FLOW-PERFORMANCE RELATIONSHIP IN DEFI YIELD AGGREGATOR

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ABSTRACT
Decentralized Finance (DeFi) is a new financial infrastructure with particular characteristics and application services similar to traditional financial products, such as exchange, lending, derivatives, and asset management. This paper empirically investigates Yearn finance protocol to demonstrate a flow and performance relationship and compare the results to mutual fund research in traditional finance. The selected protocol is one of the fastest-growing and largest in DeFi yield aggregator protocols for on-chain asset management, which launched in the Ethereum blockchain in 2020. Our main observations are retrieved from the Ethereum blockchain using Web3.py -one of the python libraries- from January to December 2021. We employ the fixed-effect model in our regression and analysis of the insight protocol by looking at a transaction level. According to the findings, there is a positive non-linear relationship between fund flows and recent performance for using stablecoin invested in the pooled fund, which the result is consistent with mutual fund research in traditional finance. On the other hand, we cannot find this relationship for using cryptocurrency. Then, we look further into stablecoin holder behaviors. Finally, our findings show that, on average, the stablecoin holders prefer the leverage strategy, which offers a chance of higher returns, including higher risks.
Keywords: Asset Management, Blockchain, Decentralized Finance, Fund Performance, Leverage

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INTRODUCTION

Digitalization is currently disrupting many services, including finance. Applying Decentralized Finance (DeFi) technology challenges traditional financial services such as exchange, lending, derivatives, and asset management. However, there are numerous advantages to utilizing new blockchain technology, which can increase capital efficiency in the investment process. (Chen & Bellavitis, 2020; Schär, 2021) explain that DeFi is a new open financial application built on permissionless blockchain technology and operated by smart contracts. Moreover, the particular characteristics of DeFi provide more decentralized, open, permissionless, transparent, innovative, and interoperable. This new breed allows investors to control their financial assets and allows them to verify transaction and protocol execution publicly.

This paper focuses on on-chain asset management in DeFi yield aggregators, a major growth driver in DeFi and mainly used for portfolio diversification. It employs various strategies, represented as fund managers in traditional finance, based on the combination of smart contracts to increase the value of pool funding or act in the investors' best interests. An example of DeFi yield aggregator is Yearn vault, one of Yearn finance products.

The unique features of blockchain technology allow retail investors to easily access investment in DeFi yield aggregators, which are similar to mutual funds. Moreover, (Saengchote, 2022) investigates Compound investors' yield farming with a leverage strategy by examining the redeposit of borrowed tokens in the cToken contract (Compound's depository receipt) into accepted protocols for generating higher returns. The result shows that the DeFi yield aggregator is one of the investors who use leverage for yield farming. It can be stated that DeFi yield aggregator invests in a manner similar to hedge funds in traditional finance. It seems that using new technology can improve new investment opportunities in asset management for the financial market.

In traditional asset management, a mutual fund is a popular alternative investment that provides numerous advantages for increasing the accessibility of financial markets to retail investors. Several papers investigate the flow-performance relationship of mutual funds in traditional finance. It claims that rational investors are the key market factor in dealing with high and low quality of the mutual fund industry to maintain high-quality products in the market with information problems. (Ippolito, 1992) reports that fund flows are sensitive to past performance in a positive linear relationship. Next, (Chen, 2018; Chevalier & Ellison, 1997; Ferreira et al., 2012; Sirri & Tufano, 1998) also report a positive relationship, but in convexity. Furthermore, (Berk & Green, 2004) document that the flow-performance relationship is positive but not persistent. Lastly, (Ivković & Weisbenner, 2009) show that only inflow is related to performance.

We see much research explaining the fund flows and performance in traditional finance. Nevertheless, a few papers have been written to explain the conceptual level of DeFi yield aggregator. In this paper, we would like to further analyze the insight protocol by looking at a transaction level to examine a flow-performance relationship in DeFi yield aggregator for Yearn vault case study; whether this relationship is similar to traditional finance. Therefore, we can understand how the market handles many information problems through DeFi rational investors, which are the critical factor in the market equilibrium.

