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Federated Risk-Based Access Control Model for P2P Lending Platforms: A Multi-Agent Systems (MAS) Approach

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Abstract

This study addresses the inherent risk management challenges in decentralized finance, particularly for peer-to-peer (P2P) lending platforms. We propose a novel framework that leverages a Multi-Agent System (MAS) to establish a collaborative network encompassing loan originators, investors, regulators, and service providers. This distributed approach facilitates federated risk management, where risk assessment and mitigation responsibilities are shared across these entities. The MAS employs a comprehensive nine-factor assessment (detailed in Table 5) to evaluate industry risk profiles, considering industry environment, competition, and internal capabilities. This data is further visualized using a color matrix (Tables 5 & 6) and utilized alongside state diagrams (Figure 2) to depict the workflow and manage tasks within the P2P lending process. Additionally, the MAS informs a novel Federated Risk-Based Access Control (FRkBAC) system that tailors access permissions (lending origination, disbursement, etc.) based on dynamic risk assessments of industry trends and individual borrower profiles. This data-driven approach fosters trust within the P2P ecosystem and represents a significant advancement in decentralized finance risk management compared to traditional methods.

Keywords:

P2P Lending;

Multi-Agent Systems (MAS);

Federated Risk Based Access Control (FRkBAC).

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1- Introduction

P2P lending operators in Malaysia are mandated to be legally incorporated entities under the Malaysian Companies Act 1965, with a minimum paid-up capital requirement of RM5 million. Before they can start operations, these operators must provide proof to the Securities Commission (SC) Malaysia that they meet the specific criteria set out in SC regulatory guidelines. This includes evaluating the suitability of the operator's board of directors, their ability to maintain an organized, fair, and transparent marketplace, and having the necessary information technology infrastructure in place.

The inherent risk on digital platforms, due to the absence of deposit security measures, increases the vulnerability of potential depositors and amplifies concerns about possible defaults. In the realm of P2P platforms, it is evident that depositors would shoulder a significant portion of the risk, with issues such as default rates and transparency of credit rating methodologies contributing to an investor's uncertainty. In a growing economy like Malaysia, these uncertainties create significant hurdles in attracting more investors to digital financial technology (FinTech) platforms. The lack of deposit security measures on these FinTech platforms heightens the sense of risk and vulnerability among potential investors. Recent financial scandals, such as those involving Enron, Madoff Investment Securities, and WorldCom, have further diminished trust in the financial sector, as indicated in the Edelman Trust Barometer report (see Table 1). Data

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from this report, covering the years 2011 to 2022, consistently ranks the financial services sector, including banking, as the least trusted among the eight industries surveyed. Despite a modest increase in trust from 37% in 2011 to 56% in 2022, this sector's improvement is relatively minor compared to other industries. This context sets the stage for a critical analysis of P2P lending platforms in Malaysia, as summarized by *iMoney* [1], which provides insights into the operational and regulatory challenges faced by these platforms in a dynamically changing financial landscape. Unlike traditional banks, P2P platforms do not directly assume credit risk; instead, they calculate credit default risk using proprietary formulas that are not disclosed publicly [2]. The instability of such platforms is underscored by the collapse of hundreds of P2P lending platforms in China since 2013, with fraud often cited as a contributing factor, highlighting significant risks for [3].

Table 1. Edelman and Trust Report on Trusted Industries (2011 to 2022)

Sectors	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*
Technology	68%	79%	73%	79%	78%	74%	75%	75%	78%	75%	68%	74%
Food & Beverage	65%	64%	62%	66%	67%	64%	66%	66%	69%	67%	65%	68%
Consumer Packaged Goods	47%	62%	60%	65%	66%	61%	63%	61%	65%	62%	60%	61%
Telecommunications	38%	60%	60%	60%	63%	60%	63%	64%	67%	65%	61%	64%
Automotive	55%	66%	66%	70%	71%	60%	65%	63%	69%	67%	60%	66%
Energy	45%	53%	57%	59%	60%	58%	62%	63%	65%	63%	59%	62%
Healthcare	56%	56%	57%	59%	61%	53%	53%	65%	68%	67%	66%	69%
Financial Services	37%	45%	46%	48%	54%	51%	54%	55%	57%	56%	52%	56%

