Trust fraud: A crucial challenge for China's e-commerce market

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A B S T R A C T

Currently, China's e-commerce market is growing at an unprecedented pace, however, it is faced with many challenges, among which the trust fraud problem is the biggest issue. In this article, we use Taobao as an example and conduct a thorough investigation of the trust fraud phenomenon in China's e-commerce market. We present the development history of trust fraud, summarize its unique characteristics, and explore the reasons why so many sellers commit fraud. We further propose a dynamic time decay trust model that aims to deter trust fraud by raising its cost and promote the growth of small and medium-sized sellers. The model utilizes detailed seller ratings as the data source, and incorporates a transaction amount weight, a time decay coefficient, and three trust factors in the calculation of trust. We test the model on real transaction data from Taobao, and the experimental results verify its effectiveness. Our proposed trust model yields a practical approach to online trust management not only in the Taobao market but also for other e-commerce platforms.

1. Introduction

In recent years, China's e-commerce market is developing very rapidly. The total e-commerce sales increased to RMB5.88 trillion (US$944 billion) in 2011, a year-on-year increase of 129.2%, which accounts for 4.32% of total retail sales in China (The Beijing News 2012). According to an analysis by the Boston Consulting Group, by the end of the year 2015, the size of China's e-commerce market will possibly surpass that of the U.S. market and become the world's next e-commerce superpower (Walters et al. 2011).

On the surface, China's e-commerce market appears to be flourishing, however, it faces many challenges, among which the trust fraud problem is the biggest issue. In this article, we utilize Taobao as an example to carry out an in-depth look at this problem, which has been ignored before. Taobao now is in a prime position, dominating China's consumer-to-consumer (C2C) market with a 90.3% market share, followed by Tencent's Paipai with a 9% market share.

To manage trust among buyers and sellers, Taobao has adopted a similar feedback system to eBay. On Taobao, each buyer can offer a feedback rating to the seller after completing a transaction. A positive rating raises a seller's trust score by one point. A negative rating lowers a seller's trust score by one point. A neutral rating does not affect a seller's trust score. The overall trust score is accumulated by adding these ratings together.

Taobao makes use of "heart", "diamond", "crown", and "gold crown" to denote different seller trust levels. (In contrast, eBay

uses stars to denote seller feedback scores. As a seller's feedback score increases, his star will change color.) On Taobao, each level includes a scale of 1 to 5. For example, a trust score of at least 4 earns a seller one heart, and a trust score of at least 251 earns a seller one diamond. If a seller's trust score reaches 10,001, her trust level will be upgraded to one crown. If her trust score continues to grow and reaches 500,001, then she will receive one gold crown. Thus, the higher the trust score, the more trustworthy will the seller be. This feedback system enables buyers to examine sellers' previous transactions and provides valuable reference for buyers to make purchase decisions. Reputable sellers are rewarded and may enjoy premium prices and a higher probability of future sales (Brown and Morgan 2006).

Although there are sellers on eBay who manipulate trust by purchasing or exchanging positive feedback ratings (BlackHat-World 2010, 2012), the feedback system has still proven to be quite effective (Brown and Morgan 2006). Taobao has met a big challenge using a similar feedback system though. Compared to eBay, Taobao's trust fraud problem is much more serious. Here's why:

1.1. Trust fraud is widespread on Taobao

According to Taobao's research, the highest percentage of detected fraud transactions accounted for about 47% of all the rated transactions and the lowest percentage was nearly 9% during the period from October 17, 2008 to May 17, 2009 (Chen and Yang 2009). It is not only the small sellers who artificially boost their reputations. Also there are super sellers who commit trust fraud to make their businesses look prosperous so as to attract more customers. A seller will feel left behind if all of her competitors

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artificially increase their reputations when the seller does not. A gold-crown seller, with a score of 500,001 points on Taobao, confessed to a reporter that half of his trust scores before getting the gold crown title were all obtained by committing trust fraud (MoneyWeek 2011). Estimates suggest that about 80% of Taobao sellers have committed trust fraud during the process of their businesses, more or less (MoneyWeek 2011).

1.2. Trust fraud breeds a huge gray industry

Since many sellers hope to promote their reputations as quickly as possible, some professional scammers see this as an opportunity. They have begun to offer services to artificially increase seller's trust scores. The part-time jobs of scammers now have turned into a large gray industry, in which sellers are the core, and buyers, scammers, trust fraud companies and logistics companies are all involved on the periphery. The interests of all sides are closely related and quite complicated. According to the available statistics, there are about 1,000 active trust fraud companies that are operating inside the Taobao ecosystem at present. Among them, there are three to five that manage to earn millions of RMB each year (Beijing Youth Daily 2009). Suppose that there are four million active sellers on Taobao and a quarter of them pay RMB500 (US$80) annually to artificially boost their reputations. This creates RMB1 billion (US$160 million) in the trust fraud market.

1.3. Trust fraud corrupts China's e-commerce

Since it takes little time and effort to increase reputation by committing fraud, many fraudulent sellers rely on this shortcut and gradually deviate from the principles of conducting honest business. They are anxious to achieve quick success and get instant benefits. A fraudulent seller's reputation can increase extremely fast. In recent years, many sellers have committed trust fraud on Taobao to boost their reputations, which leads to reputation inflation: all sellers have high trust scores eventually. Buyers are already aware of this feedback-based trust-enhancing strategy. They have doubts about the effectiveness of Taobao's feedback system as a result. Some of them do not trust the system any longer, which in turn reduced buyer-seller trade in this marketplace. Some particiants may stop shopping online and will not come back again.

In this article, we mainly focus on the trust fraud problem in China's e-commerce market and propose a new dynamic trust model. This article is laid out as follows. Section 2 provides a literature review. Section 3 discusses the trust fraud phenomenon, and analyzes its characteristics and the reasons behind its development. Section 4 presents our proposed dynamic trust model, which aims to decrease the chances of online trust fraud and promote the growth of small-sized and medium-sized sellers. Section 5 presents our experimental results and proves the effectiveness of our proposed trust model. Section 6 concludes.

2. Literature Review

There has been a lot of research on the e-commerce trust across various disciplines, including Economics, Management, Computer Science and Sociology. Brown and Morgan (2006) and Dini and Spagnolo (2009) have shown that fraudulent sellers artificially enhance their reputations by trading positive feedback ratings on eBay. These sellers listed items such as e-books, jokes or riddles for a very low price, like a penny, inclusive of shipping fees. The words "positive feedback" may be included in the title of an auction or hidden in the text of its description, which suggests that this is a sale or an exchange for feedback ratings. More than 6500 listings on eBay involving feedback trade were identified over

the period from June to December 2005 (Brown and Morgan, 2006). Even at the end of year 2008, it was still easy and cheap to manipulate trust on eBay (Dini and Spagnolo 2009).