LITERATURE REVIEWS

Decentralized Finance (DeFi): On-chain asset management

Decentralized Finance (DeFi) is a new financial infrastructure with applications similar to traditional financial products, such as exchange, lending, derivatives, and on-chain asset management. This paper focuses on yield aggregators, one of the on-chain asset management. It is similar to asset management in traditional finance, but a set of smart contracts develops it. Furthermore, all data are enforced to be stored in blockchain. The previous work by (Cousaert

et al., 2021) describes its mechanism that allows investors to invest in the pool funds managed by smart contracts to generate yield by investment policy. Since we cannot update all transactions, including interest, in the blockchain every time because of having a fee. Therefore, investors will receive the depository receipt, representing the recorded index for accrued interests after the deposit. When investors want to withdraw, they must use the same depository receipts to redeem their principal and yield at any point in time. In contrast, the pool funds in asset management in traditional finance, e.g., mutual funds, are managed by fund managers. Moreover, it does not require depository receipts for recording the accrued interests. However, there are some risks that investors have to bear in asset management in traditional finance. For example, investors lack liquidity for withdrawals and transparency in observing their transactions. Furthermore, (Chevalier & Ellison, 1997) investigate agency issues between investors seeking to maximize return and fund managers seeking to profit from increased inflows which investment behavior of fund managers might have the potential to deviate from investors' best interests. In comparison, (Schär, 2021) provides the benefits of on-chain asset management in dealing with traditional finance problems. For example, investors can withdraw their funds at any time (permissionless), observe their token flows and balances by themselves (transparency), and reduce the agency problem for fund managers.

Flow-performance relationship of mutual funds in traditional finance

Several previous papers study fund flows in mutual funds and past performance, which have a positive relationship. Mutual fund investors will invest in the funds depending on the managers' ability and fund management fees. Regarding managers' ability, (Ippolito, 1992) shows a positive linear flow-performance relationship indicating that the investment behavior of rational investors denies poor-quality funds and allocates their capital to the best performers. Furthermore, (Chen, 2018; Chevalier & Ellison, 1997; Ferreira et al., 2012; Sirri & Tufano, 1998) also report that the relationship result is similar to (Ippolito, 1992), but the relationship is convexity. Moreover, (Berk & Green, 2004) document that the flow-performance relationship is positive; however, this relationship is not persistent because it depends on individual manager ability and decisions. In addition, some papers studied individual fund-level inflows and outflows that are affected by performance differently. (Ivković & Weisbenner, 2009) show that inflows are only related to relative performance to other funds pursuing the same objective. In contrast, outflows are related to absolute returns and taxes after selling the shares of funds.

For the fund management fee, (Berk & Green, 2004; Sirri & Tufano, 1998) show that as the fee increase, the funds with higher fees will be less attractive when compared with passive funds that affect a flow-performance relationship.

RESEARCH METHODOLOGY

The Data used in the study

Yearn vault performance

Yearn finance launched in 2020, and it is one of the fastest-growing DeFi protocols which are run on the Ethereum blockchain. The concept of annual percentage yield (APY) does not apply to Yearn vault performance because the interest rate of Yearn vault does not fix, as it is in traditional finance. Thus, return on investment (ROI) is used instead to measure the performance of Yearn. The ROI is a ratio between net profit and cost; however, ROI is calculated indifferently in this case. Hence, ROI is a key performance indicator to evaluate investment efficiency, which can be comparable to different vaults, and to represent approximate returns in the short-term such as daily and weekly. The estimated ROI is calculated by the difference in depository receipt price (or yvTokenPrice) in a specific timeframe.

Fund flows, return on investment, total net asset

In Fig. 1, we begin this part by explaining how to extract our observations using Web3.py, one of the python libraries, to communicate with the Ethereum blockchain and obtain the data in smart contracts. The Ethereum blockchain is a peer-to-peer network in which individual nodes can access all blockchain data. Hence, we use Alchemyapi.io as a free-node web service provider to obtain the API (Application Programming Interface) and the Ethereum network URL before we code in python to connect the blockchain nodes. Once we understand how to connect the blockchain nodes, we use python to get the latest daily block number of the Ethereum blockchain at the end of the day; since all transactions are stored in the blockchain. Moreover, we have to retrieve each vault address and ABI (Abstract Binary Interface) from the Etherscan.io website, and we also have to know how to call the function in smart contracts, which can see in the protocol document, to read the blockchain data. In this paper, we use 'pricePerShare', 'totalAssets', and 'totalDebt' functions to obtain the daily yvToken price, total asset, and total debt, respectively. When we have all our input variables, we go to the python shell and import the required python modules and libraries; then, we start to code in the logic of looping over the latest daily block number between January and December 2021.

