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COMPARATIVE STUDY OF DATA GENERATION FOR NORMAL, LOGNORMAL, AND GAMMA DISTRIBUTION USING PLS AND USURY MODEL

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ABSTRACT

Mathematical modeling in the world of economics and banking has particular relevance, especially in terms of providing capital for business activities, particularly for Micro, Small, and Medium Enterprises (MSMEs). Currently, banking activities are predominantly dominated by conventional banks that apply interest, which in Islamic Sharia is considered as riba, and it is incumbent upon Muslims to avoid riba and conduct all their affairs in accordance with Islamic Sharia. This research discusses a mathematical model of a profit-loss sharing system in accordance with Islamic Sharia using the profit-loss sharing model scheme, which is one of the investment models in Islamic finance with a musyarakah contract. The data is derived from the daily profit and loss of a micro trader for the period of September 2023 in Cijantung, East Jakarta, which is then generated for periods of 35, 40, and 50 days, following normal, lognormal, and gamma distributions, with an investment capital of Rp 1,500,000, Rp 3,000,000, and Rp 4,500,000, and profit-sharing portions of 2%, 5%, and 7%. This research is capable of demonstrating a profit-sharing scheme and optimization functions in profit distribution, as well as determining parameters that are more advantageous for traders and capital owners compared to the usury model because the imposed penalties are considered burdensome for the public. Generating data following a normal distribution provides a more realistic profit-sharing scheme but a lognormal and gamma distribution yields the largest profit-sharing portion for investor and trader.

Keywords: Gamma Distribution, Generation, Lognormal Distribution, Normal Distribution, Profit Loss Sharing

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PRELIMINARY

The presence of Micro, Small, and Medium Enterprises (MSMEs) is considered crucial for economic development, as they play a significant role in economic growth and job creation. In 2019, MSMEs contributed 60% to the Gross Domestic Product (GDP) and 14% to total national exports. However, the COVID-19 pandemic has taken a toll on MSMEs, causing a decline in daily revenue (Susanti et al., 2020). The pandemic, declared by the WHO in March 2020, led to the implementation of Large-Scale Social Restrictions (PSBB) in Indonesia, affecting the economy, including the capital market, and making investors more cautious due to the market's uncertainty (Parwati et al., 2023). One of the underlying problems faced by micro, small, and medium enterprises (UMKM), especially the impact of the pandemic, is the limited sources of financing, leading them to borrow money and become dependent, especially on usury (Afisa et al., 2023).

Loan sharks provide a money lending service with high-interest rates, which can result in the total interest payments exceeding the original debt if installment payments are delayed. Many people are often drawn to loan shark activities due to their quick and flexible processes, making them accessible to a smaller demographic (FN & Rahmawati, 2019). While cooperatives can be a better alternative for financing, they often face challenges in providing sufficient funds for MSMEs due to limited budget allocations from local authorities (Ondang et al., 2019). As a result, MSME owners frequently resort to expensive and risky usury model practices, trapping them in a cycle of debt.

The economic micro-system is still dominated by conventional banking and usury models, both legal and illegal, which charge interest or usury. Usury is considered a grave sin in Islam and can lead to inequality and envy in society (Latif, 2020). In the Islamic economic system, as stated in QS. Ar-Ruum:39, usury is prohibited in lending money as it is seen as an exploitative and unfair transaction, particularly burdening MSMEs as they have to repay borrowed capital with late payment penalties. Therefore, there is a need to develop an investment model based on the Islamic economic system.

The Islamic economic framework is a system in which the production, allocation, and utilization of resources adhere to principles rooted in the Quran and the Prophet's teachings (Sumarti, 2019). There are various types of agreements (akad) in Islamic economic activities, one of which is the Musyarakah contract or business cooperation-based contracts (Rohman et al., 2021). Musyarakah is a cooperative contract between two or more parties, where capital ownership is shared between the capital provider and the business operator, and profits and losses are divided based on a mutually agreed-upon ratio (Hasanah & Ichfan, 2021). One application of the Musyarakah contract that is not well-known is the profit and loss-sharing system from the daily income of micro-traders. Within the Musyarakah contract, there is a profit-sharing ratio that varies according to the agreement between the capital provider and the business operator (Latif, 2020).

