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# Orchestration of Federated Risk for P2P Lending Platforms: A Multi-Agent Systems (MAS) Approach

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## Abstract

Federated risk management in the context of Peer-to-Peer (P2P) lending should be a collaborative approach with multiple autonomous entities (i.e. agent systems) working together to assess, monitor, and mitigate risks. Orchestration of these agents is crucial in facilitating risk evaluation, surveillance, and mitigation tactics. By employing Multi-Agent Systems (MAS), the orchestration of risk, regulatory compliance, and stakeholders' interests are better protected. The framework of federated risk management in P2P lending aims to address challenges and risks inherent in decentralized platforms. In recent years, the P2P lending industry has experienced significant growth, attracting both borrowers and investors seeking an alternative financial system. However, this growth has exposed the industry to various risks, including credit risk, fraud, and information asymmetry. As a result, the need for a robust risk management framework has become increasingly critical. In this paper, we delve into the role of intelligent agents and their protocol for collaborative dynamics that uses the portfolio's return (Rp) and the risk-free rate (Rf), divided by the standard deviation of the portfolio's excess return (σp) for various investment portfolios. Our framework allows MAS to analyze data from diverse sources, default rates, payback history, and portfolio risks to propose adaptive strategies for risk mitigation.

Keywords: P2P Lending; Multi Agent Systems (MAS); Risk Free Rate; Portfolio Excess Return.

## **1. Introduction**

The banking industry, a cornerstone of global finance, has historically fueled economic growth through lending, fostering trust in its ability to drive progress [1]. However, amidst periods of stagnation and resistance to change, notably exemplified by the 2008 financial crisis, doubts have surfaced regarding the suitability of traditional banking structures [2]. The upheaval of the financial system commencing in 2008 eroded public trust in the conventional intermediaries of the financial realm, notably regulated banks.

The resultant collapse not only plunged the mainstream financial infrastructure into turmoil, burdening millions of borrowers with unprecedented debt, but also precipitated a constriction that severed individuals and small enterprises from vital sources of credit [3]. Consequently, those seeking financial assistance were compelled to explore alternative avenues [4]. Entrepreneur Giles Andrews envisioned a remedy for the shortcomings of Britain's banking sector. Traditional borrowing practices subjected prospective borrowers to arduous application procedures and unsatisfactory customer service experience.

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Andrews proposed a revolutionary concept: direct and instantaneous connectivity between borrowers and lenders, obviating the need for cumbersome processes and bypassing the intermediary role of banks [5]. Initially conceived as a straightforward mechanism for facilitating online loans between individuals, P2P lending has evolved into a multifaceted ecosystem encompassing diverse technologies, institutions, and ancillary startups [3]. Despite this, traditional banking remains prevalent in many developed nations, though facing increasing pressure from the burgeoning Financial Technology (Fintech) sector, which compels banks to adapt and innovate to maintain relevance [6].

"Financial Technology" represents the convergence of traditional finance with modern technologies [7], spanning three key epochs: FinTech 1.0 (1866-1967), FinTech 2.0 (1968-2008), and FinTech 3.0 (2009-present). FinTech 1.0 witnessed the gradual digitization of financial transactions, including the introduction of credit cards. FinTech 2.0 marked significant milestones such as ATM deployment and online banking, reshaping global finance. The advent of FinTech 3.0 heralded the rise of new market players and technology start-ups, democratizing access to innovative financial products, including P2P lending platforms [8]. In developed economies, this revolution is labeled FinTech 3.0, while in developing economies [9], it is known as FinTech 3.5, each characterized by disruptive market forces driving digital financial innovation and fostering trust in novel financial systems [8, 10]. As posited by Nguyen et al. [11], FinTech endeavors can be delineated into six primary classifications: payments, market facilitation, investment administration, deposit-taking and lending, insurance, and capital mobilization. Table 1 elucidates the principal catalysts propelling FinTech undertakings within the financial domain.