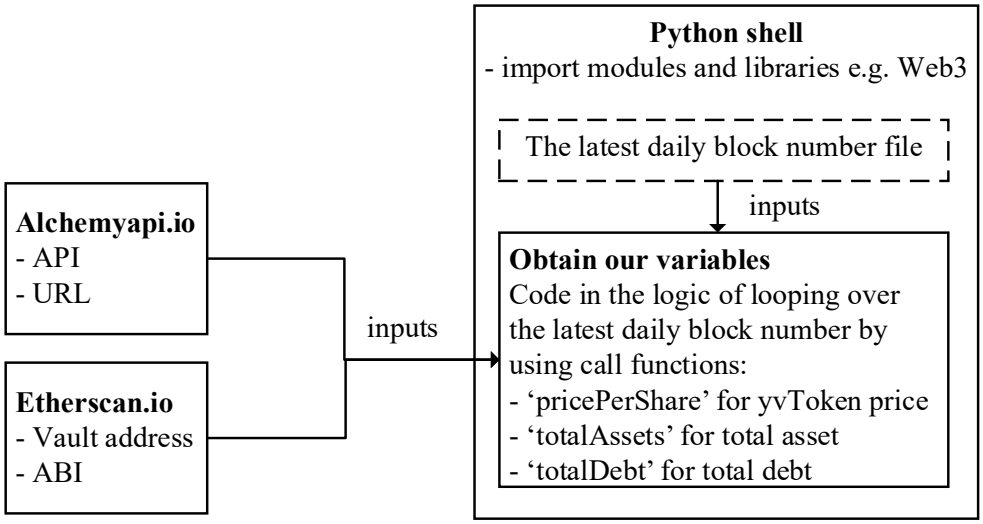

Figure 1 Variable extraction flows from the Ethereum blockchain

We collect the daily data from the extraction process; therefore, we have to change our data on a weekly basis for our regression analysis. Since we already obtain the yvTokenPrice from the Ethereum blockchain, we can compute the percentage of return on investment in a specific timeframe:

$$ROI_{i,t} = \frac{yvToken\,\mathrm{Pr}ice_{i,t} - yvToken\,\mathrm{Pr}ice_{i,t-1}}{yvToken\,\mathrm{Pr}ice_{i,t-1}} \quad (1)$$

Where (1) $ROI_{i,t}$ is the percentage of return on investment of vault i at week t. (2) $yvToken\,\mathrm{Pr}ice_{i,t}$ is the price of wrapped token of vault i at the end of week t. (3) $yvToken\,\mathrm{Pr}ice_{i,t-1}$ is the price of wrapped token of vault i at the end of week t-1.

Again, we obtain the total asset and total debt from the Ethereum blockchain. We can calculate the total net asset (TNA) as part of fund flows calculation.

$$TNA_{i,t} = TotalAsset_{i,t} - TotalDebt_{i,t} \quad (2)$$

For our dependent variable, the percentage of fund flows is calculated by following (Sirri & Tufano, 1998) under the reinvestment assumption.

$$Flow_{i,t} = \frac{TNA_{i,t} - TNA_{i,t-1} * (1 + ROI_{i,t})}{TNA_{i,t-1}} \quad (3)$$

Where (1) $Flow_{i,t}$ is the percentage of fund flows of vault i at week t. (2) $\ln(TNA)_{i,t}$ is the total net asset of vault i at the end of week t. (3) $\ln(TNA)_{i,t-1}$ is the total net asset of vault i at the end of week t-1.(4) $ROI_{i,t-1}$ is the percentage of return on investment of vault i at week t.

Incentive rewards, market conditions

We retrieve the Yearn finance governance token price as an incentive reward (daily YFI price) and market condition factor (daily BTC price) in USD dollars by directly downloading the excel file from the Coingecko website between January and December 2021. Then, we change our data on a weekly basis.

Summary Statistics

Before we begin the analysis, we clean the data by trimming at 1% percentiles for the outliers and adjust our data by the mean and standard deviation of the individual vault to ensure that it is similar to a normal curve. Table. 1 summarizes the data statistics for all the main variables in weekly frequency used in our research from January to December 2021. We compute fund flows as the dependent variable following (Sirri & Tufano, 1998); the overall average fund flows is -30.2% per week (-1,570.4% per year), with a weekly standard deviation of 16.1% (837.2% per year). The independent variable is calculated using the Yearn finance instruction; the average lagged return on investment is 0.130% per week (6.76% per year), with a weekly standard deviation of 0.188% (9.78% per year). Finally, our control variables are reported in Table 1.

Table 1 Summary statistics of all main variables in weekly frequency from January to December 2021

Variables	Obs.	Mean	Std. Dev.	Min	Max	Median
%Flow	1,184	-30.2	16.1	-69.8	24.8	-30.5
%Flow of Stablecoin	163	-33.0	17.4	-66.2	20.6	-33.6
%Flow of Cryptocurrency	1,021	-29.8	15.8	-69.8	24.8	-30.1
%lagged ROI	2,053	0.130	0.188	0.000	1.35	0.060
Lagged ln(TNA)	1,507	7.70	5.37	-13.1	19.8	8.61
ln(YFI price)	2,219	10.5	0.216	9.88	11.3	10.4
ln(BTC price)	2,219	10.8	0.205	10.3	11.1	10.8
%BTC return	2,151	-0.449	9.82	-34.1	25.0	-0.230
%BTC volatility	2,152	3.76	1.16	1.69	8.23	3.58

Data analysis

Flow-performance relationship in DeFi yield aggregator

The first hypothesis is about the relationship between fund flows and fund performance because we want to examine how rational investors respond to the DeFi market. Hence, if a flow-performance relationship does not exist in DeFi yield aggregators, we expect fund flows not to increase over time in the individual vault that generates high returns. In other words, we should not see a statistically significant positive in β_1 which represents the coefficient of a recent performance.