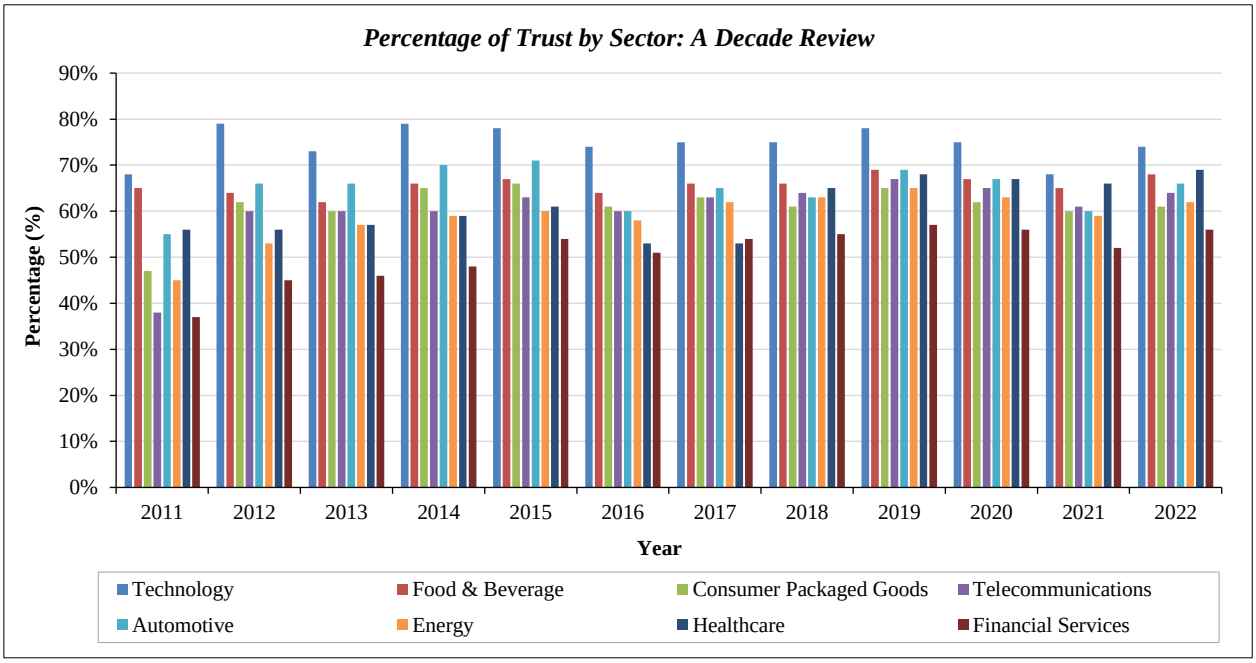

Figure 1. Edelman and Trust Report by Sector from 2011 to 2022

In Malaysia, the first instance of a P2P lending platform default occurred in August 2018, primarily attributed to a slowdown in SME business activities, which resulted in failed repayments to the platform, as reported by Funding Society Malaysia [4]. Although Funding Society Malaysia reports a default rate of 1% or lower, isolated delinquency events continue to generate investor apprehension regarding potential capital impairment. In research conducted by Gonzalez [5], the author identified trust-enhancing heuristics, emphasizing the need for advanced technologies to aid in monitoring and recovering bad loans.

Additionally, a study on the impact of reputation on Chinese P2P platforms revealed that it both directly and indirectly investors' decisions, indicating the significant influence of platform credibility on investment choices [6]. The research findings indicated that the reputation of P2P lending platforms significantly affects investor decisions, both directly and indirectly [7]. While so, Rosavina et al. [8] explored the factors influencing SMEs' adoption of P2P lending platforms for securing loans. The aforementioned research underscores the centrality of trust in fostering SME engagement with P2P lending platforms. While both banks and P2P lenders fulfill the core function of debt provision, trust constitutes a critical, yet frequently inadequate, element within the P2P sector, as evidenced in Thakor et al. [9]. This lack of trust continues to impact the growth and acceptance of P2P lending among potential users.

2- Literature Review

Small and medium enterprises (SMEs) increasingly rely on peer-to-peer (P2P) lending platforms to bridge their persistent funding gaps. Research suggests a significant funding shortfall for micro-SMEs, estimated at approximately $21.5 million in 2019 [10]. P2P lending offers a convenient alternative, with retail investors constituting the primary source of funds. This reliance on retail participation has grown demonstrably, rising from 88% in June 2019 to 95% by December of the same year [10]. However, despite its remarkable growth, online P2P lending remains a subject of debate among researchers, investors, and policymakers. Critics highlight potential drawbacks such as information asymmetry, inadequate credit assessment processes, and elevated default risks, which can deter investor participation [11].

While acknowledging these inherent risks associated with online P2P transactions, several studies have emphasized the platform's potential for efficient financial resource allocation. Compared to traditional credit mechanisms, online P2P lending offers advantages such as efficient capital allocation, competitive interest rates, and reduced transaction costs [12]. Given the increasing importance and widespread adoption of online P2P lending, a critical analysis of the factors influencing investor participation within this online market ecosystem is warranted. Research on P2P lending platforms in Malaysia reveals several key findings. A crucial issue identified by Nguyen et al. [13] is the limited awareness of these platforms among both the general public and young adults. Misconceptions regarding risk, investor protection, and a lack of prior investment experience act as significant barriers to adoption [14]. Focusing on trust and usage intention among retail investors, a study by Rabbani et al. [14] highlights income and privacy concerns as determinants of trust, while reciprocity, perceived usefulness, and ease of use play a crucial role in influencing usage intention. Collectively, these findings emphasize the need for Malaysian P2P platforms to prioritize awareness campaigns and trust-building initiatives. Studies conducted within the Malaysian context also highlight a knowledge gap regarding P2P lending, even amongst individuals with a relatively high degree of financial literacy [13]. Research by Alfian [1] further emphasizes this point, demonstrating that loan characteristics such as credit rating and borrower stage can significantly impact interest rates, even for seemingly comparable loans. This underscores the importance of enhancing knowledge and understanding of P2P lending, particularly among potential investors. The factors influencing lending decisions on Malaysian P2P platforms have also been explored. Building upon prior research [2, 13] examined the relationship between interest rates and various risk factors, including credit rating, industry, borrower stage, loan purpose, and duration. These findings offer valuable insights for both investors and borrowers, shedding light on the potential risks and rewards associated with P2P lending in Malaysia. While a growing number of investors are utilizing P2P platforms, a significant knowledge gap and concerns regarding trustworthiness persist [13]. However, the platform offers a streamlined avenue for both investors and borrowers to achieve financial goals. As financial literacy continues to improve in Malaysia, future generations stand to benefit significantly from this innovative financial tool. It is important to note that the reference to [15] may not be directly relevant to the Malaysian context, as it focuses on a study conducted in the United States. Further research exploring the specific loan purposes influencing investment decisions within the Malaysian P2P market would be valuable.