#### Table 1. Main Drivers of the FinTech Ecosystem

Automation and big data in Trading and investments	Block Chain and Cryptocurrencies Lending and Funding Mobile transfers and Payments	Lending and Funding	Mobile transfers and Payments
Artificial Intelligence (AI) for Robo chatbot and financial advisors	Distributed ledger technology,	Loans (student loans, property loans, and health loans)	Mobile banking
Machine Learning (ML) for his data	transforming national identification system, digitization of government and	Crowdfunding (donation startun	Card-less payments
analytics and nontraditional data	legal system	investment, culture)	PayPal
analytics High-Frequency Trading (HFT)	Cryptocurrencies (Bitcoin and Ethereum, Dogecoin)	Peer-to-peer lending (P2P lending) consumer and businesses	TechFin products (Apple Pay, Google Pay, Alipay, Amazon Pay)

Described by Muthaiyah [12] as the origination of loans between private individuals via online platforms, with financial institutions serving solely as mandated intermediaries, P2P lending has been further conceptualized by Gai et al. [13]. They propose leveraging social networks to mobilize communities of entrepreneurs and investors, thereby enhancing the efficiency and efficacy of fund aggregation and transfer.

## 2. Literature Review

P2P lending is the online process of facilitating loans between individuals and businesses [14]. Borrowers can select from a range of lenders, making it a flexible option for securing funds quickly. The global P2P lending market is experiencing significant growth driven by increasing demand for finance and loans, coupled with lower operating fees compared to traditional financial services. However, stringent government regulations regarding loan approvals pose a challenge to the market's expansion. Nonetheless, the COVID-19 pandemic has had a positive impact on P2P lending, offering relief to businesses struggling with financial constraints [15]. Technological advancements, such as the Internet of Things and blockchain, further propel the market's growth by enhancing efficiency. In North America, the P2P lending market is thriving due to widespread adoption and technological innovation.

Similarly, China leads the Asia-Pacific region, fueled by a growing number of small and medium-sized enterprises and government initiatives promoting cashless technologies. The United Kingdom, where P2P lending originated, has seen steady growth despite economic challenges like Brexit. In the United States, P2P lending gained momentum with the establishment of platforms like Prosper and Lending Club, despite regulatory setbacks [16-17].

China emerged as a global leader in P2P lending, surpassing other countries in market share and loan volume, although it faced challenges like fraudulent activities and investor losses [18]. In Southeast Asia, P2P lending is gaining traction, especially in countries like Indonesia, where it dominates the FinTech market [19].

P2P lending operators are required to be a legal entity incorporated under the Companies Act 1965, possessing a minimum paid-up capital of RM5 million. Before commencing operations, the prospective P2P operator must furnish evidence to the Securities Commission Malaysia (SC) demonstrating compliance with stipulated criteria outlined in regulatory guidelines. Key considerations include the assessment of the operator's board of directors to ascertain their suitability, an assessment of the capacity to maintain an organized, equitable, and transparent marketplace, alongside possessing the requisite information technology infrastructure. This lack of deposit security on digital platforms heightens vulnerability and risk for prospective depositors, amplifying concerns about potential defaults. Regarding P2P platforms, evidence indicates that depositors bear much of the risk, with default rates and credit rating methodologies often remaining opaque to informed investors. In a burgeoning economy like Malaysia, such uncertainties pose barriers

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to attracting more investors to these digital platforms. Digital platform investments do lack such deposit security measures, fostering a sense of vulnerability and risk among potential depositors. The ongoing digital transformation is reshaping the banking landscape, promising a markedly different future. Faced with intense competition, evolving consumer expectations, and innovative business models, banks must adopt process automation to instill confidence in their clientele. Recent scandals involving entities like Enron, Madoff Investment Securities, and WorldCom have further eroded trust in the financial sector, as highlighted in the Edelman Trust Barometer report. Table 2 summarizes P2P lending platforms in Malaysia by Liu et al. [20]. While so, Table 3 highlights data from 2011 to 2022, and observes that the financial services sector, including banking, is consistently ranked as the least trusted among the eight industries surveyed. Despite a modest increase from 37% in 2011 to 56% in 2022, this improvement pales in comparison to other industries, as depicted in Figure 1.