In conventional practices with a fixed profit-sharing proportion, the higher a trader's income, the more significant the profit allocated to the investor, as the profit ratio remains the same in all situations. This is considered unfair because the hard work of the trader benefits the investor more. It can be said that the model used is suitable for addressing issues in determining a fair distribution in the profit and loss-sharing scheme between traders and investors (Sumarti & Marendri, 2017).

This study discusses a mathematical model for micro-investment with a Profit Loss Sharing (PLS) model created to determine a profit-loss sharing scheme in accordance with Islamic law for micro-traders to free them from usury model practices considered usurious and harmful. The PLS model is generally used in micro-business capital investment, assuming that capital is given to traders already engaged in buying and selling activities, traders record daily profits according to the payment period, and financing is used to increase income (Sumarti, 2019). This research aims to determine the optimal profit distribution and the right parameters for capital providers and traders, assuming the amount of capital provided, the time period, and the profit-sharing ratio from the time period of the original daily profit and loss data, which is then generated following normal, log-normal, and gamma distributions. In addition to the investment model based on the Musyarakah contract, this research will also include an analysis of the usury model model, which is a financing practice commonly used by MSMEs.

This research is expected to provide a clearer perspective on the importance of investment models based on Islamic economic principles in supporting the growth and development of SMEs based on daily profit and loss income following data generation from normal, lognormal, and gamma distributions. Additionally, this research distinguishes itself from previous studies that followed lognormal (Sumarti et al., 2015) and gamma (Murniati, 2017) distributions because the generated data results with a normal distribution are considered more realistic in the context of daily trader income.

METHODS

The research method used is quantitative research, which is an approach that uses statistics to process numerical data with an emphasis on the objectivity of results (Kotronoulas et al., 2023). It involves the use of questionnaires for data collection, which are then tested for validity and reliability. Additionally, the problem is divided into variables with appropriate symbols (Sahir, 2022). The primary data used is the daily profit and loss data of a trader in the Cijantung area, East Jakarta for the period of September 2023.

Table 1. Daily Profit and Loss

t	1	2	3	$\cdots$	29	30
$\omega(t)$	70000	-782000	545000	$\cdots$	797000	-548000

The following steps were taking in this study

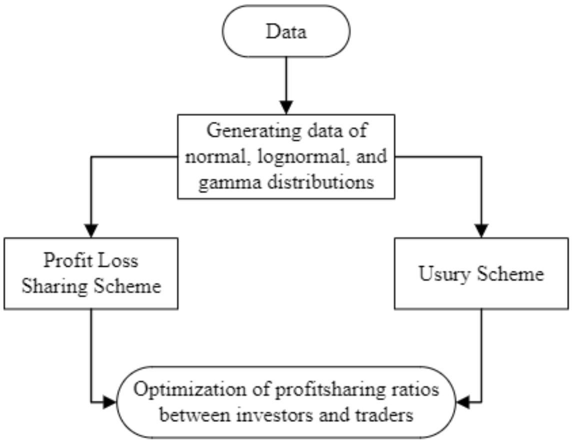

Figure 1. Data Analysis Procedure

Generation of Normal, Lognormal, and Gamma Distributions

Normal (Herhyanto et al., 2021), lognormal (Li & Yang, 2023), and gamma (Ramachandran & Tsokos, 2020) distributions are continuous probability distributions that have density function and R code for data generation (Budiharto & Rachmawati, 2013):

Table 2. Density Function and R Code

Distribution	Density Function	R code
Normal	$f(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$	rnorm(n, mean, sd)
Lognormal	$f(x) = \frac{1}{\sigma y\sqrt{2\pi}} exp\left(-\frac{(logy-\mu)^2}{2\sigma^2}\right)$	rlnorm(n, meanlog, sdlog)
Gamma	$f(x) = \frac{1}{\Gamma(\alpha)\beta^{\alpha}} x^{\alpha-1} e^{-\frac{x}{\beta}}$	rgamma(n, shape=alpha, rate=1/beta)