Table 2. Peer to Peer lending platform in Malaysia

Name	Default Rate	Minimum Investment	Fees	Average Net returns
Capbay	<0.1%	RM10,000	10% to 30% of interest earned	8.2% p.a.
CapSphere	0%	RM200 initial deposit RM50 per campaign	1 to 2% of monthly repayments	Not Stated
QuicKash	1.34%	RM100	1.35% - 1.50% per repayment	Not Stated
B2BFinPal	3.15%	RM1,000 initial deposit RM100 per campaign	30% of interest earned	10.9% p.a.
Funding Societies	3.27%	RM100 initial deposit RM100 per campaign	- Business term financing: 2% p.a. of each repayment - Accounts receivable financing: 15% of interest earned - Accounts payable financing: 30% of interest earned	Not Stated
Fantastic	8.72%	RM2,000 initial deposit (if using the "Smart Invest" feature); otherwise, no initial deposit is required, RM50 per campaign	- Monthly repayments: 2% of repayment amount - Bullet repayments: 1% of repayment amount	27.88% since 2017
Alixoco	2.59%	RM500	0.35% to 2% of repayment	12% p.a.
MicroLEAP	0%	RM50	2% of the first monthly repayment of each campaign	Not Stated
Nusa Kapital	not stated	RM500	10% of returns	Not Stated
Money Save	not stated	RM5	Up to 15% of interest payment; up to 50% on prepayment	Not Stated
Co-founder	not stated	RM1,000 initial deposit, RM100 per campaign	- For investments that are 12 months or under 20% of interest - For investments that are over 12 months: 2.0% p.a. on principal	Not Stated

In a similar study, Xia et al. [16] highlights debt consolidation as the most common lending purpose, while small business and moving are considered riskier loan purposes. They emphasize that loan purpose, in conjunction with demographic variables and solvency, plays a pivotal role in predicting the probability of default (PD) and annualized rate of return (ARR). According to Xia et al. [16], the borrower's lending purpose is crucial for investors in determining which loans are more likely to attract their investment, thereby influencing lending decisions in P2P platforms. Several significant conclusions have been made from research on P2P lending systems in Malaysia. The limited knowledge of these platforms among Malaysian adults and young adults, respectively, is brought to light by Nguyen et al. [13]. Misconceptions regarding the risk and investor protection of the platforms, as well as a lack of prior investing expertise, are blamed for this lack of information. While so, Rabbani et al. [14] concentrate on the trust and usage intention of retail investors; income and privacy are important factors in determining trust, while reciprocity, utility, and convenience of use are important factors in determining usage intention. The aggregate findings of this research highlight the necessity for P2P lending platforms in Malaysia to up their game in terms of awareness and trust-building. Studies conducted in Malaysia on peer-to-peer lending platforms indicate that the general public and young adults are not well-informed about them [13]. Despite this, individuals in Malaysia possess a high degree of financial literacy [13]. Research has also been done on the possible risk exposures for individual investors on these platforms [17]; the results show that loans with comparable credit ratings and company phases might have varied interest rates [13].

These studies all seem to point to the necessity of raising knowledge and comprehension of P2P lending platforms in Malaysia, especially among prospective investors. Lending decisions made in Malaysia on P2P platforms are influenced by a variety of variables. Research from Rabbani et al. [14] discovered that the possibility of lending is highly influenced by loan tenure, age, and financing purpose. As for Nguyen et al. [13], the study conducted additional research on these platforms to examine the correlation between interest rates and risk characteristics, including credit rating, industry, company stage, purpose of loan, and length. Both investors and borrowers can benefit from these results, which offer insightful information on the possible risks and rewards of peer-to-peer lending in Malaysia. In 2016, Malaysia became one of the first countries in Southeast Asia to regulate P2P lending. The Securities Commission Malaysia (SC) took proactive steps to introduce guidelines to govern P2P lending. The regulatory framework was designed to protect the interests of all parties involved and to ensure the stability and integrity of the financial system. These regulations mandated that all P2P platforms must be officially licensed and regulated by the SC. They outlined criteria for both investors and borrowers, specified the types of allowable investments, and introduced rigorous requirements for risk disclosure, making the platforms more transparent and reliable [17]. Table 2 summarizes P2P lending platforms in Malaysia [1].

Peer-to-peer (P2P) lending fundamentally involves investors financing individuals and businesses through online platforms, offering an alternative to traditional banking systems with their stringent lending criteria [1]. P2P lending often yields higher returns than conventional investments, though it carries a greater risk for investors. P2P platforms determine interest rates based on the borrowers' risk profiles, similar to traditional banks [1]. However, banks are more focused on minimizing risk in their loan approvals due to the regulatory requirements to maintain a capital reserve between 5% to 20%, ensuring they can cover short-term expenses like customer withdrawals [18]. The success of the P2P lending model will significantly contribute to the financial ecosystem in Malaysia by:

- ***Increasing Access to Finance***: SMEs and other underserved segments have benefited from easier access to funds.
- ***Promoting Financial Inclusion***: By allowing a broader range of investors to participate, P2P lending has helped to democratize finance.
- ***Innovating Financial Solutions***: P2P platforms continue to innovate with technology-driven solutions like automated risk assessments and blockchain for increased transparency and security.

3- Defining Industry Risk Scale

In our study, we examined 807 investment notes from 25 industries represented on P2P lending platforms in Malaysia (see Table 3). They are namely Funding Societies, Capsphere, Alixco, microLEAP and Cofundr as well as drawing upon insights gained from market review. Following that, table 4 highlights the level of risk associated with a particular industry.

Six distinct risk scales, ranging from very low risk to very high risk is conceptualized for MAS computation. Each risk level is accompanied by specific criteria designed to facilitate the accurate assessment of the industry's risk profile. This approach aids in precisely categorizing the varying degrees of risk, enabling MAS evaluation. For instance, a "Very Low Risk" scenario occurs when all nine factors are assessed as low risk, typically in a stable and mature industry.

On the other hand, a "Very High Risk" scenario indicates that all nine factors are considered high risk, suggesting a challenging business environment, such as in a declining industry facing an economic downturn, intense competition, and technological risks. The goal is to enable MAS to comprehend and categorize risk exposure based on a

comprehensive assessment thus resulting in Federated Risk-based access control (FR_kBAC) based on inputs from various critical factors before investment actions are carried out on P2P platforms.

