Systemic Risk in P2P Lending Systems: An Ontological Exploration

Jiaqi Yan, Department of Informatics, University of Zurich

Daning Hu, Department of Informatics, University of Zurich

Yani Shi, School of Economics and Management, Southeast University

Abstract

Peer-to-peer (P2P) lending is a new type of online financial service directly connect individuals who want to borrow money to those who want to lend it. This mechanism has reduced the liquid risk and bankruptcy concerns of the platforms, and the platforms have few connections with each other in P2P lending systems. Therefore, essentially few attention was given to the possible contagion effects on the stability of the P2P lending system as a whole. However, with the evolution of P2P lending, a huge variety of P2P lending models has emerged to meet different needs of borrowers and lenders. For instance, in order to encourage lending in an environment where the credit rating system is underdeveloped, many platforms offered the service of guarantee payments. These platforms take the responsibility for the payment to lenders when default occurs. It has changed the platforms' original role of mere intermediary agency, and increase the bankruptcy risk of the platforms if there isn't adequate fund to repay the lenders in the case of default. These evolved P2P lending business models have raised our concerns of contagion risk in P2P systems. In this paper, we present a broad examination of the systemic risk in the P2P lending system from an ontological exploration. By identifying the entities and their relationships in the P2P lending system, we aim to analyze the potential causes of an initial shock in P2P lending, how the shock can propagate and contagion within the financial system.

Keywords: P2P lending, ontology, systemic risk, bankruptcy of P2P platforms

Introduction

Peer-to-peer (P2P) lending is a new type of online financial service directly connect individuals who want to borrow money to those who want to lend it. Compared with the traditional commercial banking system, the online lending system has different characteristics of risk control and management. In the original online lending model, the loan transaction is directly completed by the connected borrowers and lenders, and the platform does not involve in any fund transactions. If borrowers cannot repay back on time and cause a loss to lenders, the platform will not be responsible for any compensation. This mechanism has reduced the liquid risk and bankruptcy concerns of the platforms, and the platforms have few connections with each other in P2P lending systems. Therefore, essentially few attention was given to the possible contagion effects on the stability of the P2P lending system as a whole.

However, with the evolution of P2P lending, a huge variety of P2P lending models has emerged to meet different needs of borrowers and lenders. For instance, in order to encourage lending in an environment where the credit rating system is underdeveloped, many platforms offered the service of guarantee payments. These platforms take the responsibility for the payment to lenders when default occurs. It has changed the platforms' original role of mere intermediary agency, and increase the bankruptcy risk of the platforms if there isn't adequate fund to repay the lenders in the case of default. We have also witnessed the involvement of third-party guaranty institutions in the P2P market. These guarantee companies work as partners with the P2P lending platforms and provided guarantees for the platforms, which have in turn connected the platforms with common guarantee fund sources. These connections and the exposed bankruptcy risk of the P2P platforms have raised our concerns of contagion risk in P2P systems.

To study the systemic risk in P2P lending systems, an important challenge is to better understand the dynamics and complexities of the business models and the interaction between stakeholders in the P2P lending domain, as the analytical underpinning for studying the financial instability of P2P lending systems. In this paper, we present a broad examination of the systemic risk in the P2P lending system from an ontological exploration. By identifying the entities and their relationships in the P2P lending system, we aim to analyze the potential causes of an initial shock in P2P lending, how the shock can propagate and contagion within the financial system. The rest of the paper is organized as follows: we review the literature background of online P2P lending and systemic risk management in the next section. Section 3 present the ontologies of the P2P lending system. Section 4 discusses future research directions.