Model Profit Loss Sharing (PLS)

In the PLS model, the capital owner provides an investment fund of A with a repayment period of T. The mathematical model for installment repayment is as follows (Sumarti, 2019):

$$S(t,p) = I(t) + B(t,p) + C(t), t = 1,2,\ldots,T \quad (1)$$

$S(t,p)$ = The installment paid by the trader on day t

$I(t)$ = The principal installment paid on day t, which is the division of A by T or $I_b = \frac{A}{T}$

$B(t,p)$ = The profit-sharing on day t

$C(t)$ = The installment paid on day t to cover the previous day's installment

p = Profit-sharing portion

The profit sharing amount $B(t,p)$ with a profit-sharing portion $p > 0$:

$$B(t) = \begin{cases} p\big(\omega(t) - I(t) - C(t)\big) & ; \omega(t) - I(t) - C(t) > 0 \\ 0 & ; \omega(t) - I(t) - C(t) \leq 0 \end{cases} \quad (2)$$

$B(t)$ = The profit-sharing amount on day t

$\omega(t)$ = Net profit on day t

$$I(t) = \begin{cases} I_b & , jika\ \omega(t) > I_b \\ \omega(t) & , jika\ 0 < \omega(t) \leq I_b \\ 0 & , jika\ \omega(t) < 0 \end{cases} \quad (3)$$

In practice, the PLS model also includes the debt that must be paid by the trader if they experienced losses on the previous day, denoted as $H(t)$. Additionally, there is $TH(t,p)$, which represents the amount of net profit brought home by the trader on day t (Sumarti, 2019).

When a trader is experiencing losses $\omega(t) < I_b$, the amount of installments that cannot be fully paid is included in the debt $H(t)$ and paid together with the installments in the form of installments $C(t)$.

$$H(1) = I_b - I(1) \quad (4)$$

$$C(1) = 0 \quad (5)$$

$$C(t) = \begin{cases} H(t-1) & , if\ \omega(t) - I_b \geq H(t-1) \\ \omega(t) - I_b & , if\ 0 < \omega(t) - I_b < H(t-1) \\ 0 & , if\ \omega(t) - I_b \leq 0 \end{cases} \quad (6)$$

$$H(t) = tI_b - \sum_{i=1}^{t} I(i) - \sum_{i=2}^{t} C(i) \quad (7)$$

Ratio Optimization

The goal of ratio optimization is to find the optimal value of the portion/ratio p from (1). The parameter $r_s(p)$ and $pd_s(p)$ represent the respective profit rates for the investor and the trader. The value of $r_s(p)$ is obtained from the implicit equation (Sumarti, 2019):

$$A = \frac{S(1,p)}{\big(1 + r_s(p)\big)} + \frac{S(2,p)}{\big(1 + r_s(p)\big)^2} + \cdots + \frac{S(t,p) + H(T)}{\big(1 + r_s(p)\big)^T} \quad (8)$$

The solution for the equation $r_s(p)$ is determined through numerical simulation methods to find its roots, such as the bisection method or Newton-Raphson method. The profit parameter for the trader is obtained as:

$$pd_s(p) = \frac{\sum_{i=1}^{T} TH(i,p)}{\sum_{i=1}^{T} \omega(i)} \quad (9)$$

Usury Model for Supplementary Optimization

Traders obtain a loan of A, with a loan administration fee of 10%, and must repay the debt with interest p, resulting in a total installment of $A(1+p)$, for $t = 1,2,\dots,T$ (Sumarti, 2019),

$$S_{rt}(t) = I(t) + C(t) \quad (10)$$

$$I_b = \frac{A(1+p)}{T} \quad (11)$$

$$I(t) = \begin{cases} I_b & , if \ \ \omega(t) > I_b \\ \omega(t) & , if \ 0 < \omega(t) \le I_b \\ 0 & , if \ \omega(t) < 0 \end{cases} \quad (12)$$