Nowadays, eBay does not allow sellers to include the word "feedback" or to make any reference to eBay feedback in a listing title except when that word is used to describe the item for sale (eBay 2012). As a result, the public feedback market has disappeared, however, trust fraud still exists. Fraudulent sellers make posts in forums or websites outside of eBay to look for partners who are willing to exchange positive feedback ratings. They discuss fraud strategy in posts or through private email messages (BlackHatWorld 2010, 2012). If fraudulent sellers commit fraud in a careful and secret way, the results of their actions are very hard to detect.

Ba (2001) has pointed out that online trust can be established through a community responsibility system. In addition, Ba and Pavlou (2002) have investigated the extent to which trust can be induced by proper feedback mechanisms, and how some risk factors play a role in the process of trust formation. Later, Ba et al. (2003) proposed a trusted third party who assigns a digital certificate to each participant in online auction communities. The analytical results demonstrate that a market participant should behave honestly to maximize her benefits.

Zacharia and Maes (2000) proposed a centralized trust model SPORAS, which introduces a reputation mechanism for loosely connected online communities. Kamvar et al. (2003) presented Eigen-Trust, a distributed and secure model to compute global trust values based on power iteration. The algorithm aggregates the normalized local trust values by a weighted sum of all raw reputation ratings. In Ramchurn et al. (2003), a concrete computational trust model was developed, which took into account both the direct and indirect interactions between agents.

Wang and Vassileva (2003) proposed a Bayesian network-based trust model to combine different aspects of trust. Yu and Singh (2000) presented a social mechanism for reputation management which aims at avoiding interaction with undesirable participants. Liang and Shi (2005a, 2005b) developed a trusted middleware for P2P applications by combining two models. PET, a personalized trust model, employs reputation and risk evaluation, and M-CUBE, a multiple-currency based economic model, laid a foundation for resource-sharing in untrustworthy peer-to-peer (P2P) computing environments.

Xiong and Liu (2003, 2004) proposed PeerTrust, an adaptive trust model for quantifying and comparing the trustworthiness of peers. The model is based on a weighted sum of five factors including feedback records, feedback scope, credibility, transaction context and community context. Bizer and Oldakowski (2004) outlined a trust architecture that has trust policies combining reputation, context and content-based trust mechanisms.

Other related work has touched on trust in recommender systems. Donovan and Smyth (2005) have indicated that the trustworthiness of users plays an important role in guiding recommendations and they presented two computational trust models. The experimental results showed that their models managed to improve the predictive accuracy during recommendation. Andersen et al. (2008) used an axiomatic approach from the theory of social choice and proposed a recommender system in which agents cannot induce others to share their opinions by lying or modifying their trust links. Massa and Avesani (2004) have advocated a trust-aware collaborative filtering algorithm to increase the coverage of recommender systems while providing more accurate rating predictions.

Compared with previous works, our contribution is threefold. First, we thoroughly investigate trust fraud in China's e-commerce industry, and reveal the seriousness of this problem. Second, we give a detailed introduction on the historical evolution of trust

fraud methods and summarize their distinctive characteristics. Third, we propose a new dynamic trust model to lower the chances of trust fraud. We will verify its effectiveness through experiments using real transaction data. Our proposed trust model will have application value in the real world, and can help to promote the management of trust in China's e-commerce industry.

3. Trust fraud on Taobao

We next will give a detailed introduction about trust fraud on Taobao, by first presenting the history of trust fraud's development. Then we will summarize its distinctive characteristics. We also will explore the reasons why so many sellers have chosen to commit fraud on Taobao.

3.1. History of trust fraud development

During the first few years after its foundation, Taobao was busy competing with its biggest rival – eBay China. At that time, Taobao mainly concentrated on attracting more sellers and buyers to its marketplace. The trust issue was not its main focus. Nowadays, Taobao is dominating China's e-commerce market, however, trust fraud is flourishing and Taobao members are at risk of developing a culture of pursuing short-term financial gain at all cost (Epstein 2011).

When Taobao was just starting up, if a seller's trust level was one diamond, then he was regarded as trustworthy enough in most buyers' opinions. At this time, quickly obtaining at least a one-diamond reputation on Taobao was the primary objective of new sellers. Trust fraud on Taobao, as a result, is usually called *brush diamond* in Chinese. The words vividly describe the phenomenon that a new seller with few or no transactions surprisingly turns into a one-diamond seller overnight, just like a magician uses a magic brush to create diamond out of nothing. In fact, the improved reputation is not acquired through real transactions but by fake trading. Scammers who live on artificially-boosted reputations for sellers are called *brushers* in Chinese.

Although Taobao was founded four years later than eBay, trust fraud techniques developed much faster on Taobao. In the mid-2000s, Taobao became aware of this problem and began to put in a lot of effort to detect online trust fraud. Now it has become a competition though. Professional *brushers* try their best to find system vulnerabilities and continue to upgrade the techniques they use. As a result, trust fraud methods on Taobao have evolved across five different generations. Each generation has surpassed the preceding one, and it gets harder and harder for Taobao to detect such fraud.

3.1.1. First-generation trust fraud: trust fraud by the sellers themselves
This is the most elementary way for fraudulent sellers to obtain undeserved positive ratings. Basically, they set up multiple accounts on Taobao. Then they use these accounts to purchase items from themselves, and in the end leave themselves positive ratings and good comments. Using this method, fraudulent sellers make themselves look trustworthy. It is very easy for Taobao to detect these fraudulent sellers since their multiple accounts use the same IP address and the cookies also indicate multiple "buyers" have logged in from the same computer.

3.1.2. Second-generation trust fraud: trust fraud by machines
The first-generation method is usually used by sellers to promote their own reputations. From the second generation onward, trust fraud on Taobao became a new business. Professional *brushers* started making a living by committing fraud on Taobao full-time. This was also the beginning of large-scale online trust fraud. *Brushers* began to utilize computer software to generate fake IP ad-

dresses and fake accounts. Usually, *brushers* asked Taobao sellers to list virtual products in their storefronts, such as cards to add mobile phone minutes, electronic documents and Q coins (the virtual money used to buy virtual items in the online instant messaging community known as QZone). Then, *brushers* used those fake accounts to hypothetically purchase virtual products that did not require logistics. After the fake transactions were made, the software automatically left positive ratings and good comments for the sellers. As a result, the sellers' trust scores grew very rapidly. The second-generation trust fraud method has obvious regularities though, such as buyers' accounts sharing similar naming rules, and the interval between purchases and confirmations are typically very short. As a result, this method was also easy to detect, and so it is rarely used any longer.

