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A game-theoretic model for the role of reputation feedback systems in peer-to-peer commerce

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ABSTRACT

We propose a dynamic game-theoretic model to study how a reputation feedback system affects a peer-to-peer (P2P) trading platform. Continuums of buyers and sellers with bounded rationalities are paired to trade periodically. Sellers have private knowledge on their own types that encode tendencies to cheat. Their reputation scores are, on the other hand, visible to all and periodically updated by their trading partners. A buyer can use a seller's score to assess the latter's characters and decide whether to trade. Using a continuity-based fixed point theorem, we first establish the existence of equilibria that convey information on traders' behaviors as well as the type-score composition on the market. We then look into a special case which, for model tractability, includes two types of sellers with two score levels. Besides the proportion of prone-to-cheating sellers, it indicates that how much sellers value their future payoffs also plays a major role in determining the prevalence of online frauds. Therefore, reputation feedback systems are especially beneficial under high trading volumes, which can in turn, for instance, be facilitated by attracting more buyers to the online marketplace.

1. Introduction

Due to advances made by computing and telecommunications technologies, peer-to-peer (P2P) commerce has gradually come to the fore of people's daily lives. P2P platforms, such as eBay, Uber, and Airbnb, offer individuals convenient online marketplaces to exchange goods and services that are under-utilized by some but highly desired by others. However, due to the lack of supervision, P2P commerce faces various challenges in terms of safety, reliability, and integrity; see, e.g., Baker (2014). Buyers trading on online P2P platforms often rely on the verbal descriptions and images that sellers post, with dubious trustworthinesses, for information on the goods and services they demand. Therefore, promoting trusts between buyers and sellers and reducing frauds committed by sellers are critical for safeguarding buyers' rights and maintaining the sustainabilities of online marketplaces.

A multitude of mechanisms have been proposed for these purposes. Specific online payment systems have been implemented to support secure and instantaneous transactions between online traders. Still, reputation feedback systems stand out as the main tool that P2P platforms use to promote sellers' honest behaviors and trusts among all participants. For instance, both buyers and sellers on eBay are able to, along with comments, leave positive (+1 point), negative (−1 point), or neutral (0 point) ratings for their counter parties. These form the basis on which eBay updates each trader's total rating, star level, and positive feedback percentage. All rating and feedback percentage information of an ebayer will be observable by others and will influence their intentions to trade with this individual.

Meanwhile, both Uber and Airbnb have adopted five-star ratings systems. For a particular listing, Airbnb publishes an aggregate of the primary scores that guests have left. The aggregate ratings of the listings can be viewed by guests before booking. Uber does not show any driver's information to riders before they submit riding requests. However, the driver's star rating will be sent to a rider as soon as his/her riding request is accepted. Intuitively, it is easy to understand why these various feedback systems have found such popularity at their respective P2P platforms. With them in place, the platforms' participants will behave better, because how they treat their counter parties will affect how their own reputation scores will be updated and hence how they will fare in the future.

Scientifically, however, it remains unresolved as to whether and how feedback systems actually work. Extant research into online feedback systems has various limitations. Dellarocas (2005) examined a binary

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reputation mechanism, where buyers can report the outcome of a transaction as "satisfactory" or "unsatisfactory". His model did not consider heterogeneity in the seller population. Yang et al. (2007) did allow multiple seller types; however, they did not derive the convergence to equilibrium trading behaviors. Still more attempts will be discussed in Section 2.

In this paper, we provide a model that resembles real feedback systems in many major aspects. Our nonatomic-game setup imitates the large numbers of participants in P2P platforms. The bounded rationalities that traders are endowed with reflect the finiteness of computational resources in day-to-day decision makings. These features help us in establishing the existence of equilibrium behaviors for online trading participants. Realistically, we let sellers have private knowledge on their tendencies to cheat. What can save the market from collapsing under sellers' potentially mischievous behaviors are (a) their openly accessible scores that are periodically updated by their trading partners according to how the latter are treated, (b) their own interests in their long-term gains which can be affected by their scores, and (c) buyers' autonomies on basing trading decisions on the scores of their potential partners. The equilibrium existence then paves way for our study of a more special system which yields insights on how the feedback system works in P2P commerce.

In particular, we take the nonatomic-game (NG) approach by assuming continuums of buyers and sellers. Sellers differ in their types θ, namely, indicators of their tendencies to cheat when being left to their own devices. Buyers can see the reputation scores ω of their trading partners but not their true types. Each score ω can be understood as corresponding to some aggregate of the whole set of comments and ratings that a merchandise/service provider has received in a real P2P platform. We assume an exogenous score-updating behavior for buyers after each trade. When a pair of buyer and seller are matched, the buyer can first base her decision on whether to proceed with trading on the seller's score; the seller can then decide to behave honestly or just cheat, by weighing between his short-term gains and long-term prospects; afterwards, the buyer will follow her rulebook to update the seller's score according to how she has been treated. We show that a steady-state equilibrium of the entire trading system will emerge. The equilibrium consists of a complete depiction of traders' behaviors, sellers' long-term payoffs, and the market's type-score composition.