If the trader cannot pay the installment or has not paid off the debt due to losses, there is a penalty of d. For $t = 2,3,\dots,T$,

$$H(1) = I_b - I(1) \quad (13)$$

$$C(1) = 0 \quad (14)$$

$$C(t) = \begin{cases} H(t-1) & , if \ \omega(t) - I_b \ge H(t-1) \\ \omega(t) - I_b & , if \ 0 < \omega(t) - I_b < H(t-1) \\ 0 & , if \ \omega(t) - I_b \le 0 \end{cases} \quad (15)$$

$$H(t) = \begin{cases} 0 & , if \ \omega(t) - I_b \ge H(t-1) \\ H(t-1) - (\omega(t) - I_b) + d & , if \ 0 < \omega(t) - I_b < H(t-1) \\ H(t-1) + (\omega(t) - I_b) + d & , if \ 0 < \omega(t) \le I_b \\ H(t-1) + I_b + d & , if \ \omega(t) \le 0 \end{cases} \quad (16)$$

Parameters for optimizing the determination of the profits for the investor and the trader from the usury model model are r_{rent} and pd_{rent}, which satisfy the equations:

$$A = 10\%A + \frac{S(1)}{(1+r_{rt})} + \frac{S(2)}{(1+r_{rt})^2} + \cdots + \frac{S(T) + H(T)}{(1+r_{rt})^T} \quad (17)$$

$$pd_{rt} = \frac{\sum_{i=1}^{T} TH(i)}{\sum_{i=1}^{T} \omega(i)} \quad (18)$$

RESULT AND DISCUSSION

The generation of daily trader profit and loss data following a normal, lognormal, and gamma distribution. In the case of lognormal and gamma distributions, data generation was only done for profit data, and then the log values of the profit data were determined. The results of the three distributions generated using Rstudio for time periods T=35, 40, and 50 are:

Table 3. Data Generation Process and Summary

T	Distribution	t				Summary		
		1	35	40	50	Min	Mean	Max
	Normal	-123826	-1714379	–	–	-1794293	217030	2158151
35	Lognormal	478487	1689729	–	–	132548	1165213	4078909
	Gamma	459438	1833249	–	–	53684	860461	2395885
	Normal	377410	-608997	381154	–	-1816297	364026	1760639
40	Lognormal	478487	1689729	563945	–	132548	1155022	4078909
	Gamma	459438	1833249	528371	–	53684	834365	2395885
	Normal	2293405	287488	539216	591731	-2213052	451733	2382918
50	Lognormal	423303	425899	703099	2277997	96953	1189766	5781136
	Gamma	766891	1921617	2471848	624906	89972	940837	2938242

The data generated by lognormal and gamma distributions result in data where all values are positive (Sumarti, 2019), this implies that traders consistently make profits every day. The author is interested in calculating the returns for profit-sharing schemes that vary, where the generated results can also be negative, signifying a situation where traders don't make profits and may even incur losses $(\omega(t) \leq 0)$. investment is only provided to traders whose $\overline{\omega(t)} > 0$ (Murniati, 2017) and from the generated data above can proceed to determine the profit-sharing scheme using the PLS model between traders and investors because, during the time period T, traders tend to make a profit more frequently than incurring losses with three data generates.

Assuming that the amount of capital provided by the investor is Rp 1,500,000, Rp 3,000,000, and Rp 4,500,000 for time periods of 35, 40, and 50 days, and profit-sharing ratios of 2%, 5%, and 7%, the following calculations will be made using the PLS model. The calculation for PLS model can be implemented by (1) until (7) are:

Table 4. PLS Model – Normal Distribution, A=3000000, p=2%, T=35

t	$\omega(t)$	$I(t)$	$H(t)$	$C(t)$	$B(t,p)$	$S(t,p)$	$TH(t,p)$
1	-123826	0	85714	0	0	0	-123826
2	1182653	85714	0	85714	20224	191653	991000
3	-1213072	0	85714	0	0	0	-1213072
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
35	-1714379	0	171429	0	0	0	-1714379