3.1.3. Third-generation trust fraud: trust fraud between two sellers
The third generation of trust fraud method involves cooperation among fraudulent sellers. They set up online group chats using instant messaging software and communicate with each other within messaging groups. Then they work together to obtain undeserved trust scores. The principle of this method is as follows. Within the group, seller s_i purchases a RMB10 product from seller s_j, and seller s_j purchases an equal value product from seller s_i. They do not actually deliver the two products. The RMB10 transaction total transfers from seller s_i to seller s_j, then comes back to seller s_i. Both seller s_i and s_j incur no financial cost other than their time; however, both sellers' respective trust scores increase.

When analyzing the transaction records among a group of sellers, it is easy to detect this kind of trust fraud since almost every seller within the group has transaction connections with each of the other sellers. To hide from Taobao's detection, a fraudulent seller needs to join new instant messaging groups every day to have many different fraudulent partners with various IP addresses. He will not know much about those partners though. So he also will not be sure whether his partner will be careful enough to change his IP address or clear all cookies when committing fraud with him each time. If any of his fraudulent partners does not follow the so called "safety rules" for fraud, then he might be detected and punished by Taobao, and all his previously-obtained undeserved positive ratings will be confiscated. Once one fraudulent seller is caught, many others who previously have had fake transactions with him will have a difficult time to escape discovery.

Aside from being caught by Taobao, there are also other risks associated with using an instant messaging group for trust fraud. For example, suppose that seller s_i purchases a product from seller s_j, and then seller s_i confirms the transaction and seller s_j receives the payment. It is then seller s_j's turn to purchase seller s_i's product, however, he may refuse to pay. Due to the lack of guarantee and the fact that their agreement is not protected by law, seller s_i can do nothing in this situation. There are a great many scammers who specially cheat such sellers.

3.1.4. Fourth generation trust fraud: trust fraud among multiple sellers
To avoid detection by Taobao, a more advanced cooperation pattern among multiple sellers emerged as the fourth-generation trust fraud method. Suppose there are five sellers within the group. Seller s_1 hypothetically purchases a product from seller s_2, seller s_2 hypothetically purchases a product from seller s_3, seller s_3 hypothetically purchases a product from seller s_4, seller s_4 hypothetically purchases a product from seller s_5, and at last seller s_5 hypothetically purchases a product from seller s_1. The larger the group, the less likely the group's activities will be detected by Taobao. Since multiple sellers take part in fourth-generation trust fraud activity, this method is often used among people who are acquainted with one another already. If this is the case, the risk of being cheated by other sellers is greatly reduced, however, the risk

of being discovered by Taobao will increases since group activities among acquaintances tends to leave clues that can be followed.

3.1.5. Fifth-generation trust fraud: trust fraud through a third-party platform

At the end of 2006, the fifth-generation method involving the first third-party *brush diamond* platform emerged. The basic principle of the platform is as follows. Sellers all log into the platform with registered user names. Suppose seller s_i wants to obtain a positive feedback rating by falsely selling an RMB10 product, then s_i publishes this task on the platform. The platform deducts RMB10 from s_i as a deposit. Another member u takes over the task and purchases the product from s_i's storefront on Taobao using his own money. Then he confirms the receipt of the product and offers s_i a positive rating on Taobao. Seller s_i receives RMB10 from u for the fake transaction. Afterwards s_i's RMB10 deposit is transferred to u's account on the third-party platform. Meanwhile, member u also gains bonus points from the platform. Money only is transferred from one account to another and is returned, however, both the buyer and seller will have no financial losses. When there are enough active members on this platform, it is hard for Taobao to detect such trust fraud activities, since the process of making fake purchases is very similar to real transactions on Taobao. The so-called "buyers" and "sellers" come from all over China and there actually are real cash flows that occur among them.

If member u himself owns an online shop, then he may do the same thing as seller s_i does and gets undeserved trust scores for free. Certain bonus points will be deducted from u's account for publishing a task on the platform. So if a seller wants to get positive feedback ratings for free, he must accept tasks and fulfill them first. In this way, he can obtain the desired bonus points for publishing his own task. If u is a professional *brusher*, then he will earn money from the platform by serving other sellers to artificially boost their reputations. The platform earns money from sellers who want to get undeserved trust scores but do not want to take over other sellers' tasks. These sellers just pay a fee to the third-party platform and the platform will be in charge of all the rest of the work. Present, a one-diamond reputation costs a seller about RMB150–RMB300, while a one-crown reputation costs a seller about RMB3500–RMB7000 (Tianshan Net 2012).

"All for one and one for all" is the motto of *brush diamond* platforms. Ironically, these platforms which aim to commit trust fraud, also claim that they will guarantee the safety of customer deposits, as well as the *brush diamond* process. It is fairly that the executives of these platforms escape and take away all their customers' deposits though (Guangzhuo Daily 2011). The sellers who still have deposits on the platforms lose heavily. Their interests are not protected by law, since their behavior is in itself improper.

Despite these concerns, *brush diamond* platforms still currently enjoy a booming business. There could be three reasons for this phenomenon: first, there is no clear and direct law against *brush diamond* behavior, so it is very hard to trace and punish those professional *brushers*. Second, unlike eBay, Taobao is totally free without any insertion or transaction fee. Therefore, *brush diamond* activities on Taobao essentially involve a zero-cost business. Third, there are still a certain number of sellers who want to get undeserved trust scores. As *brush diamond* companies have a market and manage to make money, they continue to exist and develop.

3.2. The characteristics of trust fraud on Taobao

Trust fraud is not a problem that is specific to Taobao. As the world's largest C2C e-commerce trading platform, eBay also has trust fraud problems of its own (Nickson 2010). Compared to eBay though, Taobao's problem is more serious and has its own unique characteristics.

3.2.1. Good organization

Trust fraud activities on Taobao are well organized and are not one man's act. Among all the *brush diamond* companies, nearly ten of them have more than fifty employees. There is a clear division of labor among these employees too. Some are in charge of technical support, some are responsible for advertising and promotion, and some are in charge of management.