P2P platforms, unlike traditional banks, do not bear any credit risk and details of credit default risk are based on a formula only known to the operator of the platform [21]. Evidence from the collapse of hundreds of P2P lending platforms in China since 2013 [22], due to frauds, clearly signals potential risks possessed by P2P platforms to investors. In Malaysia, the first P2P lending platform defaulted in August 2018. The reason for this default is mainly because of its SMEs' business slowdown that led to its default payments to the platform, according to Funding Society Malaysia [23]. Although the default rate for P2P lending platforms remained at 1% and below as reported by the CEO of Funding Society Malaysia, this is still worrying to investors. In a study conducted by Banerjee et al. [24], the authors examined the trust-enhancing heuristics that show a need for technologies to assist monitoring and bad loan recovery. In another similar study, the impact of Chinese peer-to-peer (P2P) platform reputation directly and indirectly affects investors' investment decisions [25].

The findings of their study showed that P2P lending platform reputations have played both direct and indirect roles on investor's investment decisions. A study from Dammag & Nissanke [22] examined the adoption of P2P lending platforms to determine the factors that encourage SMEs to use P2P lending platforms in obtaining loans. The findings of the study shows that trust greatly influenced SMEs' investment decisions. Banks and P2P lenders perform similar functions, as both extend debt financing. Nevertheless, trust is a crucial component [25] that is still lacking. To assist investors in comprehending relevant data before making their investment decision we propose the use of MAS (i.e. software agents). Since the potential investor needs to assess the risk of investment before deciding on the investment decision on the lending platform, the investor must gather complete facts about the investment. The data can be overwhelming as it will have to include more data than what is represented by the investment notes provided on the platform. P2P lending platforms have emerged as a disruptive innovation, enabling direct lending between individuals and businesses without the involvement of traditional financial institutions. However, the decentralized nature of P2P lending introduces inherent risks that necessitate effective risk management strategies [22].

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% to 1.50% per repayment	not stated	
B2BFinPal	3.15%	RM1,000 initial deposit RM100 per campaign	30% of interest earned	10.9% p.a.	
			Business term financing: 2% p.a. of each repayment;		
Funding Societies 3.27%	RM100 initial deposit, RM100 per campaign	Accounts receivable financing: 15% of interest earned;	not stated		
		Accounts payable financing: 30% of interest earned.			
Fundaztic	8 72%	RM2,000 initial deposit (if using "Smart Invest" feature); otherwise no initial	Monthly repayments: 2% of repayment amount	27.88% since 2017	
Tunuztie	0.7270	deposit required, RM50 per campaign	Bullet repayments: 1% of repayment amount	27.0070 Since 2017	
Alixoco	2.59%	RM500	0.35% to 2% of repayment	12% p.a.	
MicroLEAP	0%	RM50	2% of 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	
Cofundr not stat		RM1,000 initial deposit, RM100 per	For investments that are 12 months or under: 20% of interest		
	not stated	campaign	For investments that are over 12 months: 2.0% p.a. on principal	not stated	

#### Table 2. Peer-to-Peer Lending Platform in Malaysia

Sector/Year	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%
Automative	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%

Table 3. Edelman and Trust Report on Trusted Industries (2011 to 2022)



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

## 3. Multi Agent Systems and Trust

This paper explores the application of MAS in developing a policy framework for federated risk management in P2P lending, leveraging the capabilities of autonomous agents to enhance risk assessment, monitoring, and mitigation. This paper uses the FIPA (Foundation for Intelligent Physical Agents) specifications for the execution of MAS. These are autonomous systems that rely upon upholding or enforcing trust concerning transaction processing, integrity, data provenance, auditability, and adherence to policy.

Trust attributes can also be defined as compliance, data provenance, as well as truth and fairness [24]. Our framework allows software agents to gather and analyze data from diverse sources, default rates, and the history of portfolio risks and proposes adaptive strategies for risk mitigation. The main idea here is to determine the use of risk-based assessment for better investment decision-making. Intuitively, the larger the risk, the greater the risk band, and the higher the return.

## 4. Multi Agent System Design for P2P Lending Platforms

Considering P2P lending platforms and autonomous risk management based on individual risk profiles of investors, MAS design will consist of i) agents, ii) interactions, iii) communication protocols, and iv) risk and mitigation.