Table 5. PLS Model – Lognormal Distribution, A=3000000, p=2%, T=35

t	$\omega(t)$	$I(t)$	$H(t)$	$C(t)$	$B(t,p)$	$S(t,p)$	$TH(t,p)$
1	478487	85714	0	0	7855	93570	384917
2	646881	85714	0	0	11223	96938	549943
3	3311823	85714	0	0	64522	150236	3161587

⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
35	1689729	85714	0	0	32080	117795	1571934

Table 6. PLS Model – Gamma Distribution, A=3000000, p=2%, T=35

t	$w(t)$	$I(t)$	$H(t)$	$C(t)$	$B(t,p)$	$S(t,p)$	$TH(t,p)$
1	459438	85714	0	0	7474	93189	366249
2	1814912	85714	0	0	34584	120298	1694614
3	60574	60574	25140	0	0	60574	0
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
35	1833249	85714	0	0	34951	120665	1712584

Optimal profit sharing with PLS model for A=3000000 and p=2% are obtained:

Table 7. Optimal Profit-Sharing PLS Model A=3000000 and p=2%

Dist	T					
	35		40		50	
	Investor	Trader	Investor	Trader	Investor	Trader
Normal	3172791	4423254	3376129	11198294	3632352	20795966
Lognormal	3755649	37026805	3850487	41673868	4114437	54607393
Gamma	3542323	26573818	3599993	29399676	3877358	42990540

Calculations using the usury model, assuming that the trader receives the same additional capital, time periods, and interest rates same as PLS model, an administrative fee of 10% of the amount of capital provided, as well as a late payment penalty of Rp 30,000. The calculation for usury model can be implemented by (10) until (16) are:

Table 8. Usury Model – Normal Distribution, A=3000000, p=2%, T=35, d=30000

t	$\omega(t)$	$I(t)$	$H(t)+d$	$C(t)$	$S(t,p)$	$TH(t,p)$
1	-123826	0	87429	0	0	-123826
2	1182653	87429	0	87429	174857	1007796
3	-1213072	0	117429	0	0	-1213072
⋮	⋮	⋮	⋮	⋮	⋮	⋮
35	-1714379	0	234857	0	0	-1714379

Table 9. Usury Model – Logormal Distribution, A=3000000, p=2%, T=35, d=30000

t	$\omega(t)$	$I(t)$	$H(t)+d$	$C(t)$	$S(t,p)$	$TH(t,p)$
1	478487	87429	0	0	87429	391059
2	646881	87429	0	0	87429	559452
3	3311823	87429	0	0	87429	3224395
⋮	⋮	⋮	⋮	⋮	⋮	⋮
35	1689729	87429	0	0	87429	1602300

Table 10. Usury Model – Gamma Distribution, A=3000000, p=2%, T=35, d=30000

t	$\omega(t)$	$I(t)$	$H(t)+d$	$C(t)$	$S(t,p)$	$TH(t,p)$
1	459438	87429	0	0	87429	372009
2	1814912	87429	0	0	87429	1727483

3	60574	60574	56855	0	60574	0
⋮	⋮	⋮	⋮	⋮	⋮	⋮
35	1833249	87429	0	0	87429	1745821

Optimal profit sharing with usury model for A=3000000, d=30000 and p=2% are:

Table 11. Optimal Profit-Sharing Usury Model A=3000000 and p=2%

Dist	T					
	35		40		50	
	Investor	Trader	Investor	Trader	Investor	Trader
Normal	3245143	4350902	3450000	11124423	3480000	20948318
Lognormal	3060000	37722455	3060000	42464355	3060000	55661830
Gamma	3150000	26966141	3150000	29849669	3060000	43807898

For a given investment amount and a specific time period, whether using the PLS model or the usury model, it affects the amount of profit obtained. Different investment amounts with the same time period tend to yield the same profit. Additionally, the larger the profit-sharing ratio provided, the greater the profit given by the trader to the investor, but the trader's net income becomes smaller (Murniati, 2017). The rate of return for the PLS model (8) and (9):

