on page 133), these price targets seem to be high. Moreover, even among "experts", the differences can be significant (the price target of Sterne Agee is less than half that of JP Morgan Chase). One should, however, keep in mind that the recommendations of most of these companies may not be independent of their own interest, due to the fact that, for example, JP Morgan, Merrill Lynch and Barclays Capital are underwriters of the IPO (see Michaely and Womack (1999) and Dechow *et al* (2000)).

We will have to wait and see how Zynga evolves on a longer timescale, but, so far, our analysis indicates that Zynga is in a bubble, its price not being reflected by its economic fundamentals. Zynga may be symptomatic of a greater bubble, affecting the social networking companies in general, as suggested by the overpricing of Facebook and Groupon (Cauwels and Sornette (2012)).

7 ARBITRAGING ZYNGA'S BUBBLE

While the market price of Zynga should converge to its fundamental value in the long run, a prediction of its price movements on a shorter timescale is difficult. However, it is possible to develop investment strategies by using a combination of our determination of Zynga's intrinsic value and a well-known phenomenon: namely, the drop in market price when insiders are allowed to sell their shares at the end of their lock-up period.

7.1 End of lock-up and its implications

When a company goes public, only a fraction of their shares are put on the market (14% in the case of Zynga). The rest of the shares are locked-up for a period of, typically, 180 days. It is common for IPOs to have a lock-up period in order to prevent insiders from massively selling their shares after the IPO, thereby driving the market

value of the company down. There is a vast amount of literature exploring the effect of the end of the lock-up period on the share value of a company. While there is a broad consensus on the fact that companies, on average, experience abnormal negative returns following the end of the lock-up period, different authors give different explanations of this effect. Field and Hanka (2001) find that venture-capital-backed firms experience the largest price drop at the end of the lock-up period. Bradley *et al* (2001) confirm the finding and add that the "quality" of the IPO underwriters as well as the price increase since the IPO are positively correlated with the drop in share value. Gao (2005) finds that firms with the highest forecast bias and the highest forecast dispersion by analysts experience the largest drop. Finally, Ofek (2008) makes the argument that a significant increase in share supply can explain the price drop subsequent to the end of the lock-up period. He further argues that the higher the stock-price volatility before the end of the lock-up, the bigger the drop in share value.

While most of the above-mentioned authors find it difficult to develop an arbitrage strategy to take advantage of this effect, we should stress that they all based their works on samples of companies independent of any view regarding their intrinsic value. If they could bias their sample toward the companies whose market value is significantly higher than their fundamental value, we would expect a different outcome. We hypothesize that the overvaluation of the company would be reflected in its market price as soon as insiders, better informed about the fundamentals of their company, are allowed to trade freely, ie, at the end of the lock-up period. We believe that the information asymmetry between outside traders (the only ones who are allowed to trade the shares of Zynga from its IPO) and insiders would be incorporated in the price formation of such a company, and would move its market price toward its fundamental value.

7.2 Prediction for Zynga

7.2.1 Timeline

On March 23, Zynga announced that inside investors, including CEO Mark Pincus, would sell about 43 million shares (see Zynga (2012b)). This move was surprising, since Zynga's inside investors were subjected to a lock-up period ending on May 29. However, a secondary offering was authorized by the underwriters of the IPO and was concluded on March 28 with the shares being sold over the counter for US$12/piece (US$0.36 of which went to the underwriters). On that day, the share value of Zynga experienced a large drop, going from US$13.02 to US$12.24 (this corresponds to a 6% decrease). It should be noted that, subsequent to this transaction, these insiders are again subject to a lock-up period and will not be able to trade until its end. In

practice, the remaining locked shares are released in the market in several steps (see Zynga (2012c)).

(1) Approximately 115 million shares held by nonexecutive employees around April 30 (or three days after Zynga discloses its financial statement for the first quarter of 2012).

(2) Approximately 325 million shares held by nonemployee stockholders that have not participated in the secondary offering (see Section 7.2) on May 29, 2012.

