Moonwell Finance

Smart Contract Audit Report

Prepared by: **Halborn**

Date of Engagement: **January 24th, 2022 - February 1st, 2022**

Visit: **Halborn.com**

DOCUMENT REVISION HISTORY

VERSION	MODIFICATION	DATE	AUTHOR
0.1	Document Creation	02/01/2022	Ataberk Yavuzer
0.2	Document Edits	02/02/2022	Ataberk Yavuzer
0.3	Draft Review	02/02/2022	Gabi Urrutia
1.0	Remediation Plan	02/07/2022	Ataberk Yavuzer
1.1	Remediation Plan Review	02/07/2022	Gabi Urrutia

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EXECUTIVE OVERVIEW

1.1 INTRODUCTION

Moonwell Finance engaged Halborn to conduct a security audit on their smart contracts beginning on January 24th, 2022 and ending on February 1st, 2022. The security assessment was scoped to the smart contracts provided to the Halborn team.

1.2 AUDIT SUMMARY

The team at Halborn was provided one week for the engagement and assigned a full-time security engineer to audit the security of the smart contract. The security engineer is a blockchain and smart-contract security expert with advanced penetration testing, smart-contract hacking, and deep knowledge of multiple blockchain protocols.

The purpose of this audit is to:

- Ensure that smart contract functions operate as intended
- Identify potential security issues with the smart contracts

In summary, Halborn identified some security risks that were mostly addressed by the Moonwell Finance team.

1.3 TEST APPROACH & METHODOLOGY

Halborn performed a combination of manual and automated security testing to balance efficiency, timeliness, practicality, and accuracy in regard to the scope of the smart contract audit. While manual testing is recommended to uncover flaws in logic, process, and implementation; automated testing techniques help enhance coverage of smart contracts and can quickly identify items that do not follow security best practices. The following phases and associated tools were used throughout the term of the audit:

- Research into architecture and purpose.
- Smart Contract manual code review and walkthrough.
- Graphing out functionality and contract logic/connectivity/functions(solgraph)
- Manual Assessment of use and safety for the critical Solidity variables and functions in scope to identify any arithmetic related vulnerability classes.
- Static Analysis of security for scoped contract, and imported functions.(Slither)
- Dynamic Analysis (ganache-cli, brownie, hardhat)

RISK METHODOLOGY:

Vulnerabilities or issues observed by Halborn are ranked based on the risk assessment methodology by measuring the **LIKELIHOOD** of a security incident and the **IMPACT** should an incident occur. This framework works for communicating the characteristics and impacts of technology vulnerabilities. The quantitative model ensures repeatable and accurate measurement while enabling users to see the underlying vulnerability characteristics that were used to generate the Risk scores. For every vulnerability, a risk level will be calculated on a scale of 5 to 1 with 5 being the highest likelihood or impact.

RISK SCALE - LIKELIHOOD

5 - Almost certain an incident will occur.
4 - High probability of an incident occurring.
3 - Potential of a security incident in the long term.
2 - Low probability of an incident occurring.
1 - Very unlikely issue will cause an incident.

RISK SCALE - IMPACT

5 - May cause devastating and unrecoverable impact or loss.
4 - May cause a significant level of impact or loss.
3 - May cause a partial impact or loss to many.
2 - May cause temporary impact or loss.
1 - May cause minimal or un-noticeable impact.

The risk level is then calculated using a sum of these two values, creating a value of 10 to 1 with 10 being the highest level of security risk.