#### Agents:

- 1. Borrower Agents: Individuals or businesses seeking loans.
- 2. Lender Agents: Individuals or institutions willing to lend money.
- 3. Risk Assessment Agents: Assess the creditworthiness of borrowers and determine loan terms.
- 4. Matching Agents: Match borrowers with suitable lenders based on their preferences and criteria.
- 5. Transaction Agents: Facilitate loan transactions, including loan origination, repayment, and interest calculation.

#### Interactions:

- 1. Borrower-Lender Interaction: Borrower agents submit loan requests, and lender agents review loan opportunities and decide whether to fund them.
- 2. Risk Assessment Interaction: Risk assessment agents evaluate borrower creditworthiness based on financial data, credit history, and other relevant factors.
- 3. Matching Interaction: Matching agents match borrowers with lenders based on loan requirements, risk profiles, and preferences.
- 4. Transaction Interaction: Transaction agents handle loan origination, fund transfer, repayment schedule, and interest calculation.

#### **Communication Protocols:**

- 1. Loan Request Protocol: Borrower agents submit loan requests, specifying the loan amount, repayment terms, and purpose.
- 2. Lender Review Protocol: Lender agents review loan requests, assess risk, and decide whether to fund them.
- 3. Risk Assessment Protocol: Risk assessment agents collect borrower information, assess credit risk, and provide risk scores.
- 4. Matching Protocol: Matching agents match borrowers with lenders based on risk profiles, loan criteria, and preferences.
- 5. Transaction Protocol: Transaction agents facilitate fund transfers, loan origination, repayment schedule, and interest calculation.

## **Risks and Mitigation Strategies:**

- 1. Market Risk: Economic downturns or fluctuations impacting borrower repayment capacity. Mitigation: Diversify loan portfolios across different industries and regions, conduct stress testing, and establish risk management protocols.
- 2. Regulatory Risk: Changes in regulations affecting P2P lending operations. Mitigation: Stay updated with regulatory changes, comply with relevant laws and regulations, and maintain open communication with regulatory authorities.
- 3. Liquidity Risk: Inability to match borrower demand with available lender funds. Mitigation: Implement liquidity management strategies, maintain reserve funds, and establish secondary markets for loan trading.

Regular monitoring, evaluation, and adaptation of MAS is essential to ensure its effectiveness and resilience in dynamic financial environments. In the next section, we elaborate on MAS risk mitigation via the default rate analysis (i.e. standard deviation and or which is key for evaluating risk profiles or risk appetite for potential investors

## 5. Multi Agent System for Default Rate Assessment Method

Standard deviation is a statistical measure used to quantify the amount of variation or dispersion in a set of data points. In the context of predicting default rates in P2P lending, the standard deviation can provide insights into the volatility or variability of default rates across different loan categories, borrower segments, or time periods. Steps on how standard deviation can be incorporated to predict default rates in P2P lending and operationalization of the formula is shown Table 4.

#### **Table 4. Operationalization of Standard Deviation**

Step 1	Calculate the mean (µ):
	$\mu = \frac{\sum_{i=1}^{n} (x_i)}{\sum_{i=1}^{n} (x_i)}$
	n
	where $\mu$ is the mean, $x_i$ are the individual data points, and it is the number of data points.
Step 2	Calculate the variance $(\sigma^2)$ :
	$\sigma^2 = \frac{\sum_{i=1}^n (x_i - u)^2}{\sum_{i=1}^n (x_i - u)^2}$
	n Where $\sigma^2$ is the variance: $x$ , are the individual data points: $\mu$ is the mean and $n$ is the number of data points.
	where $\delta$ is the variance, $x_i$ are the individual data points, $\mu$ is the inear, and it is the number of data points.
Step 3	Calculate the Standard Deviation ( $\sigma$ ):
	$\sigma^2 = \sqrt{\sigma^2}$
	Let's demonstrate with a hypothetical example:
	Suppose we have the following default rate data for a P2P lending platform over the past year:
	Default Rates = {4.5%, 3.8%, 5.2%, 4.1%, 5.6% }
Step 4	Calculate the mean (µ):
	4.5% + 3.8% + 5.2% + 4.1% + 5.6%
	$\mu = \frac{1}{5} = 4.64\%$
	Calculate the variance $(\sigma^2)$ :
	$\sigma^{2} = \frac{(4.5\% - 4.64\%)^{2} + (3.8\% - 4.64\%)^{2} + (5.2\% - 4.64\%)^{2} + (4.1\% - 4.64\%)^{2} + (5.6\% - 4.64\%)^{2}}{(5.6\% - 4.64\%)^{2}}$
	5
	$\sigma^{2} = \frac{(0.14)^{2} + (-0.84)^{2} + (0.56)^{2} + (-0.54)^{2} + (0.96)^{2}}{5} = 0.4504$
	Calculate the Standard Deviation $(\sigma)$ :
	$\sigma^2 = \sqrt{0.4504} \approx 0.67\%$