Table 3. Investment Notes Evaluated (n = 807)

No.	P2P Represented Industries	Investment Notes Obtained
1	Retail and Trade	17
2	IT and Communication	15
3	Logistics	27
4	Health	8
5	Construction	13
6	Accommodation and Food Services	51
7	Wholesale and Retail; Repair of Motor Vehicles	523
8	Manufacturing	53
9	Professional, Scientific, and Technical Activities	24
10	Services	21
11	Agriculture	6
12	Education	13
13	Administration and Support Services	12
14	Personal Protective Equipment	2
15	Arts, Entertainment and Recreation	3
16	Baby Products	2
17	Service Technology Provider	4
18	Wholesale	4
19	Water Supply, Sewerage and Waste Management	1
20	Installation of Industrial Equipment	1
21	Industrial Products	3
22	Electricity, Gas, Steam and Air-Conditioner Supply	1
23	Real Estate	1
24	Mining and Quarrying	1
25	Others	1

Table 4. Criteria of Each Level of Risk

Level of Risks	Criteria of Risks from Combination
1. Very Low Risk	All of the factors are low risk.
2. Low Risk	Six factors are low risk, and three factors are medium risk.
3. Intermediate Risk	(i) Three factors are medium risk, and one is medium or low risk; or (ii) Two factors are medium risk, and two are low risk; or One factor is high risk, and the other three are any combination of low and/or medium risk.
4. Moderately High Risk	Three of the factors are assessed as high risk, and the other two are medium or low risk.
5. High Risk	Six factors are high risk, and three are medium or low risk.
6. Very High Risk	All nine factors are assessed as high risk.

4- Multi-Agent Systems Proposed Assessment Criteria

A nine-factor assessment approach (see Table 5) was used as a comprehensive method to evaluate the various risks and potential in industries like peer-to-peer (P2P) lending platforms. MAS complex computation is highlighted using a color matrix shown in Tables 5 and 6. The evaluation further uses indicators relevant to the industry's environment, competition, and internal capabilities. Here's how each of the nine factors are computed:

1. **Industry Growth Prospect:** The growth factor assesses the potential for growth within the P2P lending industry. Apart from market size, historical growth rates, projected future growth, and potential for expansion into new markets or demographics.
2. **Sensitivity to Changes in The Macroeconomic Variable:** Sensitivity involves evaluating how changes in macroeconomic variables [19] (e.g., interest rates, inflation, unemployment rates) affect the demand for loans and the default rates on loans. P2P platforms may be particularly sensitive to economic downturns which could increase default rates or reduce the amount of money available for lending.

3. **Bargaining Power of Suppliers:** For a P2P lending platform, suppliers could include financial service providers, data analysis firms, or technology providers. This factor assesses the degree to which suppliers can influence the platform's costs or operations. Limited numbers of data service or technology providers might increase supplier power.
4. **Bargaining Power of Customers / Consumers:** This evaluates the power that borrowers and lenders on the platform exert. High power might be indicated by a high sensitivity of P2P platforms to the demands and preferences of its users regarding interest rates, loan terms, and platform usability.
5. **Competitive Threats:** This factor looks at the level of competition within the P2P lending industry. Analysts would consider the number of active platforms, their market shares, and the aggressiveness of competitive actions (pricing, marketing, etc.). High competitive intensity can drive down margins and increase customer acquisition costs.
6. **Risk of Substitution of Products, Services, and Technologies:** This assesses the risk that other products or technologies could replace P2P lending services. Substitutions could include traditional bank loans, credit unions, or emerging fintech solutions that offer lower rates, better terms, or more convenience.
7. **Industry Complexity:** This factor analyzes the complexity involved in operating within the industry. For P2P lending, complexity might be driven by regulatory requirements, the need for advanced technology to assess credit risk, or the logistical challenges of managing a large number of individual loans.
8. **Industry Barriers to Entry:** Evaluates what obstacles new entrants have to overcome to compete in the P2P lending market. Barriers could include high initial technology development costs, regulatory compliance costs, and the difficulty of establishing a trusted brand.
9. **Industry Life Cycle:** Determines the current stage of the industry's life cycle (startup, growth, maturity, decline). The P2P lending industry might be in the growth stage characterized by rapid changes in market share, technology, and regulations.

Table 5. Definition of Each Level of Risk to Every Factor

Factor	Low Risk	Medium Risk	High Risk
1. Industry Growth Prospect	An established industry where sales are rising over the medium term at **a rate equal to or faster than nominal GDP growth.**	An established industry where sales are **rising between 1% and the rate of nominal GDP** growth over the medium term**, given that nominal GDP growth is greater than 1%.**	Established industry where sales are **either rising by less than 1% or are declining, over the medium term**. This category also includes start-up industries, which may be high growth, with unproven growth records.
2. Sensitivity to Changes in the Macroeconomic Variable	The business **operates in a stable industry with consistent performance,** demonstrating low sensitivity to macroeconomic variables like inflation, and monetary and fiscal policies even in dynamic economic conditions.	The business operates in an industry **with moderate sensitivity to macroeconomic changes**, is able to navigate mild variations in inflation, and monetary and fiscal policies, and employs strategies to adapt.	The **business is at risk due to its sensitivity to macroeconomic changes**, especially in industries prone to cyclical downturns, where inflation, monetary, and fiscal policy fluctuations can significantly impact performance.
3. Bargaining Power of Suppliers	The business enjoys low risk in supplier bargaining power **due to its numerous suppliers,** allowing it to manage relationships with minimal threat of price increases or disruptions.	The moderate risks in supplier bargaining **power suggest a balanced market with reasonable buyer negotiating room**, potential alternatives, and **manageable competition among suppliers.**	The business is at risk due to strong supplier bargaining power, **posing challenges in negotiating agreements and increased risks of supply chain disruptions** or cost increases.
4. Bargaining Power of Customers/Consumers	The business enjoys low risk in customer bargaining power due to its **diverse customer base and unique products/services**, allowing for stable pricing and customer loyalty.	The business operates in a **moderately competitive industry**, where customers influence pricing and terms, and must balance customer satisfaction with profitability through attentive customer management.	The business faces high risk due to strong customer bargaining power, **making it vulnerable to changes in preferences or aggressive negotiation tactics.** Strategies to enhance customer value are crucial.
5. Competitive Threats	Low competitive threats indicate a **stable business environment with minimal challenges from competitors**, characterized by barriers to entry, manageable competition, and low intensity of rivalry.	Medium competitive threats necessitate a **balanced level of competition, necessitating businesses to focus on innovation** and adaptability to navigate the dynamic market landscape.	High competitive **threats pose significant challenges to businesses, including intense rivalry, numerous competitors**, and constant pressure on prices, market share, and overall competitiveness.
6. Risk of Substitution of Products, Services, and Technologies	**No apparent substitution** risk from outside the industry.	**Limited likelihood of substitution risk** from outside the industry.	High risk of prospective **or actual substitution from outside the industry**.
7. Industry Complexity	The business operates in a **low-complex industry,** enabling efficient management, **market adaptability, minimal regulatory requirements,** and minimal value chain challenges.	The business **faces moderate industry complexity, regulatory requirements, and value chain challenges**. It requires flexibility and adaptability to manage routine operations and respond to evolving dynamics.	The business operates in a **complex industry with intricate structures, regulatory requirements, and value chain challenges**, necessitating sophisticated management, strategic foresight, and adaptability to dynamic conditions.
8. Industry Barriers to Entry	Barriers to entry are **high and are effective in limiting competitive entrants.**	Barriers to entry **are limited but partially effective in excluding competitive entrants.**	Barriers to entry are either **very low or non-existent.**
9. Industry Life Cycle	The mature industry**, with stable demand and established market players**, presents opportunities for consolidation and optimization, but companies must prioritize efficiency, differentiation, and diversification.	The industry is **experiencing growth, necessitating companies to scale operations**, manage demand, and protect against new entrants for long-term success.	The **business operates in a rapidly evolving industry with high uncertainty, significant investment,** and market norms, emphasizing innovation, brand recognition, and overcoming initial challenges.