Table 12. Rate of Return PLS Model T=35

Distribution	A	1500000			3000000			4500000		
	p	2%	5%	7%	2%	5%	7%	2%	5%	7%
Normal	Investor	0,01	0,03	0,04	0,00	0,01	0,02	0,00	0,01	0,01
	Trader	0,76	0,69	0,64	0,58	0,51	0,47	0,40	0,34	0,30
Lognormal	Investor	0,02	0,05	0,07	0,00	0,02	0,03	0,00	0,01	0,02
	Trader	0,94	0,92	0,90	0,91	0,88	0,86	0,87	0,85	0,83
Gamma	Investor	0,02	0,04	0,06	0,01	0,02	0,03	0,01	0,01	0,02
	Trader	0,93	0,90	0,88	0,88	0,86	0,84	0,83	0,81	0,79

The optimization of usury model that can be calculated with (17) and (18)

Table 13. Optimal Profit-Sharing Usury Model T=35

Distribution	A	1500000			3000000			4500000		
	p	2%	5%	7%	2%	5%	7%	2%	5%	7%
Normal	Investor	0,01	0,01	0,01	0,00	0,01	0,01	0,00	0,00	0,01
	Trader	0,76	0,76	0,75	0,57	0,56	0,55	0,38	0,36	0,35
Lognormal	Investor	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Trader	0,96	0,96	0,96	0,92	0,92	0,92	0,89	0,88	0,88
Gamma	Investor	0,00	0,00	0,00	0,00	0,00	0,01	0,00	0,00	0,01
	Trader	0,95	0,95	0,95	0,90	0,89	0,89	0,84	0,84	0,84

From Table 12. **Rate of Return PLS Model** and Table 13. **Optimal Profit-Sharing Usury Model** assuming constant capital and period, as the initial profit-sharing portion increases, the optimization for investor returns tends to increase, while for traders, it declines, with the largest portion being influenced by lognormal, gamma, and finally, normal distributions. Assuming constant capital and initial profit-sharing portion, as the period increases, the optimization for investor returns tends to increase for lognormal and gamma distributions, while the normal distribution tends to fluctuate. Conversely, for traders, the optimization continues to increase with the largest influence from lognormal, gamma, and finally, normal distributions. Assuming constant period and initial profit-sharing portion, as the capital increases, the optimization for investor returns tends to increase, while for traders, it declines, with the largest influence from lognormal, gamma, and finally, normal distributions. From these assumptions, it can be concluded that the optimal ratio for both investors and traders is achieved by utilizing data generation from lognormal distributions, followed by gamma and normal distributions.

From Table 12. **Rate of Return PLS Model** and Table 13. **Optimal Profit-Sharing Usury Model** the return values for the investor in both the PLS model $(r_s(p))$ and the usury model (r_{rt}) tend to decrease as the time period T increases. However, the profit share for the merchant in the PLS model $(pd_s(p))$ and the usury model (pd_{rt}) tends to increase. This means that both the PLS and usury models are beneficial for the merchant when the time period is extended (Sumarti, 2017).

CONCLUSION

Variations in the investment period show that optimal profit increases with an extension in the investment period. Meanwhile, variations in the investment amount result in lower profits as the investment amount increases for the same period. Although varying the investment amount doesn't lead to significant profit changes for the same period, it reflects that, within a specific period, a larger capital value will lead to a larger portion for the investor and a smaller share of profit for the merchant. As a result, the investor's share of profit decreases with an extended investment period, while the merchant's profit share increases. Overall, this model benefits the merchant when the investment period is extended and a larger investment capital is provided. This can generally have a positive impact on economic activities, especially for micro-entrepreneurs. Generating daily profit data using lognormal and gamma distributions yields better optimization of the ratio, while generating a normal distribution displays a more realistic profit-sharing scheme in everyday life. Further research can explore other types of data generation to be examined in PLS and usury models.

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