**Step 1** - Historical Default Rate Data: Collect historical default rate data from the P2P lending platform for different loan categories, borrower segments, or time periods.

**Step 2** - Calculate Mean Default Rate: Calculate the mean (average) default rate from the historical data. The mean represents the central tendency of the default rate distribution.

**Step 3** - Calculate the standard deviation of the default rates. Standard deviation measures the dispersion or variability of default rates around the mean. A higher standard deviation indicates greater variability in default rates.

**Step 4** - Assess Risk Factors: Analyze factors contributing to variability in default rates, such as loan characteristics, borrower attributes, economic conditions, and platform-specific factors. Identify high-risk loan categories, borrower segments, or time periods with elevated default rates and high standard deviation.

**Step 5** - Risk Assessment and Prediction: Use the mean default rate as the baseline expectation for default rates in each category or segment. Consider the standard deviation to assess the level of uncertainty or risk associated with the mean default rate. Higher standard deviation indicates higher uncertainty or variability in default rates, which may require more conservative risk management strategies.

Alternatively, to better understand default rates in P2P lending we can refer to Sharpe Ratio as a crucial statistic. William F. Sharpe invented the Sharpe Ratio, a mathematical technique that considers both the risk or volatility and the profits realized on investments [25]. The success of financing on these platforms can be impacted by variables including default rates, fluctuations in the economy, and challenges unique to the business. A borrower who is given a high credit score will be deemed to have lower default risk and thus will be mostly financed with a lower interest rate, and vice versa. MAS can comprehend and measure these risks to maximize the returns for their investment portfolios and make well-informed decisions for potential investors.

According to World Government Bonds [26], the Sharpe ratio (> 1.0) is considered acceptable by investors. A ratio (> 2.0) is rated as very good. A ratio of (=>3.0) or higher is considered excellent. A ratio (< 1.0) is considered suboptimal. In short, the Sharpe Ratio indicates how much extra return an investor might get for the degree of risk taken. Upon categorizing the investment notes that we gathered according to their respective industries, the summary for 25 industries and number of investment notes are summarized on Table 5. We examined 807 investment notes from various

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P2P platforms in Malaysia, namely Funding Societies, Capsphere, Alixco, microLEAP and Cofundr as well as drawing upon insights gained from our analysis. Later, we implemented Sharpe Ratio analysis on industry-specific portfolios. Sharpe ratio offers insight into risk-adjusted performance independent of those affiliations. It serves as a valuable tool to gauge the extent to which historical excess returns were associated with heightened volatility, with excess returns measured against a benchmark and volatility assessed through the standard deviation formula based on return variance from the mean. A higher Sharpe ratio indicates better risk-adjusted performance, as it represents a higher return relative to the risk taken. The effectiveness of the ratio hinges on the assumption that the historical record of relative risk-adjusted returns possesses predictive value.