In this assessment, MAS thoroughly analyzes data insights based on nine factors (see Table 5) to evaluate the risks associated with represented industries (see Table 3). Regular monitoring, evaluation, and adaptation of MAS is crucial to ensure its effectiveness and resilience for risk assessment. MAS is designed based on the Finite State Machines (FSM) principle for risk assessment and evaluation. State diagrams depict the transition from one state to another, for example, there are 13 states as depicted in figure 2 which reflects tasks to be completed. The statement "states can be sequentially tagged to tasks" suggests that in state diagrams, states can be associated with tasks or actions that need to be performed when the system is in that particular state.

Scenario 1. Factsheet A vs. Factsheet B

Table 7 provides a comparative analysis of Factsheet A and Factsheet B. Both documents share identical financing notes, MBAP, and a payment term of 120 days. However, they diverge in terms of interest rates. While Factsheet A offers an interest rate of 4.33%, Factsheet B proposes a higher rate of 5.60%. Notably, Factsheet B operates within the consumer electronics sector, known for its elevated competitive risk and growth potential compared to Factsheet A, which belongs to the agriculture industry. Additionally, Factsheet B has a track record of being struck off or winding up, whereas Factsheet A has solely encountered instances of bankruptcy or winding up. Given these considerations, Factsheet B emerges as a high-risk investment opportunity, as indicated by its market positioning, default probability, and industry context. Consequently, the higher interest rate associated with Factsheet B does not constitute an over-promising or under-promising scenario for investors.

Scenario 2. Factsheet C vs. Factsheet D

Table 7 provides a comparison between Factsheet C and Factsheet D, focusing on their financing notes and MBIAP. Both factsheets offer a payment term of 30 days, yet their interest rates vary - 0.85% for Factsheet C and 0.90% for Factsheet D, with a negligible difference of 0.05%. However, the risk profiles diverge significantly between the two. Factsheet C has a history of minor litigation, while Factsheet D's company currently holds multiple outstanding investment notes on the platform, markedly increasing its default risk. The probability of default for Factsheet D is notably higher, ranging from 3.86% to 5.19%, compared to Factsheet C's 1.25% to 2.47%. Furthermore, Factsheet C operates within the Technology, Media, and Telecoms industry, renowned for its competitiveness and robust growth potential, while Factsheet D operates in the Food and Beverage sector, characterized by lower competitiveness and growth prospects. Considering these factors, Factsheet D emerges as a significantly higher-risk investment compared to Factsheet C. The slight difference in interest rates, given these substantial differences in risk, is justified. Therefore, the higher interest rate associated with Factsheet D is reasonable and aligns with the risk profile, ensuring it does not over-promise or under-promise investors.

