European Journal of Operational Research 249 (2016) 417–426

Contents lists available at ScienceDirect

European Journal of Operational Research

journal homepage: www.elsevier.com/locate/ejor

Instance-based credit risk assessment for investment decisions in P2P lending

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ARTICLE INFO

Article history:
Received 17 January 2014
Accepted 20 May 2015
Available online 29 May 2015

Keywords:
Data mining
P2P lending
Credit risk assessment
Instance-based method
Investment decisions

ABSTRACT

Recent years have witnessed increased attention on peer-to-peer (P2P) lending, which provides an alternative way of financing without the involvement of traditional financial institutions. A key challenge for personal investors in P2P lending marketplaces is the effective allocation of their money across different loans by accurately assessing the credit risk of each loan. Traditional rating-based assessment models cannot meet the needs of individual investors in P2P lending, since they do not provide an explicit mechanism for asset allocation. In this study, we propose a data-driven investment decision-making framework for this emerging market. We designed an instance-based credit risk assessment model, which has the ability of evaluating the return and risk of each individual loan. Moreover, we formulated the investment decision in P2P lending as a portfolio optimization problem with boundary constraints. To validate the proposed model, we performed extensive experiments on real-world datasets from two notable P2P lending marketplaces. Experimental results revealed that the proposed model can effectively improve investment performances compared with existing methods in P2P lending.

1. Introduction

Peer-to-peer (P2P) lending, also known as person-to-person lending, allows individuals to directly lend to and borrow from each other on an Internet-based platform, without the involvement of traditional financial intermediaries. In this marketplace, borrowers submit applications for loans, called listings, by specifying loan details, such as loan amount and description. Then, prospective lenders are allowed to fund these listings partially by specifying the loan amounts they will provide. If the total dollar amount requested by a listing is fulfilled within a pre-specified period of time, the listing becomes a loan. Due to the elimination of a traditional financial intermediary, and a more dynamic environment that taps into the collective intelligence of the crowd, P2P lending has the potential to reduce financing costs and increase efficiency of the financial market.

To help personal investors manage risk, state-of-the-art P2P lending platforms, such as Prosper and Lending Club, provide risk ratings for each loan. Such ratings take into account many variables about the loan and the applicant, such as FICO scores, the amounts and terms of the loans, borrowers' assets, debts, types of employment, and so on. This process of credit rating is similar to those traditional evaluation techniques commercial banks employ to evaluate the risk levels of borrowers. As a result, loans are categorized into a small number of risk groups. For example, Prosper uses a seven-level risk rating (i.e., AA, A, B, C, D, E, NR). This "rating-based" model provides basic evaluation of loans' credit risk, and the loans within each rating group are assumed to bear the same level of risk. In order to diversify their portfolios, investors are allowed to pick loans from different risk groups, according to their risk-return preferences.

Rating-based credit risk assessment models are practical and has been widely utilized by financial institutions for issuing loans. However, this model may be too coarse to meet the needs of personal investors in P2P lending. Since traditional financial institutions possess large amounts of cash, they are able to fund millions of loans, which facilitates myriad opportunities for diversification. For P2P lending, each personal investor has much less money for investment. However, because they are allowed to partially fund each loan, effective diversification has been made possible. Therefore, investors in the P2P lending marketplace not only need to decide which loans to fund, but also how much money to allocate to each of them, which minimizes risk for a given expected return. While this feature presents as a typical portfolio optimization problem, it is very challenging to

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http://dx.doi.org/10.1016/j.ejor.2015.05.050
0377-2217/

accurately assess the credit risk of each individual loan for P2P lending, which will serve as necessary input for portfolio optimization. Moreover, real-world P2P lending marketplaces typically impose minimum investment amount constraints. For example, the minimum required investment on each loan is $25 at Prosper. Such constraints are substantial for individual investors in P2P lending, due to their limited amount of total funds. Thus, a new decision making tool is required for lucrative P2P lending.

In this study, we propose a more accurate credit risk model for P2P lending, which allows personal investors to optimize investment decisions. Without enough historical data of closed loans for each individual borrower, it is impossible to predict the performance of new loans based on a borrower's past ones. As a result, we identified past loans with similar attributes, and aggregated performance outcomes to predict the performance of a new loan. This is called an "instance-based" approach.

Specifically, in the proposed instance-based model, we first defined the similarity of loans as the difference between their probabilities to default, which was derived from a logistic regression of borrower's credit attributes. We then predicted the return of each loan as a weighted average of similar loans, and the risk as the weighted variance, where the optimal weights were learned within the mathematical framework of kernel regression. Furthermore, based on this instance-based credit risk model, we formulated the investment decisions in P2P lending as a portfolio optimization problem with boundary constraints. To validate the proposed model, we performed extensive experiments on real-world data from two state-of-the-art P2P lending marketplaces. Experimental results demonstrated that the proposed model effectively outperforms existing rating-based models.

The remainder of this paper is organized as follows. A literature review is performed in Section 2, and a description of the data is provided in Section 3. Section 4 is devoted to describing the instance-based model for credit risk assessment. Combined with a formal formulation of portfolio optimization in P2P lending, Section 5 describes the investment decision model. To better explain the model, an end-to-end example of the instance-based credit risk assessment and investment decision process is provided in the appendix. In Section 6, we report empirical results on effectiveness of the proposed model. Finally, Section 7 concludes this work.