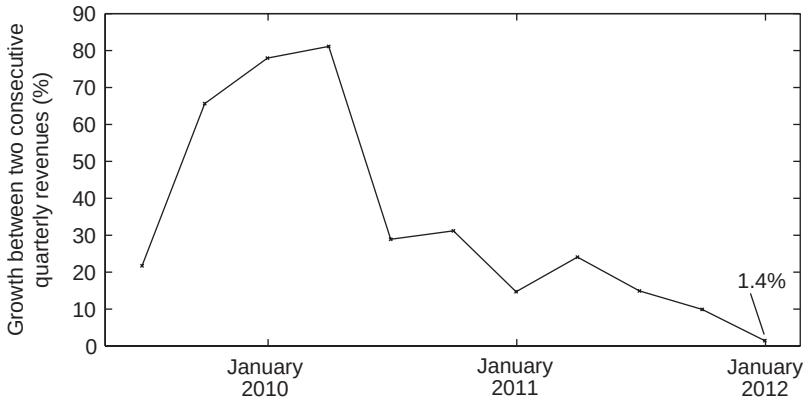
(3) Approximately 50 million shares held by directors, executive employees and the stock holders who participated in the secondary offering (such as Mark Pincus) on July 6, 2012.

(4) Approximately 150 million shares, held by the same persons as in (3), on August 16, 2012.

7.2.2 Effect of the financial results for the first quarter of 2012

When trying to predict the future price movements of Zynga, one cannot ignore the fact that, on April 26, three days before the end of the first part of the lock-up period, the company will release its financial results for the first quarter of 2012. To understand the implications of this report on Zynga's price movement, we use our diagnosis of a bubble. Indeed, during a bubble, phenomena like herding and imitation are dominant among traders (Sornette (2003)). As such, the market players are very sensitive to new information, giving rise to behaviors inconsistent with its content. We believe that the release of Zynga's financial statement on April 26 can be such an event. According to our model, Zynga's yearly revenue per user is saturating. This can be seen in part (a) of Figure 7 on page 130, where the yearly revenues per user, computed at each quarter as the running sum of the four previous quarters, are well fitted by a logistic function. The saturation of Zynga's yearly revenues per user is a powerful argument for the diagnosis of a bubble in Zynga's market valuation. Even with a hypothetical US$357 million of revenues for the first quarter of 2012 (which were announced as an estimation on April 26) corresponding to a 15% increase from the US$311 million of revenues last quarter, the yearly revenues per user would fall right onto our logistic fit. Hence, even a 15% increase in quarterly revenues would not be sufficient to rationally reject the saturating trend of Zynga's revenues per user that we predict. However, compared with the results of the previous quarter, which saw Zynga's revenue only rise by 1.4% (see Figure 11 on the facing page), this would be seen as a very strong performance and would most likely be followed by an increase in share value, even more so in the bubble environment that we diagnose.

FIGURE 11 Percentage difference between the revenues of two consecutive quarters.



We can see that Zynga's performance in the last quarter was very poor. This suggests that taking the 1.4% figure as a benchmark to evaluate Zynga's performance for the next quarter may lead investors to be overly optimistic, especially during a bubble period. Data source: Zynga (2011, 2012b).

7.2.3 Effect of the end of the lock-up period

At the time of writing there were about 150 million shares tradable on the market (100 million from the IPO and about 50 million from the secondary offering). The 115 million shares coming to the market around April 30 represent an important increase in the free-floating shares of Zynga. As such, and because Zynga satisfies most of the conditions given in Section 7.1 leading to a large price decrease, we predict a drop of Zynga's market value around that date. Note that what happened around April 30 is conditional on what happened on April 26. We predict that this drop would be larger if Zynga's stock price increased on April 26 and smaller if the stock price decreased on the same date. Such a phenomenon could take place at any such date.

7.2.4 Proposed strategy

We believe that there is a high probability of strong corrections in Zynga's price after each partial lift of the lock-up period. While we have shown that even an apparently strong performance on April 26 would be in line with our diagnostic of Zynga's saturating revenues per user, one should not be surprised to see its share value rise in this bubble environment. In the long run, we predict that Zynga's market value will converge to its intrinsic value of US$3.4 billion.