We use a fixed effect model in our regression following (Ippolito, 1992) and variables following (Sirri & Tufano, 1998) to investigate our first hypothesis. We observe the data

between January and December 2021 and regress on a weekly basis. The regression is following:

$$Flow_{i,t} = \beta_0 + \beta_1 ROI_{i,t-1} + \beta_2 \ln(TNA)_{i,t-1} + \beta_3 \ln(YFI)_{i,t} + \beta_4 \ln(BTC)_{i,t} + \beta_5 (BTCreturn)_{i,t} + \beta_6 (BTCvol)_{i,t} + \varepsilon_{i,t} \quad (4)$$

Where (1) $Flow_{i,t}$ is the percentage of fund flows of vault i at week t under the reinvestment assumption. (2) $ROI_{i,t-1}$ is the percentage of the recent weekly vault i's performance. (3) $\ln(TNA)_{i,t-1}$ is a size of vault i at week t-1 in a natural logarithm form as a control variable. (4) $\ln(YFI)_{i,t}$ is Yearn finance governance rewards in a natural logarithm form as a control variable. This incentive reward might attract fund flows into Yearn finance. If it can increase fund flows, we should see a positive coefficient of ln(YFI). (5) $\ln(BTC)_{i,t}, (BTCreturn)_{i,t}, (BTCvol)_{i,t}$ are market condition proxies in the market price, return, and volatility.

Convexity in the flow-performance relationship

In the second hypothesis, we examine the shape of the relationship curve; whether there is a linear relationship between fund flows and performance. If the relationship curve is linear, we expect the size of fund flows not to respond very differently for all ranking performers; to put it another way, the magnitude of β_1 should not differ significantly across all rankings.

We also use a fixed effect model in our regression following (Ippolito, 1992) and variables following (Sirri & Tufano, 1998), which is the same as the above hypothesis, but now we change the independent variable from $ROI_{i,t-1}$ to $Rank^{k}_{i,t-1}$. The regression is following:

$$Flow_{i,t} = \beta_0 + \beta_1 Rank^{k}_{i,t-1} + \beta_2 \ln(TNA)_{i,t-1} + \beta_3 \ln(YFI)_{i,t} + \beta_4 \ln(BTC)_{i,t} + \beta_5 (BTCreturn)_{i,t} + \beta_6 (BTCvol)_{i,t} + \varepsilon_{i,t} \quad (5)$$

Where $Rank^{k}_{i,t-1}$ are:

$$Rank^{Poor}_{i,t-1} = Min(Rank_{i,t-1}, 0.25)$$

$$Rank^{Middle}_{i,t-1} = Min(Rank_{i,t-1} - Rank^{Poor}_{i,t-1}, 0.50)$$

$$Rank^{Top}_{i,t-1} = Min(Rank_{i,t-1} - Rank^{Poor}_{i,t-1} - Rank^{Middle}_{i,t-1}, 0.25)$$

(1) $Rank_{i,t-1}$ is a vault's fractional rank representing its quartile performance relative to other vaults in the same period, which ranges from 0 to 1. (2) $Rank^{Top}_{i,t-1}$ is the 1st performance quartile. (3) $Rank^{Middle}_{i,t-1}$ is the 2nd-3rd performance quartile. (4) $Rank^{Poor}_{i,t-1}$ is the 4th performance quartile.

RESEARCH RESULTS

The flow-performance relationship in DeFi yield aggregator

We do the Hausman test to select the appropriate model between fixed and random effect models before doing an unbalanced panel data regression analysis. The P-value of the Hausman test is 0.011, indicating that the fixed effect model is suitable for our analysis.

Table 2 shows the estimation results of a flow-performance relationship using a fixed-effect regression model in Eq. 4. If a flow-performance relationship does not exist in DeFi yield aggregators, we expect fund flows not to increase over time in the individual vault that

generates high returns. In other words, we should not see a significant positive coefficient of recent performance.

Before we go to our main result, we should observe the market condition proxies: BTC price level, return, and volatilities. Column 1 of Table 2 illustrates the baseline regression of fund flows and market proxies. On average, fund flows do not relate to the movement of market conditions because our regressors are not statistically significant.