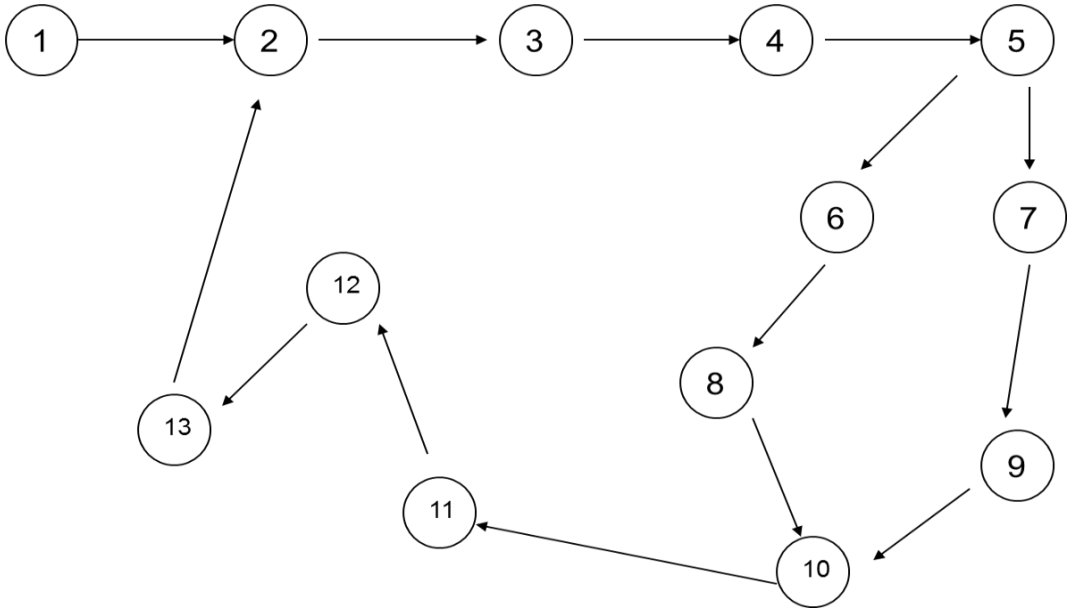

Figure 2. Finite State Machine

This study utilizes state diagrams to illustrate tasks in P2P lending, a risk graph to display varying levels of P2P lending risk, and MAS task delegation policy along with permission-role assignment [20], which we incorporate into the MAS risk ordering relation. Each state represents a progression from one phase to the next; for instance, once state order 1 (S1) is completed, state order 2 (S2) commences. Consequently, the 13 states depicted in Figure 2 correspond to a total of thirteen sequential state orders. Table 6 enumerates all thirteen state orders pertinent to P2P lending platforms.

Table 6. P2P Lending State Orders

State Order	State Name	State Description	Actions	Outcomes
1	Start	The process begins when an investor agent decides to explore P2P lending as an investment option.	Research various P2P lending platforms.	Investor agent gains an understanding of P2P lending and its potential benefits.
2	Research Platforms	The investor agent researches various P2P lending platforms available in the market.	Evaluate interest rates, borrower profiles, platform reputation, and risk assessment methods.	Investor agent identifies platforms that align with their investment goals and risk tolerance.
3	Register	Once the investor agent selects a platform, they register an account.	Provide personal and financial information to create an account.	Investor agent gains access to the platform's features and functionalities.
4	Deposit Funds	The investor agent deposits funds into their P2P lending account.	Transfer funds via bank transfers or designated payment methods.	The investor agent's account balance reflects the deposited funds.
5	Browse Listings	The investor agent browses through loan listings provided by the platform.	Review loan details including borrower profiles, loan purposes, requested amounts, interest rates, and risk grades.	Investor agent identifies potential investment opportunities based on their criteria.
6	Select Loans	Based on their investment strategy and risk tolerance, the investor agent selects specific loans.	Choose loans to invest in and diversify investments across multiple loans.	The investor agent has a diversified portfolio of selected loans.
7	Investment Confirmation	The investor agent confirms their investment choices.	Review and adjust investment allocations if necessary.	The investor agent's investment choices are finalized.
8	Funding Period	The P2P platform aggregates funds from multiple investor agents to fully fund each loan.	Wait for the funding period to end successfully.	Loan reaches its funding goal and moves to the next stage.
9	Funds Disbursement	After the funding period ends successfully, the P2P platform disburses the loan amount to the borrower agent.	Process funding to be disbursed successfully.	The borrower agent receives the funds and begins utilizing them for the intended purpose.
10	Repayments and Returns	As borrowers make repayments, the investor agent receives returns on their investment.	Monitor repayments and returns on the investment portfolio.	The investor agent receives returns in the form of principal and interest payments.
11	Monitor and Reinvest	The investor agent monitors their investment portfolio and may reinvest returns into new loans.	Regularly track repayments, defaults, and overall portfolio performance.	Investor agent makes informed decisions regarding reinvestment or withdrawal of funds based on portfolio performance.

Table 7 outlines the various tasks associated with internal controls over the processing of lending approval tasks on P2P lending platforms. It details different tasks and identifies the associated risks, indicating that certain tasks may necessitate more rigorous scrutiny than others [21]. An intuitive approach is depicted in Figure 2, which illustrates the different levels of risk. The concept of a risk band (RB) is employed to represent risks on a scale from 1 to 6, using a risk graph as demonstrated in the figure [22, 23].