The knowledge of such equilibria gives us a foundation to work with. To determine the main drivers of equilibrium behaviors, we resort to a special model involving two seller types, two potential score levels, and particular decision making rules for traders with bounded rationalities. All potential equilibria can be derived for this case in closed forms. We can then analyze the effects of exogenous parameters on the performance of the feedback system. Naturally, this model indicates that the proportion of prone-to-cheating sellers in the marketplace contributes to online frauds. More usefully, weights that sellers place on future payoffs play an equal if not more important role. Thus, the online marketplace can benefit from higher trading volumes, realizable, for instance, by attracting more buyers to it. This way, sellers would rather act honestly to maintain a good reputation with the expectation for more businesses and revenues to come in the future, than cheat for one-off gains at the perils of bad scores that have lingering ill effects.

In the remainder, we review the related literature in Section 2. The nonatomic-game model involving bounded rationalities of an online feedback system is analyzed in Section 3. We focus on a special case in Section 4 that offers identifiable equilibria and helps to generate valuable managerial insights. The paper is concluded in Section 5.

2. Literature survey

In repeated games, folk theorems in the economics literature suggest that players might use credible threats and rewards to induce each other to adopt strategies otherwise unacceptable in single-stage plays. These theorems require that the same set of players keep playing with each other forever, or any long-run player's past behaviors are either publicly known or sufficiently discernible. A general survey can be found in Hendrikx et al. (2015). Also, Wahaba et al. (2015) offered a review of trust and reputation works with particular links to web services. Moreover, (Ekmekcia et al., 2012; Liu, 2011; Liu and Skrzypacz 2014) studied reputation systems for marketplaces that consist of long-run players and short-lived opponents. Most works allowed feedback systems to track participants' historical behaviors. Interested readers may refer to (Kreps and Wilson, 1982; Fudenberg and Levine, 1992; Battigali and Waston 1997) for more related works. We feel that having every trader's entire history publicly known is somewhat too much to assume, especially in light of the fact that parties in online tradings are strangers to each other.

Closer to the reality of eBay, Uber, and Airbnb is a reputation feedback system in which only aggregates of traders' historical behaviors are available. Many research works focused on how to more accurately characterize traders' natures and affect traders' behaviors via scoring/rating systems. Ekmekci (2011) studied a product choice game between a long-lived seller and an infinite sequence of buyers, in which mappings of all past signals are provided to buyers. Liu and Munro (2012) proposed an analytical model that could classify and measure different reputation systems in the same context. More related works can be found in (Fouss et al., 2010; Hu et al., 2012). An equal if not more pressing issue in an online marketplace is that sellers' true characters are not known to buyers.

Considerable effort has been spent on the effects of reputation systems on the operations of online markets. Some detailed facts, such as purchase history and post-purchase data, were often considered in these works. Dellarocas (2003) gave an overview of the relevant literature on reputation mechanisms based on the repeated-game setting. Bakos and Dellarocas (2002) studied a trading system involving a single seller who repeatedly trades with buyers. Zhu and Zhang (2010) studied impacts of consumer reviews and ratings across products in a common category using data from the video game industry. Sun (2012) focused on the roles played by ratings' variances on demand. A few works, e.g., (Horner, 2002; Utz et al., 2012; Wolitzky, 2011), also considered practical problems ranging from sellers' identity changes to buyers' failures to leave feedbacks. Einav et al. (2016) discussed P2P markets from a broader view that envelops elements including search and matching algorithms, pricing, reputation systems, and regulations.

With the advent of various online P2P platforms, more practical investigations on reputation and feedback systems have appeared. Horton and Golden (2015) and Zervas, Proserpio, and Byers (Zervas et al., 2015) demonstrated significant ratings inflations in online markets such as Airbnb. Tadelis (2016) summarized problems with reputation systems and discussed ways to improve their practical designs. Grewal, and Holtz (Fradkin et al., 2017) showed how additional incentives for reviewing can improve information aggregation. Interested readers may also refer to works such as Dellarocas (2005) and Dellarocas and Wood (2008) on adaptations from biased public feedbacks and/or from silence (missing feedbacks), and to Chang et al. (2014), Whitby, Jsang, and Indulska (Whitby et al., 2005), and Xu, Hu, and Sang (Xu et al., 2007) on removals of unfair and malicious ratings. Instead of addressing the existing problems with reputation systems, our research aims at understanding the values of reputation systems and ways to unleash their potentials.

The two enabling features of our model are the nonatomic-game (NG) setup and the bounded-rationality assumption for players. NGs are often easier to analyze than their finite counterparts, because in them, the action of an individual player has no impact on payoffs and future state evolutions of the other players. Therefore, they are often used as proxies of real competitive systems in economic studies; see, e.g., Aumann (1964) and Reny and Perry (2006). Systematic research on NG started with Schmeidler (1973). Subsequently, Mas-Colell (1984), Khan, Rath, and Sun (Khan et al., 1997), Kalai (2004), and Al-Najjar (2008) all made valuable contributions to the subject. NGs' intimate connections with their actual finite-player counterparts have been gradually revealed; see, e.g., (Green, 1984; Housman, 1988; Yang, 2011, 2017). Leading online