Next, we include the main regressor, which is recent performance. The result shows we can reject the null hypothesis that a flow-performance relationship does not exist in DeFi yield aggregators because the average weekly fund flows for only stablecoin activity exhibits a significant positive coefficient $ROI_{i,t-1}$ of 15.6% with a 5% significance level. It can imply that a 1% increase in recent performance is associated with a 15.6% increase in fund flows with a 5% significance level. The increase of 15.6% in fund flows is much higher than the weekly average of -30.2% per week. The result is consistent with several papers, for example, (Berk & Green, 2004; Chen, 2018; Chevalier & Ellison, 1997; Ferreira et al., 2012; Ippolito, 1992; Ivković & Weisbenner, 2009; Sirri & Tufano, 1998) show that fund flows are sensitive to past performance and have a positive relationship in mutual funds. (Ippolito, 1992) reports that rational investors are sensitive to recent extreme performance and react to new information about product quality; thus, they will allocate their money to the most recent performance to maintain market equilibrium. Moreover, (Sirri & Tufano, 1998) document investor sensitivity to funding performance with a costless search in which investors can have mutual fund information at no cost. However, (Ivković & Weisbenner, 2009) show that only inflow is related to performance.

In DeFi, the return on investment does not reflect actual wealth for using cryptocurrency deposited, while it is valid for a stablecoin. Usually, the return on investment is positive, and the number of tokens increases after redemption. We can see its worth by multiplying it by the token price. Sometimes our wealth increases or decreases because of the token price fluctuations. Therefore, most people prefer to deposit stablecoin more than cryptocurrency. That is why our result shows a statistically significant in only stablecoin. Compared with traditional finance, stablecoin investment is the same as domestic portfolio investment since the percentage of return on investment has already reflected in the wealth. On the other hand, cryptocurrency investment is similar to foreign portfolio investment as the percentage of return on investment cannot tell actual investor wealth because of the exchange rate risk.

Table 2 The regression results of the flow-performance relationship in DeFi yield aggregator

VARIABLES	**(1)** **All**	**(2)** **All**	**(3)** **All**	**(4)** **All**	**(5)** **Stablecoin**	**(6)** **Crypto**
ln(BTC)	1.80	1.61	2.78	1.89	-4.23	2.28
	(2.83)	(2.93)	(3.04)	(3.83)	(8.09)	(4.83)
%BTC return	-0.011	-0.003	-0.015	-0.013	-0.107	0.004
	(0.043)	(0.043)	(0.041)	(0.041)	(0.115)	(0.047)
%BTC volatility	0.352	0.379	0.398	0.374	0.227	0.300
	(0.321)	(0.327)	(0.323)	(0.340)	(1.25)	(0.358)
%lagged ROI		0.766	0.884	0.977	15.6**	0.919
		(2.06)	(2.05)	(2.07)	(5.73)	(2.18)
lagged ln(TNA)			-0.683***	-0.686***	-0.341	-0.704***
			(0.235)	(0.236)	(0.668)	(0.257)
ln(YFI)				1.75	16.7	0.780
				(3.24)	(10.4)	(3.30)

VARIABLES	(1) All	(2) All	(3) All	(4) All	(5) Stablecoin	(6) Crypto
Constant	-55.2*	-48.1	-56.1*	-64.9**	-155.9	-59.4
	(30.4)	(31.9)	(32.9)	(31.9)	(90.2)	(35.6)
Observations	1,184	1,158	1,158	1,158	160	998
R-squared	0.053	0.052	0.064	0.064	0.368	0.066
Number of Vaults	65	65	65	65	9	56
Week Dummy	YES	YES	YES	YES	YES	YES
Vault Dummy	YES	YES	YES	YES	YES	YES

*Note: Value in parenthesis indicates standard errors. Stars represent statistically significant levels, with *, **, and *** denoting 10%, 5%, and 1%, respectively*

Finally, we include our control variables as regressors, and the estimated coefficient of recent performance is still statistically significant in a positive value. For the size of the vaults, the statistical result reports a negative value for only cryptocurrency vaults. It can imply that a 1% increase in vault size is associated with an 11.3% decrease in fund flows with a 1% significance level; this number is decreasing less than the average fund flows reported in Table 1. On average, most investors prefer smaller vaults to larger ones. This result is consistent with (Sirri & Tufano, 1998). However, there is no relationship between fund flows and incentive rewards (YFI) since it is not statistically significant. Table 3 shows the correlation between YFI and stablecoin and popular cryptocurrency prices deposited are close to zero, implying that YFI may not be a significant factor in attracting investors.