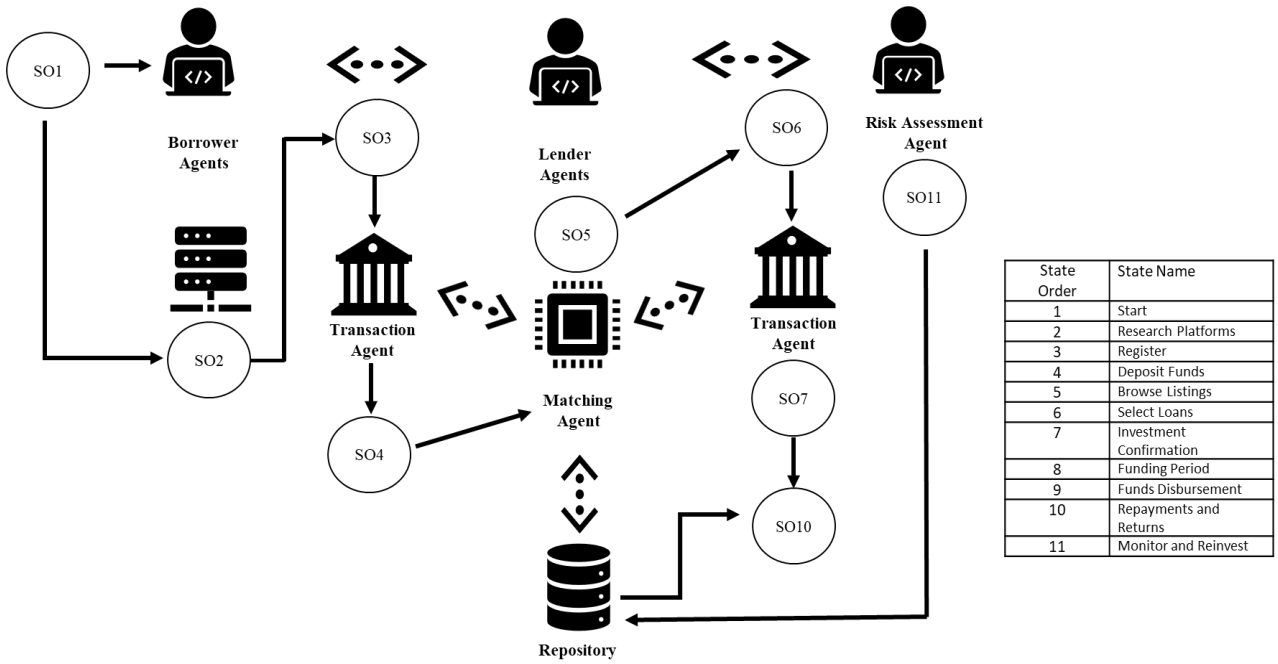

Figure 3. MAS State Order and State Names for P2P Lending States

Table 7. P2P Lending Approval Tasks

Task Name	Task Details	Description / Process	Risk Band
t1	Sets up account	Opening account	Low risk
t2	Review listing	Browsing investment listings	Low risk
t3	Review borrower profile	Industry	Low to medium risk
t4	Select investment	Term/duration and industry	Medium risk
t5	Set up the expected return	Calculate risk/return trade-off portfolio's return (Rp) risk-free rate (Rf), portfolio's excess return (σp)	Medium to high-risk
t6	Decide investment amount	Payment record query	Medium to high-risk
t7	Examine default rate	Setting auto invest preferences	Medium to high-risk
t8	Confirm selection	Payment processing	High risk
t9	Make the investment	Investing in listings	High risk
t10	Reinvest and monitor	Integrity and transparency of loan transactions	High risk

Use Case 1- Very High Risk

The industry faces limited supplier bargaining power due to few alternatives, while customer price sensitivity and technological adoption impact profit margins. Additionally, the threat of new entrants and online platforms and the risk of substitutes driven by changing consumer preferences and technological innovations further complicate the industry landscape.

Use Case 2 - High Risk

Mappings in Table 8 indicate industries that exhibit high levels of risk. These industries include Agriculture, Construction, Utilities, Manufacturing, Healthcare and Social Assistance, and IT and Telecommunications. Literature suggests that agriculture is particularly vulnerable to external variables like weather conditions and market dynamics, which significantly affect yield and profitability. A study by Kadir & Tunggal [24] noted that while various factors such as net exports, government spending, and inflation rates have temporary impacts, the nominal exchange rate has a long-term significant effect on agricultural productivity. Similarly, economic conditions and governmental policies greatly influence the construction sector, which can diminish demand and constrain growth. While so, Halim et al. [25] found that the performance of construction SMEs in Malaysia is markedly affected by macroeconomic variables including the exchange rate, interest rate, and inflation.

Table 8. MAS Risk Mapping Matrix

Industry	Risk Factor									Overall
	GR	MC	BS	BC	CT	SP	IC	BE	LC	
Agriculture										**High**
Accommodation Food Services										**Very High**
Wholesale										**Moderate**
Retail Trade										**Moderate**
Construction										**High**
Utilities										**High**
Manufacturing										**High**
Health Care and Social Assistance										**High**
IT and Telecommunication										**High**
Transportation and Warehousing										**Intermediate**

Indicator:

	Low Risk
	Moderate Risk
	High Risk

Use Case 3 -Moderately High Risk

Table 8 highlights that moderately high-risk industries are retail and wholesale industries. This gives the impression that caution may be warranted, but the situation is not considered exceptionally risky. In other words, there is a significant level of risk, but it is within a manageable range, and appropriate measures can be taken to address and mitigate these risks. Retail and wholesale industries are categorized as moderately high risk due to their intense market competition, complex and globalized supply chains, economic sensitivity, technological disruptions, and regulatory compliance.

Use Case 4 - Intermediate Risk

Transportation and warehousing have intermediate risks. This is because most risk factors mentioned are categorized under the risk level medium. The diverse manufacturing sector in Malaysia, encompassing petroleum, chemical, rubber, plastic products, food, beverages, and electronics, is influenced by the demand for innovative products and services, particularly in the technology sector. The government's commitment to sustainable economic growth, reflected in policies like the New Investment Policy, contributes to the sector's development. The industry is also subject to macroeconomic variables, such as real output, price level, money supply, exchange rates, and equity prices.

5- Conclusion

Table 8 summarizes results aligned by MAS for levels of all risk factors with the industry, resulting in the overall score representing the actual risk level. The analysis of various industries, their risk factors, and the implications for Peer-to-Peer (P2P) lending platforms offers valuable insights into the diverse investment opportunities. Low-risk industries offer stability, regulatory frameworks, and predictable market conditions. Intermediate-risk industries include manufacturing, transportation, and warehousing, Challenges such as supply chain disruptions and competitive threats exhibit growth potential. Moderately high-risk industries such as Retail and Wholesale grapple with market dynamics, competitive pressures, and the necessity to adapt to shifting consumer behaviors. In contrast, high-risk sectors include Agriculture, Construction, Utilities, Healthcare and Social Assistance, and Accommodation and Food Services. These industries contend with regulatory complexities, market volatility, and substantial capital requirements. Across these industries, the impact of technological advancements, government policies, and macroeconomic factors is significant. Therefore, we recommend that investors diversify their portfolios, assess risk tolerance, stay updated on industry-specific trends, conduct comprehensive due diligence, and adjust to the changing economic and technological environment. This analysis, incorporating Multi-Agent Systems (MAS) perspectives, serves as a crucial resource for investors aiming for a balanced and informed approach to P2P lending across various industries.

6- Declarations

6-1- Author Contributions

Conceptualization, S.M. and N.T.P.L.; methodology, Y.V.C., T.O., and K.Z.; validation, S.M. and Y.V.C.; formal analysis, S.M.; investigation, S.M.; writing—original draft preparation, S.M. and T.O.K.Z.; writing—review and editing, T.O.K.Z.; supervision, S.M. and N.T.P.L. All authors have read and agreed to the published version of the manuscript.

6-2- Data Availability Statement

The data presented in this study are available on request from the corresponding author.

6-3- Funding and Acknowledgements

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6-4- Institutional Review Board Statement

Not applicable.

6-5- Informed Consent Statement

Not applicable.