2. Literature review

P2P lending has been introduced as a new e-commerce phenomenon in the financial field for its potential to provide more economical efficiencies, as supported by an Internet-based information system (Berger & Gleisner, 2009; Wang, Greiner, & Aronson, 2009). P2P lending is also known as online social lending (Hulme & Wright, 2006), microlending (Conlin, 1999) or crowdfunding (Belleflamme, Lambert, & Schwienbacher, 2014; Mollick, 2014), each of which emphasizes a different set of unique characteristics of P2P lending. Namely, the online social interactions among participants, the small amounts of transactions, and the large number of investors who may not be experts in loan investing.

Participants in the P2P lending marketplace can be roughly divided into two groups: borrowers and lenders. Like traditional credit marketplaces, risk assessment and decision making can be viewed from their different perspectives (Wu & Hsu, 2012). From the borrower's perspective, a common goal is securing loan funding. Among all the information provided by the borrower, researchers aim to find determinants of the success of a loan. For instance, Larrimore, Jiang, Larrimore, Markowitz, and Gorski (2011) analyzed the impact of language used in the listing, which can help borrowers strengthen persuasiveness for getting funds. Puro, Teich, Wallenius, and Wallenius (2010) proposed a borrower decision aid system to help borrowers quantify their strategic options, such as starting interest rate and the amount of loan to request, in order to have their listings successfully funded. In spite of a focus on borrower's decisions, their models may also be adapted for lenders, aiming for predicting loans' pay-back statuses. Specifically, they formulate a query-based approach, which looks for similar listings in the past to make an overall prediction for a new listing. They report that this technique is equivalent to the logistic regression model in most cases, but may become less stable when only a small number of similar loans can be found. Instead of identifying similar loans in the past, our framework of instance-based model uses all loans in the past, and optimize their weights through kernel regression. Other works in borrower decision support include Wu and Xu (2011), which proposes an intelligent agent system that make recommendations to the borrowers. With a focus on system design rather than analytical modeling, their work is not being compared with ours.

When considering the lenders' perspective, researchers investigate lender's investment decision making and bidding behavior. For example, Sonenshein, Herzenstein, and Dholakia (2010) examined the roles of social accounts in influencing lenders' decisions about lending money to borrowers. Klafft (2008) examined whether lenders can profit from this new market as claimed. Based on data from Prosper.com, they found that it is possible for lenders to achieve satisfactory returns if they employ a sound strategy. Moreover, Krumme and Herrero-Lopez (2009) found that many transactions are based upon sub-optimal decisions. Puro, Teich, Wallenius, and Wallenius (2011) provided bidding strategies in the context of small loan auctions. Their study showed that bidding behavior is not homogeneous among bidders, but bidders use many different bidding strategies. It has been found that investors are more likely to bid on loans with more existing bids (Herzenstein, Dholakia, & Andrews, 2011). This phenomenon is known as herding, and is commonly observed in online social loan auctions. Existing studies provide valuable insights into how lenders screen and select loans, and succeed in bidding. However, effective decision support is lacking to guide personal investors' selection of investments, and determination of optimal amounts to put forward in each of them.

Since making decisions on whether or not to fund certain loans is a central task for investors in the P2P lending marketplace, traditional loan evaluation techniques also relate to P2P lending. In order to distinguish good loan applications (i.e., those expected to be successfully paid back) from bad ones (i.e., those predicted to default), many different data mining techniques have been used in the literature. A number of examples include logistic regression (Thomas, 2009; Wiginton, 1980), linear discriminate analysis (Rosenberg & Gleit, 1994), *k*-nearest neighbors (Chatterjee & Barcun, 1970), classification trees (Feldman & Gross, 2005), Markov chains (Frydman, Kallberg, & Kao, 1985; So & Thomas, 2011), survival analysis (Andreeva, Ansell, & Crook, 2007; Stepanova & Thomas, 2002), linear and nonlinear programming (Bugera, Konno, & Uryasev, 2002; Mangasarian, 1965), neural networks (Malhotra & Malhotra, 2002; Yang, Li, Ji, & Xu, 2001), support vector machines (Huang, Chen, Hsu, Chen, & Wu, 2004; Kim & Sohn, 2010), genetic methods (Desai, Conway, Crook, & Overstreet, 1997; Huang, Tzeng, & Ong, 2006), and so on. These studies examine the classification of each loan, but do not scrutinize loan investment portfolio as a whole.

In recent years, kernel methods have been broadly applied in many credit scoring and optimization problems (Yang, 2007; Zhang, Gao, & Shi, 2014). In this study, we exploit the mathematical framework of the kernel regression (Nadaraya, 1965) and extract the regression coefficients as the optimal weights for credit risk assessment. As a flexible statistical technique to study nonlinear relationships, kernel regression is increasingly utilized in many financial and economical studies, such as nonparametric VaR measurements (Aıt-Sahalia & Lo, 2000), nonlinear relationships between international real interest rates (Mancuso, Goodwin, & Grennes, 2003), and time-varying diffusion processes for forecasting financial