3.2.2. Professionalism

Many people who work in this gray industry are professional software engineers. They develop *brush diamond* platforms, update functions and maintain security, etc. Since they choose *brush diamond* activities as their "careers", they are motivated to try their best to discover system vulnerabilities and make use of them to earn money. Over time, they tend to adopt more subtle means to commit fraud, and so it gets harder and harder for Taobao to detect their activities.

3.2.3. Blatant advertisements

Brush diamond companies constantly send spam advertisements to sellers through instant messaging software. An example is Aliwangwang, which offers free services for online business communication to buyers and sellers on Taobao and Alibaba. A second example is QQ, a popular free instant messaging application in China. When you search for the term "Taobao *brush diamond*" in Chinese using the two most popular search engines in China, Baidu returns about 2,710,000 hits, while Google returns around 5,070,000. Baidu topped China's search engine market with a 78.3% share in the fourth quarter of 2011, while Google China ranked second with a 16.7% market share (China Knowledge Online 2012), indicating the scope of the potential for fraud. For both search engines, the advertisements of *brush diamond* platforms dominate the top few positions until this article go to press. It is interesting to note that *brush diamond* companies can publicly place such advertisements in China without fear of reprisals against them.

3.2.4. Business terrorism

In recent years, Taobao took measures to combat trust fraud by modifying its rules and deleting sellers' fake feedback ratings. But the *brush diamond* companies and fraudulent sellers rebelled against Taobao in various ways. For example, they maliciously made massive online orders from large sellers but refused to pay, and they made crank calls to Taobao's customer service center, which seriously interfered with the firm's normal work (Beijing Business 2009). There also are recorded instances of violence against Taobao to force it to compromise. This is not just a simple protest, but rather it has become a form of business terrorism.

3.3. Why sellers commit trust fraud

Studies on eBay have shown that the market rewards a seller who has accumulated a lot of positive feedback ratings (Resnick et al. 2003). When a seller's trust score achieves 50 or greater, he will see an additional 10% increase in views and prices (Gilberg 2012). Based on our experiments on Taobao, seller trust levels also appear to have a positive correlation with their recent transaction amounts (Zhang 2012). Profit, not surprisingly, is the fundamental reason for trust fraud.

During our investigation, we interviewed several sellers who had engaged in trust fraud activities. On the one hand, they were worried that their behavior might be discovered and punished by Taobao in the future. On the other hand, they felt they had no choice but to commit fraud. At present, there are more than 6.35 million sellers involved in typical online activities, and there is

fierce competition among them.[1] When a buyer searches for a product on Taobao, there will be up to 100 pages of items that may be retrieved. Usually, an overwhelming majority of buyers will choose a seller from among the ones listed on the first few pages. A combination of factors such as a seller's trust level, sales volume and popularity will determine her ranking in the search results. As a new seller or a small seller, she will not have any of the aforementioned advantages. Therefore, it will be very difficult for such sellers to compete with large sellers. And, even if small sellers sell a product at a very cheap price, many buyers still will be afraid to purchase any products from them. Without a high trust score, the seller will only sell a few products. Without good sales, small sellers will not be able to get a very high trust score. This situation creates a vicious circle. One seller we interviewed told us that he was not intending to commit fraud or cheat buyers. He just wanted to let them have a chance to notice his storefront, and this enabled him to make a living. This view is widely shared among sellers in the competitive marketplace of Taobao.

To sum up, due to the lack of a sound social credibility system, trust fraud in China's e-commerce industry is quite complex and has its unique characteristics. Some of the problems we discussed are unprecedented and have not been addressed in prior e-commerce research. In addition, there are no ready-made or obvious solutions to them at present.

4. A new dynamic trust model for China's C2C e-commerce

We next will present a new dynamic trust model to attempt to combat the trust fraud problem on Taobao. We will introduce several directions for improvement to the current C2C e-commerce trust models. We also will propose a new dynamic trust model that incorporates a transaction amount weight, a time-decay coefficient and several additional trust factors.

4.1. Improvement directions for current trust models

Based on our study of trust fraud on Taobao, we propose a number of directions for improvements to the current trust models.

- **Raise the cost of trust fraud**. The traditional method to eliminate trust fraud is to identify those sellers who have defrauded and then punish them. However, this is clearly a temporary solution: it only cures the symptoms, not the disease. A better method is to build a more reasonable trust model and control trust fraud by improving regulations and rules. The basic strategy is to raise the cost of trust fraud, so that more and more *brushers* think it will be unprofitable, and as a result they will quit (Chen and Yang 2009). A trust system that only reduces the lure of fraud without eliminating it may be sufficient to activate Yhprum's Law – "everything that can work will work" (Resnick et al. 2003). The founder of the *brush diamond* industry and previously the largest *brush diamond* company in China was WebGle. Today, WebGle serves as a platform that provides Internet third-party management services. It exited the *brush diamond* business in March 2009. High service costs and low margins were the main reasons for WebGle's decision to exit (Beijing Youth Daily 2009).
- **Build a dynamic trust model**. According to research in Sociology, trust is dynamic and non-monotonic (Abdul-Rahman and Hailes 2000). Thus, current models that view trust as a static accumulated amount should be replaced by a dynamic trust

model; large-scale sellers with high trust scores should not be able to rely on their previous reputations. Sellers' trust scores will change along with their recently obtained feedback ratings. In this way, we are able to encourage the development of small and medium-sized sellers.
- **Make trust hard to build, but easy to lose**. There is a saying attributed to the famous Japanese thinker, Daisaku Ikeda: "Trust is difficult to earn and it is easily lost – the trust built over a decade can be shattered in an instant by one offhanded remark or deed" (Ikedaquotes.org 2012). Currently on Taobao, it is easy for sellers to gain a positive feedback rating after a transaction. According to our analysis, the ratio of positive ratings is more than 99.5% among all the valid feedback ratings, based on randomly-chosen observations from a much larger data set containing over 1.3 billion feedback ratings. For super sellers, a negative feedback rating has little effect since it only leads to losing one point from the total trust score. In addition, this negative impression is likely to be counteracted by the many positive ratings that will follow. A more effective trust model should reflect the trust characteristics as we know them in real life – that trust is hard to build but easy to lose. The sellers should be required to have good long-term performance to obtain a high trust score, and they should lose a lot once they act deceptively in a transaction.
- **Improve the authenticity of feedback ratings**. The authenticity of feedback ratings is the primary basis for accurate trust evaluation. Even if there were no *brush diamond* activities on Taobao, current feedback ratings still would not truly reflect buyers' opinions about transactions. Resnick and Zeckhauser (2002) found that buyers and sellers reciprocate and retaliate in regard to feedback ratings. According to a survey conducted on Taobao, 44.2% of respondents reported that the biggest problem related to feedback is that sellers will continue to harass them if they offer a negative feedback rating. Under this situation, buyers are not willing to offer negative feedback ratings, so the authenticity of feedback cannot be guaranteed. A more effective model of trust should make use of anonymous feedback ratings instead of ones that are associated with the names of others, so that sellers cannot see which of buyers is giving them which ratings. As a result, buyers will feel free to express their true feelings without worrying about threats of reprisals or harassment. In addition, sellers will have the necessary incentives to provide good products and services each time they are involved in a transaction.