Table 3 Matrix of correlations between YFI and stablecoin and popular cryptocurrency prices

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) YFI	1.000								
(2) DAI	-0.143	1.000							
(3) LUSD	0.054	0.216	1.000						
(4) RAI	-0.063	0.192	0.181	1.000					
(5) sUSD	0.315	-0.003	0.129	-0.048	1.000				
(6) TUSD	-0.179	0.376	0.249	0.338	-0.059	1.000			
(7) USDC	-0.082	0.470	0.199	0.253	-0.047	0.729	1.000		
(8) USDT	-0.055	0.057	-0.041	-0.075	-0.056	0.050	0.064	1.000	
(9) BTC	0.168	-0.072	-0.243	0.527	-0.008	0.015	0.017	-0.099	1.000

In Table 4, we further investigate the stablecoin; since only stablecoin significantly impacts a flow-performance relationship, we can investigate what drives the returns. The statistical result shows that stablecoin vaults with only a leverage strategy play an essential role in a flow-performance relationship with a 10% significance level; the coefficient indicates that a 1% increase in recent performance corresponds to a 14.2% increase in fund flows, which is greater than the average value. Furthermore, the average percentage of recent ROI for stablecoin with leverage is 0.131% more than non-leverage, which is 0.109%.

Table 4 The regression results of the flow-performance relationship in DeFi yield aggregator by strategy

VARIABLES	(1) Leverage	(2) Non-Lev	(3) Stable Lev	(4) Stable Non-Lev	(5) Crypto Lev	(6) Crypto Non-Lev
%lagged ROI	1.60	3.64	14.2*	-0.627	1.32	-1.93
	(2.49)	(4.44)	(35.5)	(35.3)	(2.59)	(3.38)
lagged ln(TNA)	-0.914***	0.005	-3.03***	0.808	-0.798***	-0.189
	(0.265)	(0.560)	(0.380)	(0.514)	(0.258)	(1.37)
ln(YFI)	2.63	2.22	22.3	1.38	0.342	2.91
	(3.63)	(6.04)	(16.4)	(15.4)	(3.73)	(4.98)
ln(BTC)	1.19	1.47	-2.82	-2.53	1.81	9.09
	(5.15)	(7.50)	(16.2)	(13.9)	(6.04)	(8.85)
%BTC return	0.011	-0.085	-0.000	-0.075	0.018	-0.046
	(0.052)	(0.054)	(0.023)	(0.117)	(0.056)	(0.109)
%BTC volatility	0.228	0.687	-0.464	2.40	0.274	-0.131
	(0.357)	(0.754)	(1.35)	(2.10)	(0.388)	(0.256)
Constant	-63.3	-74.5	-178.5	-42.9	-49.1	-155.5
	(38.9)	(68.1)	(179.9)	(197.0)	(44.6)	(121.5)
Observations	964	194	89	71	875	123
R-squared	0.090	0.283	0.646	0.640	0.082	0.391
Number of Vaults	55	10	4	5	51	5
Week Dummy	YES	YES	YES	YES	YES	YES
Vault Dummy	YES	YES	YES	YES	YES	YES
Avg. of %lagged ROI	0.129	0.136	0.131	0.109	0.129	0.159

*Note: Value in parenthesis indicates standard errors. Stars represent statistically significant levels, with *, **, and *** denoting 10%, 5%, and 1%, respectively*

Hence, we imply that the behavior of DeFi investors is similar to traditional finance investors; most investors prefer high returns because the leverage strategy offers a chance of higher returns, including higher risks. Therefore, before we go to an example of the vaults with leverage strategy, we would like to explain interoperability in DeFi. The capital movements in traditional finance will incur costs due to various financial institutions providing various financial services. However, DeFi applications have an interoperability characteristic across different financial services because they are built on permissionless blockchain technology and deployed by the smart contract.

(Saengchote, 2021) looks into the DAI stablecoin destination flows generated by MakerDAO (a lending-borrowing protocol) using collateralized accepted tokens. According to the findings, the Compound protocol (a lending-borrowing protocol) is one of the popular DAI destinations. Furthermore, (Saengchote, 2022) also investigates yield farming with the leverage of Compound investors by examining the redeposit of borrowed tokens in the cToken contract (Compound's depository receipt) into accepted protocols. Finally, the result shows that the yield aggregator is one of the investors who use leverage for yield farming.

An example of Yearn vaults with a leverage strategy is DAI v.4.3 with GenLevComp strategy, which has MakerDAO and Compound protocol doing yield farming with leverage by redepositing minted DAI from MakerDAO (use the underlying assets as collateral) to Compound protocol. However, we do not track the route of cToken minted from the Compound. If we compare it with traditional finance, the pawnshop is similar to yield farming

by bringing investors' stuff to pledge for money. However, depositors cannot use their depository receipts to leverage it.

Convexity in the flow-performance relationship

From the first hypothesis's empirical result, we know a relationship exists between fund flows and performance. In this section, we want to examine the shape of the relationship curve using a fixed-effect regression model in Eq. 5; in other words, whether there is a linear relationship between fund flows and performance. If the relationship curve is linear, we expect the size of fund flows not to respond very differently for all ranking performers; to put it another way, the magnitude of the coefficient should not differ significantly across all rankings.