P2P represented industries	Investment Notes obtained
Retail and Trade	17
IT and Communication	15
Logistics	27
Health	8
Construction	13
Accommodation and Food Services	51
Wholesale and Retail; Repair of Motor Vehicles	523
Manufacturing	53
Professional, Scientific and Technical Activities	24
Services	21
Agriculture	6
Education	13
Administration and Support Services	12
Personal Protective Equipment	2
Arts, Entertainment and Recreation	3
Baby Products	2
Service Technology Provider	4
Wholesale	4
Water Supply, Sewerage and Waste Management	1
Installation of Industrial Equipment	1
Industrial Products	3
Electricity, Gas, Steam and Air-Conditioner Supply	1
Real Estate	1
Mining and Quarrying	1
Others	1

Table 5. Operationalization of	of Standard Deviation
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The Sharpe Ratio is expressed as the difference between the portfolio's return  $(R_p)$  and the risk-free rate  $(R_f)$ , divided by the standard deviation of the portfolio's excess return  $(\sigma_p)$ . The standard deviation is derived from the variability of returns over specific time intervals that constitute the entire performance sample being evaluated. The numerator, representing the total return differential against a benchmark, is computed as the average of the return 4 differentials observed in each incremental period within the overall sample. The formula to calculate the Sharpe Ratio is as follows:

Sharpe Ratio =  $\frac{R_p - R_f}{\sigma_p}$ 

where  $R_p$  is return of portfolio;  $R_f$  is risk-free rate, and  $\sigma_p$  is Standard deviation of the portfolio' sexcess return.

## 6. Key Findings

Sharpe Ratio calculation based on our examination of 807 investment notes from various P2P platforms in Malaysia, such as Funding Societies, Capsphere, Alixco, microLEAP, and Cofundr resulted in the following summary in Tables 6 to 15.

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Variable	<b>Retail/Trading</b>
Risk free rate (M.10-year gov bond); Rf	0.03838
Avg Return (Rx)	0.13474
Std deviation ( $\sigma$ )	0.02467
(Rx-Rf)	0.09636
Sharpe ratio, S(x)=(Rx-Rf)/σ	3.90599

#### Table 6. Sharpe Ratio (Retail and Trade industry)

## Table 7. Sharpe Ratio (IT and communication industry)

Variable	IT and Communication
Risk free rate (M.10-year gov bond); Rf	0.03838
Avg Return (Rx)	0.12757
Std deviation ( $\sigma$ )	0.03733
(Rx-Rf)	0.08919
Sharpe ratio, $S(x)=(Rx-Rf)/\sigma$	2.38956

#### Table 8. Sharpe Ratio (Logistics industry)

Variable	Logistics
Risk free rate (M.10-year gov bond); Rf	0.03838
Avg Return (Rx)	0.10030
Std deviation ( $\sigma$ )	0.04368
(Rx-Rf)	0.06192
Sharpe ratio, $S(x)=(Rx-Rf)/\sigma$	1.41745

#### Table 9. Sharpe Ratio Health Industry

Variable	Human Health and Social Work Activities
Risk free rate (M.10-year gov bond); Rf	0.03838
Avg Return (Rx)	0.08500
Std deviation ( $\sigma$ )	0.04629
(Rx-Rf)	0.04662
Sharpe ratio, $S(x)=(Rx-Rf)/\sigma$	1.00711

## Table 10. Sharpe Ratio Construction Industry

Construction
0.03838
0.10217
0.04342
0.06379
1.46908

#### Table 11. Sharpe Ratio Accommodation and Food Services Industry

Variable	Accommodation and Food Service Activities
Risk-free rate (M.10-year gov bond); Rf	0.03838
Avg Return (Rx)	0.06631
Std deviation ( $\sigma$ )	0.02136
(Rx-Rf)	0.02793
Sharpe ratio, S(x)=(Rx-Rf)/σ	1.30729

Variable	Wholesale and Retail; Motor Vehicles	
Risk free rate (M.10-year gov bond); Rf	0.03838	
Avg Return (Rx)	0.09619	
Std deviation ( $\sigma$ )	0.02681	
(Rx-Rf)	x-Rf) 0.05781	
Sharpe ratio, $S(x)=(Rx-Rf)/\sigma$	2.15597	

#### Table 12. Sharpe Ratio Calculation for Wholesale and Retail; Repair of Motor Vehicles Industry

## Table 13. Sharpe Ratio Calculation for Manufacturing Industry

Variable	Manufacturing
Risk free rate (M.10-year gov bond); Rf	0.03838
Avg Return (Rx)	0.10357
Std deviation ( $\sigma$ )	0.04123
(Rx-Rf)	0.06519
Sharpe ratio, $S(x)=(Rx-Rf)/\sigma$	1.58101