In summary, the proposed strategy is based on the following three time periods.

(1) From the time of writing (April 16, 2012) to the announcement of the financial results (around April 26, 2012): stay out of Zynga or hedge if invested.

(2) From the day after the earnings announcement (around April 27, 2012) to the end of the first lock-up period (around April 30, 2012): if the financial results are significantly above those of the previous quarter, buy Zynga for a short-term holding period; otherwise short it.

(3) From the end of the first lock-up period (after April 30, 2012): close all open long positions and short. Monitor the subsequent quarterly releases and the successive ends of future lock-up periods to position a strategy in the same spirit as above.

8 CONCLUSION

We have proposed a new valuation methodology to price Zynga. Our first major result is to model the future evolution of Zynga's DAUs using a semibootstrap approach that combines the empirical data (for the available time span) with a functional form for the decay process (for the future time span).

The second major result is that the evolution of the revenues per user in time, r_i, shows a slowing of the growth rate, which we modeled with a logistic function. This makes intuitive sense as these r_i should be bounded due to various constraints (the hard constraint being the economic one), since Zynga's players only have a finite wealth. We studied three different cases for this upper bound: the most probable one (the base case scenario), an optimistic one (the high-growth scenario) and an extremely optimistic one (the extreme-growth scenario).

Combining the hard data and soft data revealed a company value in the range of US$3.4 billion to US$4.8 billion (base case and extreme-growth scenarios).

On the basis of this result, we can claim with confidence that, at its IPO and ever since, Zynga has been overvalued. Indeed, even the extreme-growth scenario (implying US$43/DAU at saturation) would not be able to justify any valuation that the company has had up to this point. It is worth mentioning that we adopted a rather optimistic approach, as follows.

- We have taken a (slow) power law for the decay process (even in cases where exponentials might be better).

- We chose games only in the top twenty with equal probability in the simulation process (implying that there is the same probability to create a top game and an average/unsuccessful one).

- We took a 15% profit margin and supposed that all the future profits would be distributed to the shareholders.

- We implicitly assumed that the real interest rates and the equity risk premium stay constant at 0% and 5%, respectively, for the next twenty years (Cauwels and Sornette (2012)).

Given these optimistic assumptions, all our estimates should be regarded as an upper bound in our valuation of Zynga.

We should also stress that our assumptions do take into account the innovations that Zynga will have to create in order to continue its business – akin to the Red Queen's race in Lewis Carroll's *Alice in Wonderland*, with Alice constantly running in order to remain in the same spot.

While the fundamental value computed here suggests that Zynga's market price should decrease in the long term, we were able to delineate an investment strategy built on the expected future price movements of Zynga on a short-term scale. In particular, we announced that Zynga's share value would drop significantly around April 30, 2012 after a possible short run-up following the announcement of the financial results of the first quarter around April 26, 2012.

9 POSTMORTEM ANALYSIS OF THE PROPOSED STRATEGY (ADDED ON MAY 24, 2012)

This section was added on May 24, after the paper was accepted for publication on May 17, 2012. The version of the paper with our *ex ante* proposed strategy (Section 7) can be found on the arXiv with the date stamp of April 19, 2012 (Forró *et al* (2012)). In this section, we will evaluate our *ex ante* prediction in the light of the most recent events. Figure 12 on page 143 summarizes the price movements of Zynga from April 19 to May 24, 2012. The strategy was based on three time periods.

(1) *From the time of writing (April 16, 2012) to the announcement of the financial results (around April 26, 2012): stay out of Zynga or hedge if invested.*

Between April 19 and April 26, Zynga's share price dropped from US$10.2 to US$8.2 and then rebounded to US$9.42 (the opening price on April 19). Although the stock went down 7.7% in a week, its behavior was very volatile. As we did not have any strong factual information to support a clear trading strategy before April 27, not taking a position appears to have been acceptable advice.