Fig. 2 and 3 illustrate the initial analysis of the fund flows and performance relationship; it is not linear but convexity. Next, we do a multivariate analysis. Column 1 and 2 of Table 5 report the result of continuous and discrete rankings sensitivity. There are no statistically significant regressors. However, the result of further investigation of each token type in Column 3 can confirm that we can reject the null hypothesis of the linear relationship. Because fund flows are sensitive to recent performance ranking, this is sensitive in the non-linear curve, mainly in the top performers using stablecoins deposited. The coefficient suggests that a 1% increase in recent performance is associated with a 44.4% increase in fund flows with a 5% significance level. The 44.4% increase in fund flows outperforms the weekly average of -30.2%. However, there is no relationship between a flow-performance relationship for the middle and poor performers. Hence, our initial analysis graph can support this statistic by returning to Fig. 2 and 3. Our result is consistent with (Chen, 2018; Chevalier & Ellison, 1997; Ferreira et al., 2012; Sirri & Tufano, 1998), showing that the relationship between recent performance and fund flows is convex. On the other hand, (Ippolito, 1992) reports a positive linear relationship between fund flows and performance.

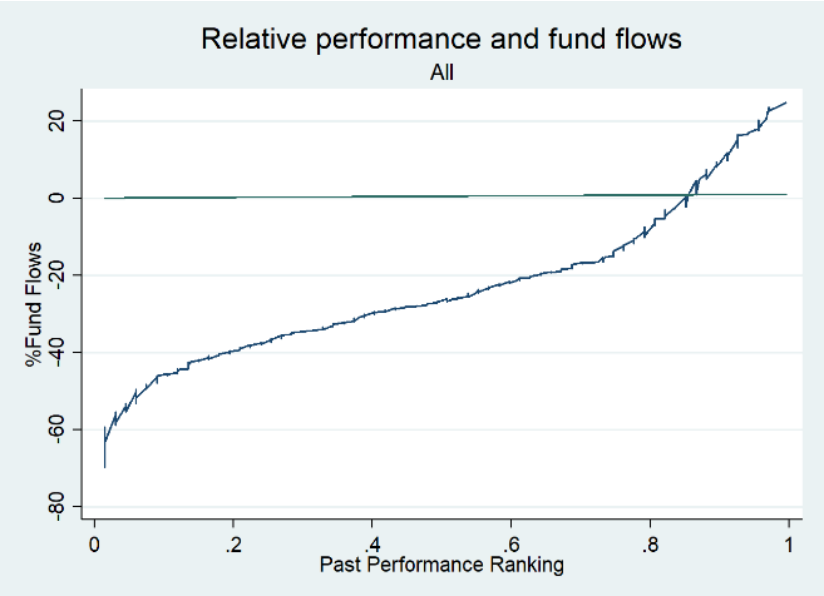

Figure 2 Relative performance and fund flows of all tokens deposited

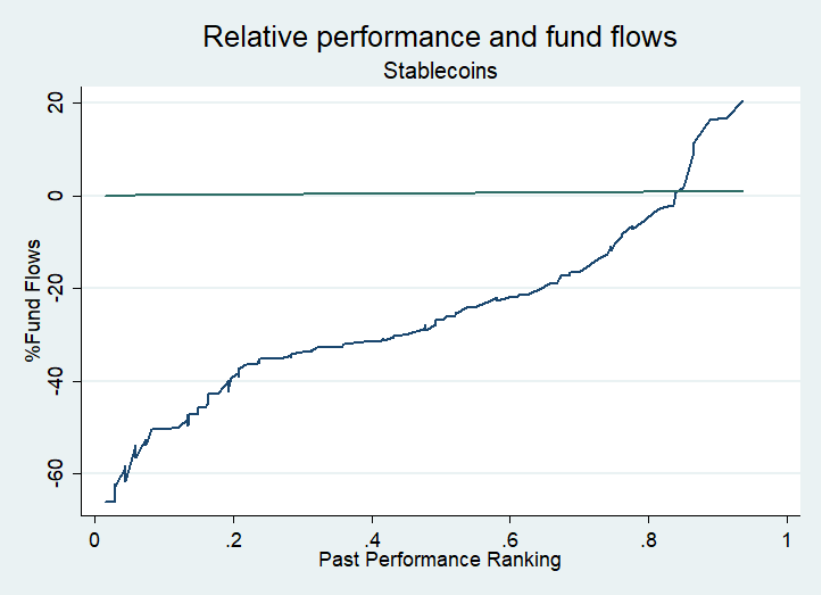

Figure 3 Relative performance and fund flows of only stablecoin deposited

Table 5 The regression results of the relative performance and fund flows by token type