## Table 14. Sharpe Ratio Calculation for Professional, Scientific and Technical Industry

Variable	Professional, Scientific and Technical Activities	
Risk free rate (M.10-year gov bond); Rf	0.03838	
Avg Return (Rx)	0.06350	
Std deviation ( $\sigma$ )	0.01715	
(Rx-Rf)	0.02512	
Sharpe ratio, $S(x)=(Rx-Rf)/\sigma$	1.46503	

## Table 15. Sharpe Ratio Calculation for Services Industry

Variable	Services
Risk free rate (M.10-year gov bond); Rf	0.03838
Avg Return (Rx)	0.08714
Std deviation ( $\sigma$ )	0.03663
(Rx-Rf)	0.04876
Sharpe ratio, $S(x)=(Rx-Rf)/\sigma$	1.33139

## 7. Results and Discussion

We use a 10-year Malaysian Government Bond return of 3.838% by World Government Bonds [26] as the risk-free rate ( $R_f$ ) and decided to calculate the Sharpe Ratio for industries with at least 10 Investment Notes including Health Industry (8 Investment Notes) and the results are as follows (Table 16).

No.	Industry	Sharpe Ratio
1	Retail and Trade	3.91
2	IT and Communication	2.39
3	Logistics	1.42
4	Health	1.01
5	Construction	1.47
6	Accommodation and Food Services	1.31
7	Wholesale and Retail; Repair of Motor Vehicles	2.16
8	Manufacturing	1.58
9	Professional, Scientific and Technical Activities	1.47
10	Services	1.33

#### Table 16. Sharpe Ratio Calculation for Services Industry

Note that even though the number of investment notes for Education and Administration and Support Services is more than 10, the Sharpe Ratio for these industries cannot be computed because they have a zero value (0) standard deviation ( $\sigma$ ). That means the expected returns in all the Investment Notes are the same within the same industries. As standard deviation is the denominator in the Sharpe Ratio formula, zero standard deviation would give rise to an infinite number. From the table above, it was found that the Retail and Trade Industry has the highest Sharpe Ratio of 3.91, followed by IT and Communication (2.39) and Wholesale and Retail; Repair of Motor Vehicles (2.16).

In general, all industries give rise to a Sharpe Ratio of more than 1, with the Health Industry being at the bottom (1.01), a borderline number, perhaps due to the minimal Investment Notes available.

## 8. Conclusion

In conclusion, peer-to-peer (P2P) lending in Malaysia is a viable way for investors and small businesses to profit from financial transactions in a simplified way without having to deal with tedious paperwork or regulatory obstacles. While there are always dangers involved with investing, P2P lending systems offer comparatively high returns, making them a desirable option for investors looking to diversify their holdings. Investors can obtain important insights into the risk-adjusted performance of different P2P lending industries by utilizing the Sharpe Ratio analysis carried out in this study. The results show that all industries have Sharpe Ratios above 1, which is a sign of good risk-adjusted returns. However, the industry with the greatest Sharpe Ratio is Retail and Trade, closely followed by Wholesale and Retail; Repair of Motor Vehicles; and IT and Communication. It is noteworthy, although, that the health sector trails behind, with a Sharpe Ratio that teeters on the edge of 1.01; it might be due to the scarcity of Investment Notes accessible for examination. With this quantitative tool at their disposal, investors may ultimately optimize their risk-return profiles and raise the likelihood of long-term financial success by making more educated decisions about industry allocation within their P2P lending portfolio.

#### **9.** Declarations

#### 9.1. Author Contributions

Conceptualization, S.M. and L.T.P.N.; methodology, Y.V.C. and T.O.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 L.T.P.N.; project administration, L.T.P.N.; funding acquisition, S.M. and L.T.P.N. All authors have read and agreed to the published version of the manuscript.

#### 9.2. Data Availability Statement

The data presented in this study are available in the article.

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#### 9.4. Institutional Review Board Statement

Not applicable.

#### 9.5. Informed Consent Statement

Not applicable.

#### 9.6. Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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