4.2. A new dynamic trust model

We now propose a dynamic trust model for Taobao. It includes the following parameters.

- *Transaction amount weight*. Various transaction amounts should be treated differently in the trust calculation.
- *Time decay coefficient*. Trust should reflect sellers' recent trading activities.
- *Trust factors*. These include quality, service and shipping speed, which should be considered and treated differently according to the buyer's opinions.

We utilized real transaction data records from Taobao to determine the above mentioned parameters. The sample data set contains general information about 3,261,269 transactions. The general information about a transaction includes the buyer ID, the seller ID, the product price, the sales volume and the total value. There are 15,976 sellers. The general information about a seller includes his trust level, trust score and the opening time of his online shop. The data set also contains 2,308,704 feedback ratings.

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[1] This number was obtained based on statistics from Taobao's backend database. Some non-active sellers haven't logged into Taobao for a long time, some have closed their online shops, and others are under investigation for alleged fraud. We removed these kinds of sellers to obtain the number of active sellers reported here.

Buyers can leave a positive, negative, or neutral rating for sellers. There are also 3,306,633 detailed seller ratings. The detailed seller rating system is based on a 1–5-star scale. 5 stars is the highest rating, and 1 star is the lowest. A detailed seller rating reflects three specific aspects of the transaction: item description, seller's service and shipping time. The time span is from March 9 to June 10, 2010, covering three months in total. To build a new trust model, we first present how to determine the three above-mentioned parameters: transaction amount weight, time decay coefficient and trust factors.

4.2.1. Transaction amount weight

Currently on Taobao, no matter how much the trading amount, one positive rating only gets a seller one point. Suppose a buyer b_k purchases a RMB10,000 (US$1,605) product from seller s_i and purchases an RMB1 (US$0.16) product from seller s_j. If the buyer b_k is satisfied with both transactions, sellers s_i and s_j obtain the same one point. In fact, the risks associated with the two transactions differ greatly. In most cases, buyers will carefully select reliable sellers from whom to purchase valuable products. They will not carefully scrutinize sellers before purchasing cheap products though. Therefore, an effective trust model must recognize the appropriate weight to apply based on each transaction's total value.

We propose to set a transaction amount weight m according to the risk associated with each transaction. The transaction risk itself is a quite complicated issue, which may involve many factors during the transaction process. We can take a roundabout approach to evaluate the risk by observing the buyers' behavior. Buyers' online behavior indirectly reflects their assessment of risk. As we all know, avoiding risk is a matter of human nature. If the majority of buyers choose to do something, then the risk is likely to be small. Conversely, if only a small number of buyers choose to do something, then the related risk is likely to be larger.

Fig. 1 shows the transaction amounts distribution of records in sample data set. The x-axis denotes the range of transaction amounts and the y-axis denotes the proportion of each range. The general trend is that the lower the price of products, the more transactions will be observed. The higher the price, the fewer transactions will be observed. As can be seen from Fig. 1a, most transaction amounts on Taobao are below RMB100 (US$14.6), which accounts for nearly 81.5% of the transaction records in the sample data set. We subdivided the range (1–100] into 10 sub-ranges (see Fig. 1b) The percentage decreases gradually from (1–10] to (90–100], from one sub-range to another except that
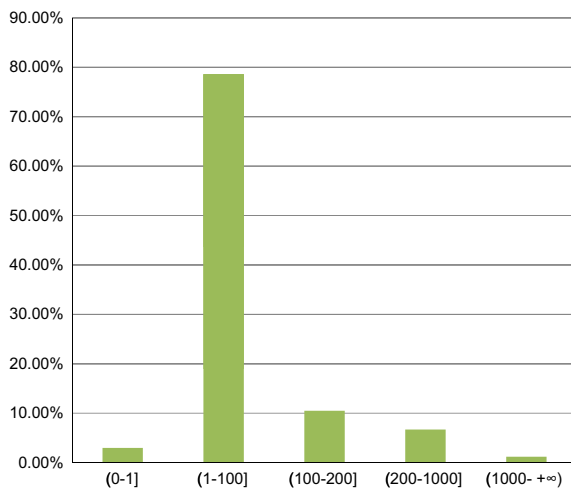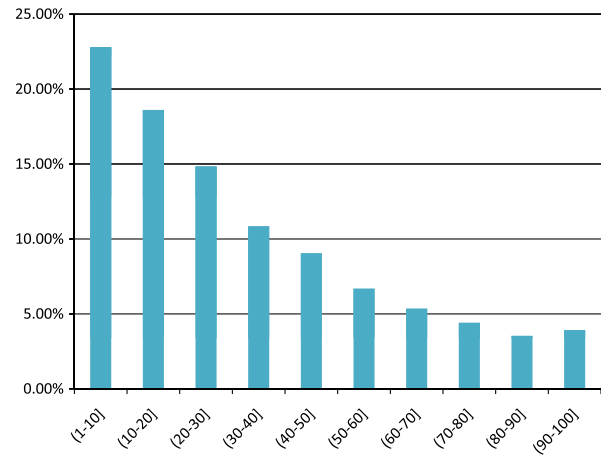

Fig. 1b. Transaction amount distribution in sub-ranges of (1–100].

the proportion of the last sub-range (90–100] is a little more than that of the sub-range (80–90].

We can set the transaction amount weight as shown in Table 1 according to the distribution of transaction volumes and the Pareto principle to establish the basic system settings.

First, we exclude the transactions of virtual products and the transactions whose amounts are less than or equal to RMB1 from trust calculation. Previously, many *brush diamond* companies utilized these kinds of transactions for trust fraud because the cost was very low. Since the majority of transactions on Taobao are for small amounts, we mainly consider how to set the trust weight for transactions whose amounts are between RMB1 and RMB1000. We divide the range (1–1000] into three ranges according to the distribution of transaction amounts. (See Figs. 1a and 1b again.) We then set the weight using the various aspects that are discussed below.