Background

Extensive studies have been carried out to investigate the risk management in online P2P lending, most of which are based on Prosper's data. As the loans are not collateralized in Prosper, lenders bear the full risk in the case of default. Thus, prior studies on risk in online P2P lending have focused on the loan default. Three categories of determinants of default risk were proposed: loan characteristics, borrower characteristics, and instrument (Everett 2008). Since information asymmetry of loans and borrowers is the major barrier for the lender to reduce the default risk (Freedman et al. 2011), several studies focused on how to mitigate information asymmetry between borrowers and lenders in the lending process. Factors that could potentially help such as borrowers' credit scores (Iyer et al. 2009), borrowers' demographic information (Kumar 2007), borrowers' social network (Lin et al. 2013), information of loan listing (Puro et al. 2010) are discussed. Investment recommendations are presented from a portfolio perspective with risk management (Zhao et al. 2014). As most of the data source come from individual P2P platform like Prosper, these studies provide a perspective of risk management in the online lending model that Prosper or the other studied platform represents.

Wang et al. (2015b) summarized 9 types of risks in the online lending industry: the risks of credit check, the risks of intermediate account, the risks of guarantee payment, the liquidity risk, the transparency risk, the technical risk, the legal risk, the leverage risk of lenders, and the ethical risk. As we can see from the literature review, most of the current studies on risk management in online P2P lending focus on risks associated with the borrowers' default, by studying some individual lending platform. There is a lack of research on the risk of the P2P lending system as a whole.

Systemic risk refers to the propagation of an agent's economic distress to other agents linked to that agent through financial transactions (Rochet et al. 1996). The most classic example of systemic risk is within the banking system, which can be found in the 2008 financial crisis. It was triggered by a rise in subprime mortgage defaults, causing liquidity shortfall in the United States banking system. It resulted in the bankruptcy of several large financial institutions such as Lehman

Brothers, pushing the banking system to the brink of a system-wide collapse. More than 160 U.S. banks failed in 2008 and 2009, while only 11 banks failed between 2003 and 2007. Because contagious bank failures are very rare in real-world banking systems, there is little empirical data available and simulation methods become the most popular research approach for studying systemic risk (Elsinger et al. 2006; Giesecke et al. 2011; Haldane et al. 2011; Schweitzer 2009).

As Farmer et al. (2009) proposed, in the modeling and analysis of systemic risk, agent-based modeling should be used to computerized simulate a number of decision-makers (agent) and institutions, help to evaluate policies designed to manage the systemic risk and foster economic recovery. Along with this call of agent-based modeling, we find recent studies of systemic risk of financial systems focus on modeling the economic agents' behavior in the financial network (Chen et al. 2013; Chen et al. 2014; Hu et al. 2012). Conceptual modeling and ontological research of the financial system provide foundations for such studies to understand and model the agents' behavior in the various stress testing scenarios. This motivates us to provide an ontological analysis of the P2P lending system for the systemic risk management.

Ontologies of P2P Lending

In order to identify and examine the systemic risk in P2P lending, we develop a set of ontologies to represent the relevant knowledge of P2P lending. The ontological framework consists of three level: the top level, the domain level, and the instance level. The top level ontology contains Actor, Goal, Activity, and Resource as the four major meta-classes: Actor models a financial institution or individual with some goals, possesses resources and carries out activities according to the principles of rationality; Goal represents an actor's strategic interests that refer to the actor's motive or desire state; Activity represents the particular course of action that can be executed for satisfying a goal; Resource represents a physical or an informational entity that the actor possesses. In addition, we define static, dynamic, intentional, and social ontologies to provide a broad knowledge representation of the P2P lending domain.

Definition 1: Ontologies of P2P Lending: Ontologies of P2P Lending is defined to be a set of constraints, which declare the entities and entities' relationships in P2P lending, $O = \{c \mid c$ is a constraint declaring the entities and their relationships$\}$.

Definition 2: Constraint Metadata: For each constraint $c \in O$, its metadata is defined as a four tuple $<cid, TY, P, H>$, where cid is the unique identifier of the constraint. $TY \in$ {static ontology, dynamic ontology, intentional ontology, social ontology}; P is the premise of the constraint; H is the conclusion of the constraint.