6-6- Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

7- References

[1] Alfian, H. (2020). What You Need To Know About P2P Lending In Malaysia. iMoney Learning Centre, Kuala Lumpur, Malaysia. Available online: https://www.imoney.my/articles/p2p-lending-guide (accessed on November 2024).

[2] Liu, Q., Zou, L., Yang, X., & Tang, J. (2019). Survival or die: a survival analysis on peer-to-peer lending platforms in China. Accounting and Finance, 59(S2), 2105–2131. doi:10.1111/acfi.12513.

[3] Bloomberg News. (2018). How China's Peer-to-Peer Lending Crash Is Destroying Lives? Available online: https://www.bloomberg.com/news/articles/2018-10-02/peer-to-peer-lending-crash-in-china-leads-to-suicide-and-protest (accessed on November 2024).

[4] Zhe, K. S. K. (2019). P2P Financing Industry Growing. The Edge Communications, Selangor, Malaysia. Available online: https://www.theedgemarkets.com/article/cover-story-p2p-financing-industry-growing (accessed on November 2024).

[5] Gonzalez, L. (2020). Blockchain, herding and trust in peer-to-peer lending. Managerial Finance, 46(6), 815–831. doi:10.1108/MF-09-2018-0423.

[6] Zhang, D., Xu, L., & Wang, C. (2024). The Impact of P2P Platforms on Traditional Intermediaries. Research in Business Applications, 10(1), 12–28.

[7] Khan, S., Shah, M., & Younas, A. (2023). Building Trust in P2P Platforms: A Reputation Management Framework. Journal of Electronic Commerce Research, 14(4), 521–538.

[8] Rosavina, M., Rahadi, R. A., Kitri, M. L., Nuraeni, S., & Mayangsari, L. (2019). P2P lending adoption by SMEs in Indonesia. Qualitative Research in Financial Markets, 11(2), 260–279. doi:10.1108/QRFM-09-2018-0103.

[9] Thakor, R. T., & Merton, R. C. (2018). Trust in Lending. 9th Miami Behavioral Finance Conference 2018, MIT Sloan Research Paper No. 5524-18. doi:10.2139/ssrn.3201689

[10] The World Bank. (2022). World Bank SME Finance: Development News, Research, and Data. World Bank, Washington, D.C., United States. Available online. https://www.worldbank.org/en/topic/smefinance (accessed on November 2024).

[11] Wang, Q., Su, Z., & Chen, X. (2021). Information disclosure and the default risk of online peer-to-peer lending platform. Finance Research Letters, 38, 101509. doi:10.1016/j.frl.2020.101509.

[12] Galloway, I. (2009). Peer-to-Peer Lending and Community Development Finance. Community Development Investment Center Working Paper, 21(3), 20.

[13] Nguyen, L. T. P., Muthaiyah, S., Sy, M. O., & Kalabeke, W. (2022). P2P Lending platforms in Malaysia: the awareness among Malaysian adults. F1000Research, 10, 1096. doi:10.12688/f1000research.73401.2.

[14] Rabbani, M. R., Bashar, A., Hawaldar, I. T., Shaik, M., & Selim, M. (2022). What Do We Know about Crowdfunding and P2P Lending Research? A Bibliometric Review and Meta-Analysis. Journal of Risk and Financial Management, 15(10), 451. doi:10.3390/jrfm15100451.

[15] Serrano-Cinca, C., & Gutiérrez-Nieto, B. (2016). The use of profit scoring as an alternative to credit scoring systems in peer-to-peer (P2P) lending. Decision Support Systems, 89, 113–122. doi:10.1016/j.dss.2016.06.014.

[16] Xia, Y., Liu, C., & Liu, N. (2017). Cost-sensitive boosted tree for loan evaluation in peer-to-peer lending. Electronic Commerce Research and Applications, 24, 30–49. doi:10.1016/j.elerap.2017.06.004.

[17] Banerjee, A., Srinivasan, S., & Pontellini, J. (2023). Decentralized Finance (DeFi) and the Future of P2P Payments. McKinsey Quarterly, 1–10.

[18] Zreik, M., & Iqbal, B. A. (2025). Navigating the Global Fintech Regulatory Landscape: Balancing Innovation and Protection. Examining Global Regulations during the Rise of Fintech, IGI Global, 71-102. doi:10.4018/979-8-3693-3803-2.ch004.

[19] Oh, E. Y., & Rosenkranz, P. (2022). Determinants of peer-to-peer lending expansion: The roles of financial development and financial literacy. The Journal of FinTech, 2(01n02), 2250001. doi:10.1142/S2705109922500018.

[20] Osborn, S., Sandhu, R., & Munawer, Q. (2000). Configuring Role-Based Access Control to Enforce Mandatory and Discretionary Access Control Policies. ACM Transactions on Information and System Security, 3(2), 85–106. doi:10.1145/354876.354878.

[21] Muthaiyah, S., Anbananthen, K. S. M., & Phuong Lan, N. T. (2021). Orchestration of autonomous trusted third-party banking. F1000Research, 10, 899. doi:10.12688/f1000research.72987.1.

[22] Muthaiyah, S. (2006). Propagation and delegation of rights in access controls and risk assessment techniques. Web Services Security and E-Business, 328–337. doi:10.4018/978-1-59904-168-1.ch018.

[23] Nissanke, N., & Dammag, H. (2000). Risk ordering of states in safecharts. Lecture Notes in Computer Science, including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics, Vol. 1943, 395–405. doi:10.1007/3-540-40891-6_34.

[24] Kadir, S. U. S. A., & Tunggal, N. Z. (2015). The impact of macroeconomic variables toward agricultural productivity in Malaysia. South East Asia Journal of Contemporary Business, Economics and Law, 8(3), 21-27.

[25] Halim, F. A., Malim, M. R., Derasit, Z., Rani, R. M., & Rashid, S. S. (2017). The impact of macroeconomic variables on SMEs in Malaysia. Journal of Physics: Conference Series, 890(1), 012138. doi:10.1088/1742-6596/890/1/012138.