4.2.2. Time decay coefficient

Trust is a dynamic concept. The closer the transaction happens to the current time, the greater the reference value should be for trust calculation. The trust score should not be a simple accumulation of feedback ratings though. Instead, it should be adjusted continuously as time passes. Thus, we introduce a time decay function for our proposed trust model in this section.

We utilized the power function to obtain the time decay coefficient, as shown below:

$$d_{t_j} = \alpha^{-\beta(t_c - t_j)} \tag{1}$$

Here t_c denotes the current time and t_j denotes a time in the past when a buyer offered a feedback rating. d_{t_j} is the time decay coefficient for a specific time t_j. The variables α and β are parameters of the time decay function. We are able to obtain different decay effects by adjusting the two parameters (Zhang and Zhu 2011). The values of α and β can be determined by combining empirical knowledge and practical experience. Fig. 2 shows the curves of different

Fig. 1a. Transaction amounts distribution in different ranges.

Table 1
Transaction amount weight.

Transaction amount	Weight
⩽1	0
(1–100]	1
(100–200]	2
(200–1000]	3
>1000	4

combinations of α and β. When the base α is determined, the smaller the β, the slower trust decays.

When parameter β is determined, the larger the base value of α, the faster trust decays. We can obtain various decays effects from drastic drops to gentle declines by tuning the two parameters. This function is simple to create and modify. Below, we chose one seller as an example to illustrate the time decay effect. Here, we let $\alpha = 2$ and $\beta = 0.1$. The related time decay coefficient can be calculated as: $d_{t_j} = 2^{-0.1(t_c - t_j)}$.

Fig. 3 shows the result, where the x-axis denotes the number of weeks and the y-axis denotes sellers' trust scores.

For the period of sixteen weeks, the blue line denotes the seller's sales each week. For example, the seller's transaction volume is 44 in the fifth week and is 26 in the sixth week. The red line shows the cumulative trust score after time decay under normal sales circumstances. To clearly illustrate the effect of the time decay function, we also simulate two extreme situations: one where the seller is good at first, however, he becomes worse and worse later in sales and service. The other one is just the opposite: the seller behaves badly at first, however, he gets better and better with time. The green line represents the former, while the purple line represents the latter. As can be seen, if a seller relies on his original good reputation and does not provide as good a product or service as before, his cumulative trust score will grow very slowly or will even decrease. Meanwhile, if the seller continually improves product quality and service, his trust score will grow rapidly. Using the time decay function, sellers will be incentivized to have continuous good performance. It will also punish sellers who begin to behave badly after obtaining a high trust score (Zhang and Zhu 2011).

Fig. 4 illustrates the effect of weighted time decay on sellers of various trust levels from "1 heart" to "1 crown."

The first column on the left shows the weighted method without time decay. All the remaining columns represent the trust calculation using different time decay coefficients. The x-axis indicates the decay circle r, while the y-axis indicates the percentage of sellers with various trust levels. For example, the second column from the left denotes the result when $r = 730$ days, and the rightmost column denotes the result when $r = 7$ days. As the decay circle diminishes, the number of low-trust sellers increases and the number of high-trust sellers decreases.

From these experimental results, we can come to the following conclusions. First, using the time decay function, the overall composition structure of sellers is stable. Second, high-trust sellers cannot rely on their previous trust scores forever. Thus, the time decay function can lower the market access threshold for new sellers.
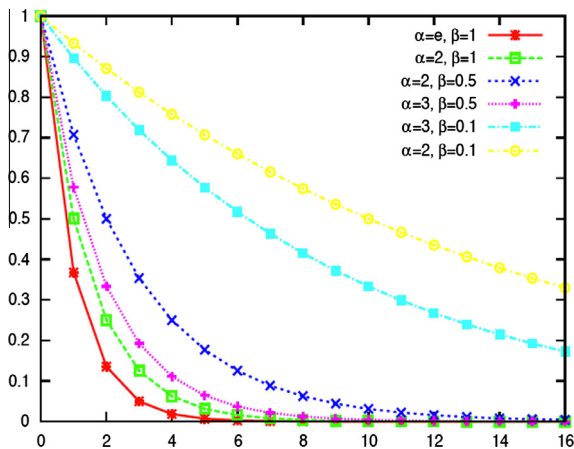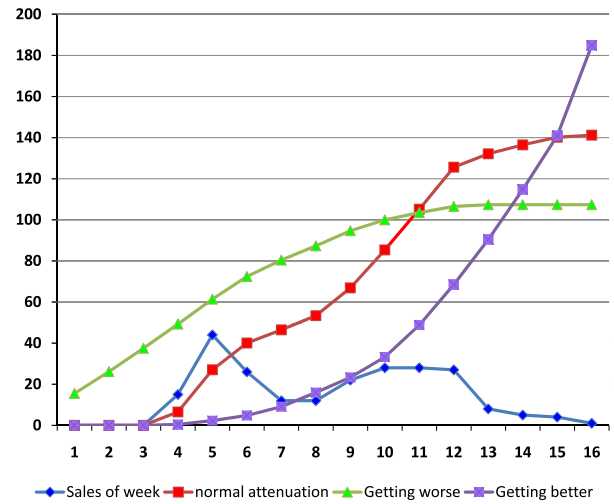

Fig. 3. The effects of the time decay function.

4.2.3. Trust factors

In our proposed model, we mainly utilize detailed seller ratings that contain three trust factors: quality, service and shipping speed. The importance of these trust factors in the trust calculation differs. According to a survey on Taobao buyers (Taobao 2011), about 71.4% of buyers pay close attention to product quality, about 35.7% of buyers are concerned about service and about 28.6% of buyers pay attention to the shipping speed. According to the above information, we set the trust factor weights, as shown in Table 2.

4.3. A dynamic trust model

We let s_i $(1 \leqslant i \leqslant N)$ denote a specific seller. We let B denote the set of buyers who have had transactions with seller s_i, and let b_j $(1 \leqslant j \leqslant H)$ denote a specific buyer. We use m to denote the transaction amount weight. We utilize w_q to denote the quality weight, w_s to denote the service weight, and w_e to denote the shipping speed weight.

Next, let $q_{b_j}^{t_k} \rightarrow s_i$ represent the rating that b_j gives to s_i at time t_k for the product quality. In addition, let $p_{b_j}^{t_k} \rightarrow s_i$ be the rating that b_j gives to s_i at time t_k for the service. Finally, assign $e_{b_j}^{t_k} \rightarrow s_i$ as the rating that b_j gives to s_i at time t_k for the shipping speed.