The static ontology defines the basic hierarchy relation and static property of the classes. Every entity in the P2P lending domain can be an instance of these meta-classes. Take actor for example, since the borrower and lender are connected through the P2P lending platform, it is obvious that domain classes of actors can be represented by these roles, such as "lender" and "platform" as shown in Fig. 1. These actors in the domain level will be further categorized into subclasses to differentiate their roles for the systemic risk management. For instance, the P2P lending platform can be classified according to their business models, such as the platform with Risk Guarantee Fund (RGF) and the platform with Risk Reserve Fund (RRF). The platforms in the real-world P2P industry correspond to the instances and inherit the of domain classes of platform. For example, RenRenDai, a P2P lending platform in China possessing 130 million Risk Reserve Fund (RRF), is an instance of the platform with RRF.

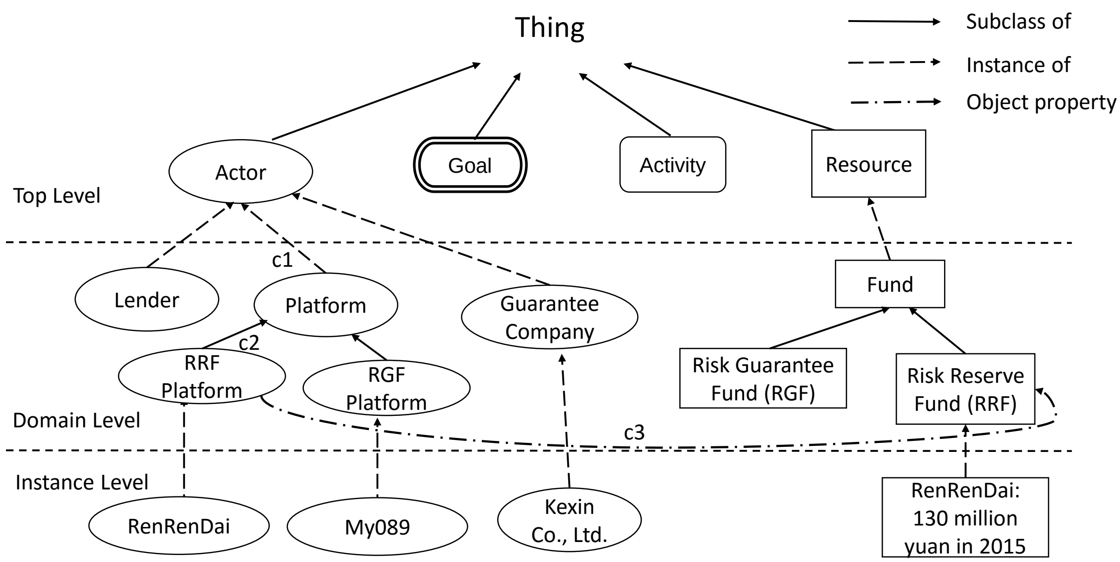

Fig. 1. A Portion of Static Ontology

Besides the graphic representation, ontologies can also be represented as constraints in first-order logic according to Definition 1 and 2. For instance, "a Platform is an instance of Actor" can be represented as c1: Platform ∈ Actor. To explain the metadata of this constraint, c1 is the unique identifier, TY=static ontology. Because this constraint states a fact in the P2P lending domain, "Platform ∈ Actor" is the conclusion of the constraint with the premise of true. Similarly, we can have other constraints represented: c2: RRFPlatform ⊂ Platform; c3: Possess(RRFPlatform, RRF); c4: RenRenDai ∈ RRFPlatform. The first-order logic facilitates the logical inference and computation. For example, because an RRFPlatform possesses some RRF, and RenRenDai is an RRFPlatform, we can infer that RenRenDai should have possessed some RRF based on the inheritance and polymorphism of the ontology.