VARIABLES	(1) Continuous rank variable [continuous]	(2) Discrete categories [discrete]	(3) Stablecoin	(4) Stable Lev	(5) Stable Non-Lev	(6) Crypto	(7) Crypto Lev	(8) Crypto Non-Lev
Rank	-2.97							
	(2.23)							
Top quartile		3.48	44.4**	64.2	40.6	-2.92	-4.38	-48.5
		(14.4)	(21.8)	(29.9)	(118.5)	(14.3)	(16.8)	(64.6)
Middle quartile		-5.67*	-7.58	-5.36	-18.7	-5.10	-5.49	-3.49
		(3.30)	(4.59)	(26.5)	(20.3)	(3.45)	(3.77)	(5.53)
Poor quartile		4.67	-22.5	-66.3	51.6	5.84	5.59	-48.1***
		(8.67)	(40.9)	(37.3)	(31.1)	(8.03)	(8.57)	(8.34)
lagged ln(TNA)	-0.665***	-0.656***	-0.365	-2.73**	0.642	-0.659**	-0.753***	-0.147
	(0.235)	(0.239)	(0.729)	(0.503)	(0.448)	(0.260)	(0.258)	(1.53)
ln(YFI price)	1.98	1.82	15.0	15.4	3.36	0.868	0.596	8.57
	(3.21)	(3.21)	(9.13)	(15.8)	(15.2)	(3.25)	(3.67)	(6.10)
ln(BTC Price)	1.25	1.63	-4.16	-7.65	-9.73	2.02	1.59	8.21
	(3.82)	(3.89)	(9.62)	(13.6)	(23.5)	(4.83)	(6.05)	(8.81)
%BTC return	-0.004	-0.006	-0.073	0.110	-0.122	0.010	0.029	-0.073
	(0.040)	(0.040)	(0.139)	(0.063)	(0.086)	(0.045)	(0.053)	(0.099)
%BTC volatility	0.407	0.407	0.090	-0.551	1.94	0.354	0.359	-0.728
	(0.332)	(0.334)	(1.20)	(1.51)	(2.93)	(0.353)	(0.391)	(0.707)
Constant	-60.4*	-64.0**	-132.2	-49.3	8.43	-59.2	-51.2	-187.0
	(31.8)	(31.6)	(102.4)	(200.4)	(255.5)	(36.0)	(45.9)	(142.9)
Observations	1,172	1,172	160	89	71	1,012	888	124
R-squared	0.066	0.067	0.367	0.659	0.655	0.069	0.084	0.433
Number of Vaults	65	65	9	4	5	56	51	5
Week Dummy	YES	YES	YES	YES	YES	YES	YES	YES
Vault Dummy	YES	YES	YES	YES	YES	YES	YES	YES

*Note: Value in parenthesis indicates standard errors. Stars represent statistically significant levels, with *, **, and *** denoting 10%, 5%, and 1%, respectively*

DISCUSSION & CONCLUSION

Our findings show that, on average, fund flows do not relate to market movements. Hence, we analyze each token type deposited: stablecoin and cryptocurrency. We find that the flow-performance relationship exists in the positive sign for only the stablecoin vault since it can reflect the actual wealth of investors. The result in DeFi yield aggregator is consistent with

several papers on traditional mutual funds, e.g., (Berk & Green, 2004; Chen, 2018; Chevalier & Ellison, 1997; Ferreira et al., 2012; Ippolito, 1992; Ivković & Weisbenner, 2009; Sirri & Tufano, 1998). They show that fund flows are sensitive to past performance and have a positive relationship. Moreover, we further examine the investor behaviors; which strategies they prefer. The result reports that the stablecoin holders would like to deposit their assets into the leverage strategy because of high returns; however, we do not find a significant statistical result for cryptocurrency. Furthermore, we find that investors prefer smaller vaults to larger vaults, which is consistent with (Sirri & Tufano, 1998), and we do not find a relationship between incentive rewards and fund flows. Finally, we also test the shape of the relationship; it is a convexity curve for only the stablecoin vault. Our result is consistent with (Chen, 2018; Chevalier & Ellison, 1997; Ferreira et al., 2012; Sirri & Tufano, 1998), showing that the relationship between recent performance and fund flows is convex. While (Ippolito, 1992) reports a positive linear relationship. Lastly, our research's implication can apply to investors because all our findings point out that most rational investors in DeFi yield aggregator prefer to deposit stablecoin more than cryptocurrency. Moreover, stablecoin holders would like to invest in funds with good performance. Therefore, new or existing investors can adopt our empirical results to create a suitable investment strategy to satisfy their return on investment. However, our research might have a limitation because DeFi has many blockchains for deploying yield aggregators, but we only focus on the Ethereum blockchain due to time limitations for extracting the data from the individual blockchain and understanding the mechanism of each yield aggregator protocol. Therefore, other papers interested in this area might explore other protocols and blockchains to analyze and compare the study results.

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