We utilize $d_{\Delta t}$ to denote the time decay coefficient corresponding to the current time t_c, where $\Delta t = t_c - t_j$. We also let N_G be the total number of rated transactions that seller s_i has up until the present time t_c. Note that buyer b_j may have multiple transactions with seller s_i and we use transaction record IDs to distinguish among the different transactions. Therefore, a seller s_i's cumulative dynamic trust score at time t_c can be calculated using the following formula:

$$T_{s_i} = \sum_{j=1}^{N_G} m \times (w_q \times q_{b_j}^{t_k} \rightarrow s_i + w_s \times p_{b_j}^{t_k} \rightarrow s_i + w_e \times e_{b_j}^{t_k} \rightarrow s_i) \times d_{\Delta t}$$

(2)

In addition, the average dynamic trust score per transaction can be calculated as follows for a recent period of time:

$$\overline{T_{s_i}} = \frac{T_{s_i}}{N_G}$$

(3)

The value $\overline{T_{s_i}}$ for a recent period of time will be an effective parameter to evaluate sellers' current trust status. We will further explain the details of this finding based on our experimental results in the following section.
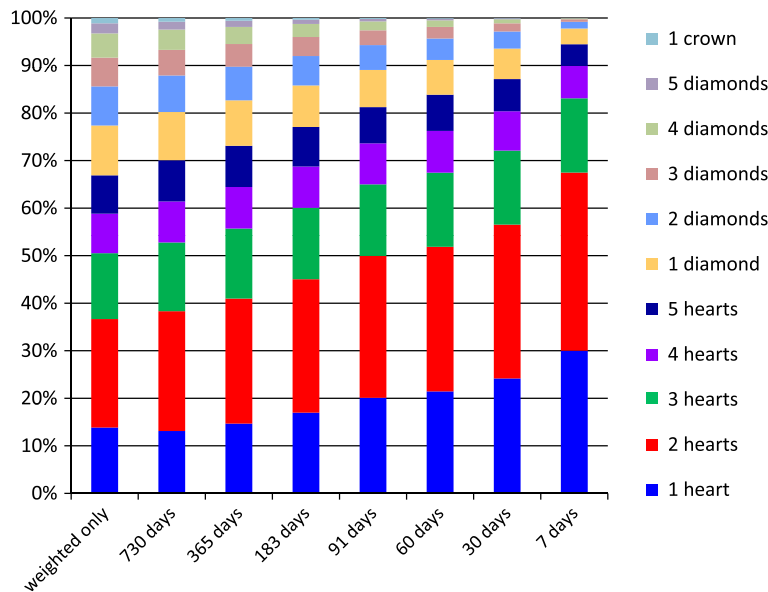

Fig. 2. Time decay curves.

Fig. 4. The effect of weighted time decay on sellers of various trust levels on Taobao.

Table 2
Trust factor weights.

Trust factor	Weight
Quality	50%
Service	30%
Shipping speed	20%

Table 3
Large-scale sellers' average trust scores calculated using the dynamic trust model.

SellerID	A_Trust	Q_Ave	S_Ave	L_Ave	$\overline{T_{S_i}}$
7897****	1157197	3.70	3.57	3.47	3.62
3344****	484663	3.80	3.79	3.70	3.78
5008****	244071	3.91	3.86	3.78	3.79
32****	332266	4.20	4.22	4.03	4.17

Table 4
Small-scale sellers' average trust scores calculated using the dynamic trust model.

SellerID	A_Trust	Q_Ave	S_Ave	L_Ave	$\overline{T_{S_i}}$
3372****	260	16.48	16.74	16.48	16.56
3463****	91	15.92	15.92	15.92	15.92
1330****	555	15.84	15.84	15.53	15.78
5736****	1331	15.97	15.10	15.97	15.71

5. Experimental results

In this section, we utilize real transaction records from the original sample data set for the experiment. First, we preprocessed the data and removed records that contained a null value in any field. In the sample of detailed seller rating records, there were 314,927 fields containing null values. Then, we associated the records in different tables to obtain all the needed information for each transaction, including seller ID, buyer ID, transaction total, price, detailed seller ratings and transaction time. In this way, we were able to identify 1,224,635 transaction records to create the cleaned data set for our experiment.

The cleaned data set shows the trading conditions for 9960 sellers in a three-month period.

Among these sellers, some had few transactions during that period and their records were not sufficient in number for trust evaluation. This led us to select 8003 sellers from the cleaned data set who made greater than or equal to 10 successful transactions. We calculate the dynamic average trust score using Eq. (3) for these sellers.

Tables 3 and 4 show the average trust scores for several super and small sellers.

We only present a small part of the experimental results. In both tables, the first column, *SellerID*, denotes the user ID of a seller, with the last four digits of their IDs omitted for privacy. The second column, *A_Trust*, denotes the cumulative trust score of a seller. This is the trust score that appeared on his online shop's homepage, when we obtained the sample data. The third column, *Q_Ave* denotes the average score for product quality given by the buyers per transaction. The fourth column, *S_Ave*, denotes the average score for service given by buyers per transaction. The fifth column, *L_Ave*, denotes the average score for shipping speed given by buyers per transaction. The rightmost column denotes the average trust score calculated using our dynamic trust model.

We ranked all the 8003 sellers according to their dynamic average trust scores. From the ranking, we observed an interesting phenomenon: many super sellers who already had trust levels such as "2 crowns" or "5 crowns'" have a low dynamic average trust score. In contrast, a lot of small-sized and medium-sized sellers have a rather high dynamic average trust score.

Currently on Taobao, many super sellers rely on their existing reputations and feel it is not necessary to provide good products or services any longer. They may receive a certain percentage of negative ratings due to bad products or services, however, it has little effect on their trust status since a negative feedback rating only leads to losing one point of their total trust scores. Moreover, this negative impression will be counteracted by the many positive ratings that will follow. (Note that more than 99.5% of buyers offer positive feedback ratings to sellers even if they are not truly satisfied with the transactions.) Using our proposed model, the advantages of the super sellers will disappear and their average trust scores will decrease gradually due to time decay. They will eventually end up at the back of the pack, as a less-preferred seller.

In contrast, some small-sized and medium-sized sellers may manage to have high dynamic average trust scores. They will stand out from millions of other sellers due to their continuous good per-

formance. As long as a seller provides good products and services, he will get a high dynamic average trust score. This will be true no matter whether the seller is large or small. This also is fair for all of the sellers and will help to promote healthy market competition.