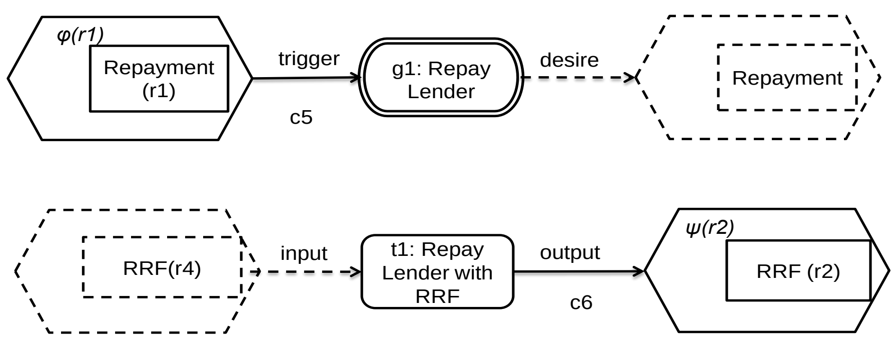

Fig. 2. A Portion of Dynamic Ontology

The dynamic relation defines the dynamic relation of resource's properties with activity and goal: The properties of resources that will trigger the goals and the properties of resources after carrying out activities. For example, the goal of "repay lender" (represented as g1) is triggered by the properties of "repayment" (we represent the resource of repayment as r1, and the property of r1 as $\varphi(r1)$). The properties of "repayment" may include the information such as deadline or amount. This constraint can be represented as c5: $\varphi(r1) \Rightarrow$ g1, in which $\varphi(r1)$ is the premise of the constraint while g1 is the conclusion. Similarly, to repay lender with RRF (represented as t1) will change the properties of repayment and RRF (i.e., the amount of RRF will be changed, as well as the deadline and amount of the repayment). We can represent the constraint of the activity of "repay lender with RRF" will change the properties of RRF as c6: t1 $\Rightarrow \psi(r2)$.

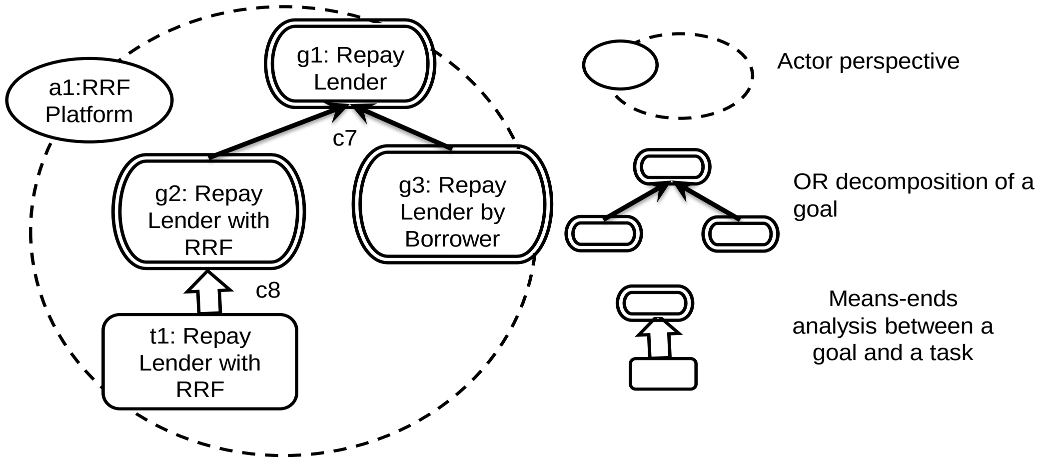

Fig. 3. A Portion of Intentional Ontology

The intentional ontology models the actor's motivations – what the actor desires or intends to do. For example, some goals of the RRF Platform (represented as a1) can be graphically represented as in Fig. 3. The goals can be further broken down into sub-goals by AND/OR decompositions. For instance, the goal of "Repay Lender" can be decomposed into "Repay Lender with RRF" (represented as g2) or "Repay Lender by Borrower" (represented as g3), which can be represented by constraint c7: g1$\Rightarrow$ g2 $\vee$g3. Means-ends analysis can be used to connect the actor's goals and activities. For instance, the goal of "Repay Lender with RRF" can be achieved by carrying out the task of "Repay Lender with RRF" (represented as t1), which can be represented as a constraint c8: (a3, g4) $\Rightarrow$ t1.