(2) *From the day after the earnings announcement (around April 27, 2012) to the end of the first lock-up period (around April 30, 2012): if the financial results are significantly above those of the previous quarter, buy Zynga for a short-term holding period; otherwise short it.*

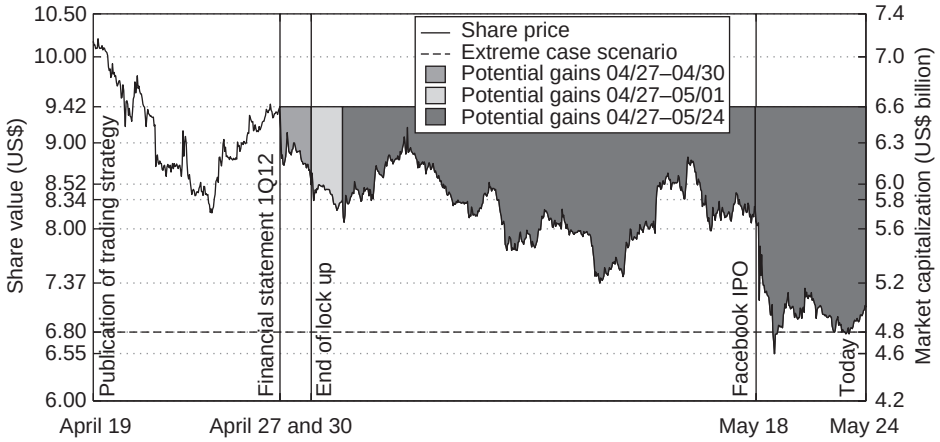
This part was undeniably a success. On April 26, after the markets closed, Zynga revealed its financial results for the first quarter of 2012. Its quarterly revenues were weak, since they only grew 3.1% since the previous quarter, confirming that the company is in its saturation phase. As a result, on April 27, Zynga experienced a drop of 9.6%, one of its largest daily drops since its IPO.

(3) *From the end of the first lock-up period (after April 30, 2012): close all open long positions and short. Monitor the subsequent quarterly releases and the successive ends of future lock-up periods to position a strategy in the same spirit as above.*

As this last part covers a large time period (from April 30 to May 24, 2012), we divide it into a short-term part (the first day) and a longer-term part (until the time of writing of the postmortem analysis, May 24, 2012).

- On the first day (April 30), the prediction was proven accurate. Indeed, as a result of the end of the lock-up period, the stock dropped a further 2.1% in a single day. Had someone opened a short position on April 27 (at the opening of the markets) and closed it on April 30 (at the closing of the markets), they would have benefited from an 11.5% drop over two trading days.
- In the longer term, the price trajectory, although quite volatile, went down significantly. This was accentuated by Facebook's IPO on May 18. Indeed, it was soon clear from the price dynamics after Facebook's IPO that it was not a big success. On the other hand, due to the use of the "overallotment" or "green shoe" option, the price would be kept artificially above the IPO price for a time. Therefore, investors targeted other social networks like Zynga, which lost 13%, LinkedIn, which lost 6%, Groupon, which lost 7% or Renren, the Chinese answer to Facebook, which lost 21%. The lack of rebound of Zynga (as yet) may be due to the loss of its status as a "proxy" for Facebook. It is worth noting that, for the first time since it went public, Zynga's value entered our fundamental valuation bracket, when on May 21 it dropped to US$6.5/share (intraday), below our extreme-case scenario of US$6.8/share. The future will tell us if this price dynamic will stabilize close to our fundamental value calculation or if the investors' more realistic perception of Zynga is only temporary.

FIGURE 12 Price dynamics of Zynga from the publication of our trading strategy on April 19, 2012 on the arXiv until May 24, 2012, just before going to press.



Potential gains that could be obtained by opening a short position on April 27 are indicated by the shaded area. The data has a ten-minute resolution. Data source: Bloomberg.

To sum up, we have successfully predicted the downward trend of Zynga. Between April 27 and May 24, 2012, Zynga's share price fell by 25%.

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