To examine the effect of our trust model, we browsed the homepages of sellers' storefronts on Taobao. For example, a small seller who gets a high average trust score of 16.6 sells top-grade electrical equipment. The average price of these products is above RMB10,000 (US$1605), so the transaction amount weight is 4 in the trust calculation. From the buyers' comments, we can tell that this seller only sold genuine branded products and provided very good services in support of the transactions. As a result, the seller received high detailed seller ratings in all the three categories.

Another example is a large-scale seller who sells all kinds of snacks. The seller's cumulative trust score was 1,157,197 when we obtained the data from Taobao. Through reading buyers' comments, we could see that a certain percentage of buyers thought the snacks were not delicious. Some buyers wrote that the packages were broken when they arrived and the delivery speed was very slow. We also noticed that some buyers even pointed out that there were many food additives in the snacks, and so they were not very healthy. Overall, many buyers were dissatisfied with this super seller. Meanwhile, the prices of most products sold in the seller's storefront were under RMB100 (US$14.6), so the transaction amount weight is set to 1 in the trust calculation. As a result, this seller's average trust score was rather low.

Currently, there is another problem that Taobao is dealing with: the trust score represents the accumulation of buyers' feedback ratings after each successful transaction, so a seller's trust score grows continuously and it will not have an upper limit. Our model can solve this problem, as the calculated average trust score will have a defined upper limit. The highest detailed seller rating for each aspect is 5. Suppose the transaction amount weight is 4, which is the highest value. Therefore, the final average trust score will be 20, which is the highest average trust score that a seller can obtain using our dynamic model. It will be very hard for sellers to reach this upper limit due to the time decay included in the trust calculation. Sellers need to perform well consistently to have a high trust score.

We select 5228 sellers from cleaned data set and ranked them according to their cumulative trust scores, as shown in Fig. 5. The x-axis denotes each seller's ranking among all other sellers in the data set, while the y-axis represents their cumulative trust scores. As can be seen from the results, the cumulative trust score has no upper limit and the range of the trust score is extremely large.
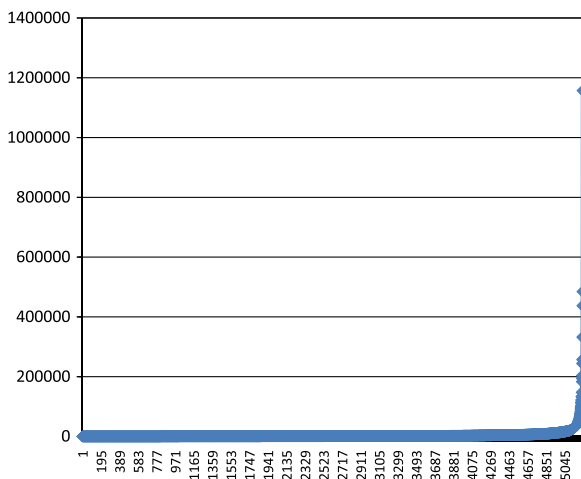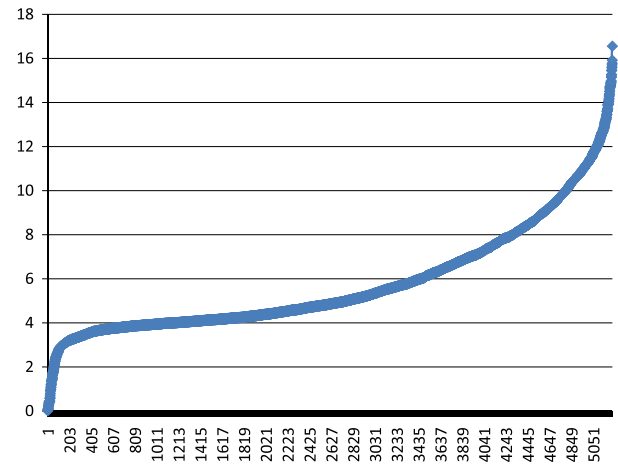

Fig. 6. The average dynamic trust scores of sellers on Taobao.

We also rank all the above sellers according to their average trust scores obtained by our proposed trust model. (See Fig. 6.) The x-axis denotes their rankings among all the sample sellers, while the y-axis denotes the average trust scores obtained by our dynamic trust model. There is a slight slope in the middle part of the curve, which indicates that a majority of sellers belong to the middle class among all the sellers. It gets harder and harder for sellers to promote when they reach a score of about 12, so there is a steep increase at the end of the curve. The highest average trust score of sellers in the sample is 16.6. It is very difficult for sellers to reach the full mark of 20.

6. Conclusions and future work

Based on the experimental results we have reported, our proposed dynamic trust model supports the following conclusions:

- The closer that a transaction occurred relative to the current time, the larger the weight of its feedback rating will be in the trust calculation.
- By adding the transaction amount weight, we have enlarge the original 5-star rating scale so it has a larger range of 20, which makes it easier for buyers to distinguish among different sellers.
- The average trust score in our proposed model has a defined upper limit and will not grow in an unrestricted manner. All sellers will seek to achieve the upper limit of the trust score, however, it will be very difficult for them to achieve this goal.
- The trust calculation rules in our model are easy to understand and implement.

In the future, we will conduct more complete tests on our dynamic trust model using large-scale data from Taobao. Meanwhile, we will consider more trust factors in the evaluation, such as the history of the online shop, illegal behavior and customer complaints, etc. We also plan to continue our in-depth cooperation with Taobao. We further hope to develop a module based on our proposed dynamic trust model, and apply it in one of Taobao's online applications to verify its effectiveness and efficiency.

To address the problems with trust in China's e-commerce, improving the trust model is an important internal solution, while building a social credibility system in China is an external solution. Social credibility, we believe, will have a great impact on the effectiveness of a trust model in China's e-commerce industry. That is because Taobao's problems are, in a very real sense, China's problems (Epstein 2011). Each year, China's economic loss caused by lack of trust reaches about RMB585.5 billion (US$94 billion)

Fig. 5. The cumulative trust scores of sellers on current Taobao.

according to statistics of year 2011 (Qian 2011). Everyone in society must pay a high price to compensate for this. The government must intervene and enforce stricter rules, while reminding people of the value of trust in society. When the internal and external solutions function together well, then we will be able to resolve China's fundamental e-commerce trust issues more effectively.

Acknowledgments

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