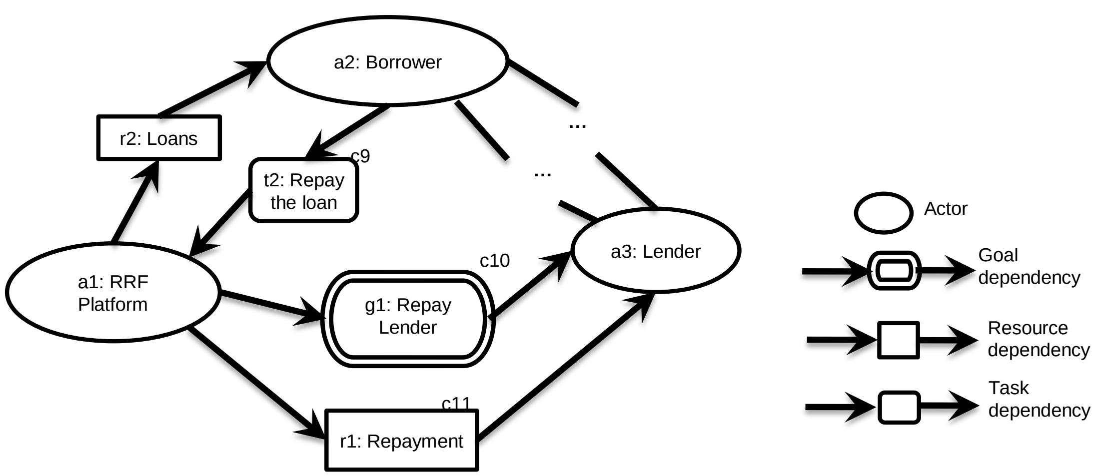

Fig. 4. A Portion of Social Ontology

The social ontology describes the social structure and interactions between actors. Three types of relationships are defined: goal dependency, activity dependency and resource dependency. For example, the RRF Platform (a1) relies on Borrower (a2) to repay the loan (t2), represented as c9: t2⊆a1 ×a2; The Lender's (a3) goal "repay lender" (g5) relies on the RRF Platform (a1), represented as c10: g1⊆a1×a3; The Lender (a3) has the resource of "repayment" (r1) depended on the RRF Platform (a1) (#r1⊆a3 ×a1), while the Borrower (a2) has the resource of "loans"(r2) depended on the RRF Platform (a1) (#r2⊆a2 ×a1).

Future Research

We plan to conduct a multi-agent simulation based on the proposed ontologies to identify and examine the systemic risk in the Chinese P2P lending industry. The simulation builds on the works of (Hu et al. 2014; Hu et al. 2012), which analyze the systemic risk through simulating the financial network. To do so, we will build the ontologies of Chinese P2P lending systems with real-world data and simulation data. Based on the computation and inference of the ontologies, we explore the inter-platform relationships and build the network of P2P Lending platforms. To explore the inter-platform connections based on our proposed computable ontology, we classify the financial institutions in the P2P to build the domain level ontology, including platforms and other guarantee and insurance institutions, according to the recent survey of business models in the Chinese P2P lending industry (Wang et al. 2015a). We are designing methods to simulate the lenders and borrowers based on the public available data of the platforms, including transaction volume, registered users, borrowing amount, top 10 lenders' transaction, unpaid loan volume, etc. Based on the built ontologies, the computational algorithm proposed in (Hu et al. 2014) can be used to model the interactions of stakeholders in various stress testing scenarios, which provides a foundation to explore the inter-platform relationships.

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