10 - CRITICAL
9 - 8 - HIGH
7 - 6 - MEDIUM
5 - 4 - LOW
3 - 1 - VERY LOW AND INFORMATIONAL

1.4 SCOPE

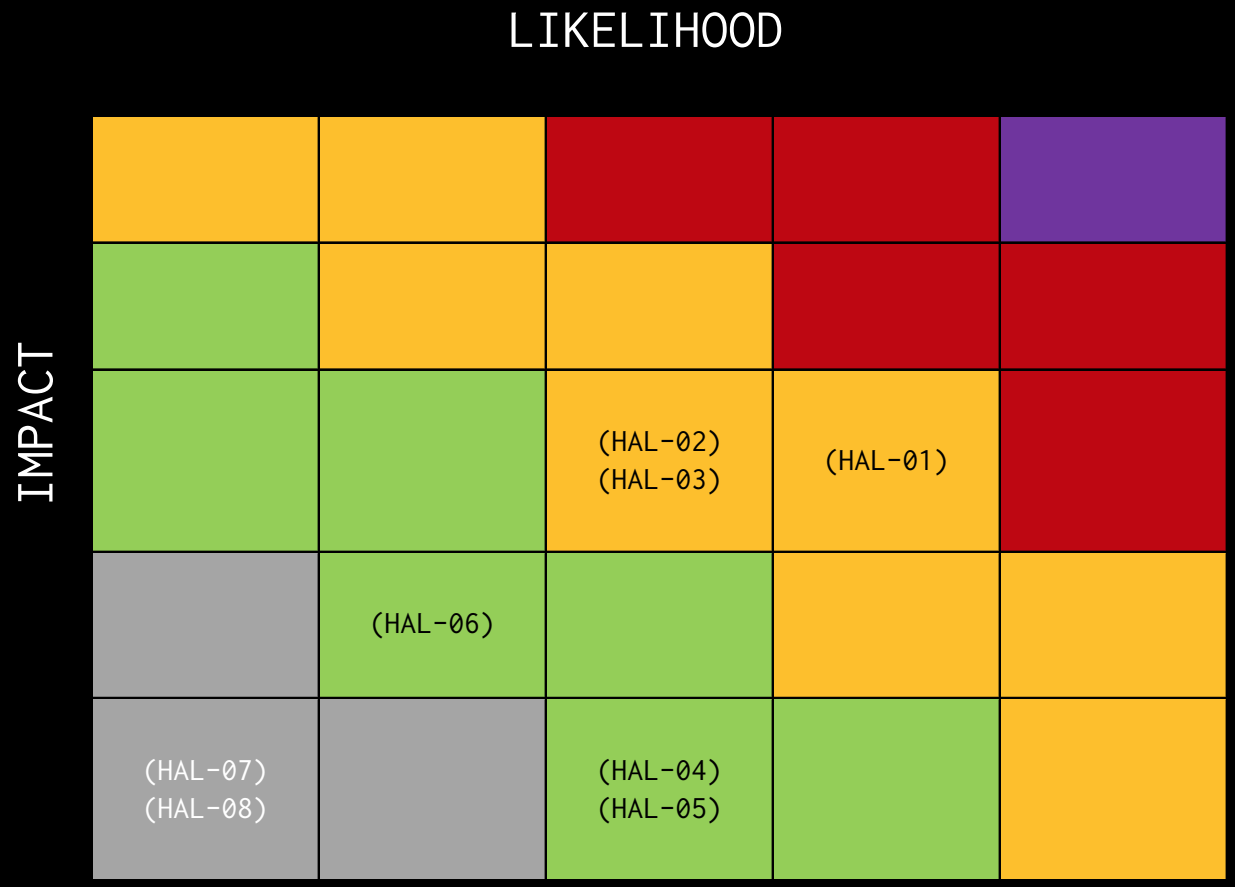
1. Moonwell Finance Smart Contracts

   (a) Repository: Moonwell Finance - Moonwell Core

   (b) Commit ID: 70fb9c4a899ba0cd787855582ea3bd803317f51a

2. ASSESSMENT SUMMARY & FINDINGS OVERVIEW

CRITICAL	HIGH	MEDIUM	LOW	INFORMATIONAL
0	0	3	3	2



EXECUTIVE OVERVIEW

SECURITY ANALYSIS	RISK LEVEL	REMEDIATION DATE
(HAL-01) ALLOWING ERC777-KIND TOKENS ON PROTOCOL LEADS RE-ENTRANCY	Medium	SOLVED - 02/04/2022
(HAL-02) USE OF DEPRECATED CHAINLINK API	Medium	SOLVED - 02/04/2022
(HAL-03) ASSETS MAY LOCKED DOWN ON GOVERNORALPHA CONTRACT	Medium	SOLVED - 02/04/2022
(HAL-04) SHORT CIRCUIT IS NECESSARY FOR GAS OPTIMIZATION	Low	NOT APPLICABLE
(HAL-05) GOVERNORALPHA DOES NOT CONTROL QUEUED PROPOSALS ON CANCEL METHOD	Low	NOT APPLICABLE
(HAL-06) MISSING ZERO ADDRESS CHECKS	Low	RISK ACCEPTED
(HAL-07) MULTIPLE PRAGMA VERSIONS	Informational	SOLVED - 02/04/2022
(HAL-08) UNUSED FUNCTION PARAMETERS	Informational	SOLVED - 02/04/2022

FINDINGS & TECH DETAILS

3.1 (HAL-01) ALLOWING ERC777-KIND TOKENS ON PROTOCOL LEADS RE-ENTRANCY - MEDIUM

Description:

The ERC777 standard allows the token contract to notify senders and recipients when ERC777 tokens are sent or received from their accounts with function hooks. These hooks are called as callbacks. If the recipient of the token is a smart contract, the smart contract may cause to re-entrancy by calling another transfer function.

During the tests, it was seen that the protocol could be affected by this vulnerability if ERC777-kind tokens are planned to be used. This may cause loss of funds.

Code Location:

Listing 1: MToken.sol (Lines 701,702,717)

```
696         //////////////////////////
697         // EFFECTS & INTERACTIONS
698         // (No safe failures beyond this point)
699
700         /* We write previously calculated values into storage */
701         totalSupply = vars.totalSupplyNew;
702         accountTokens[redeemer] = vars.accountTokensNew;
703
704         /* We emit a Transfer event, and a Redeem event */
705         emit Transfer(redeemer, address(this), vars.redeemTokens);
706         emit Redeem(redeemer, vars.redeemAmount, vars.redeemTokens
                );
707
708         /* We call the defense hook */
709         comptroller.redeemVerify(address(this), redeemer, vars.
                redeemAmount, vars.redeemTokens);
710
711         /*
```

```
712          * We invoke doTransferOut for the redeemer and the
                 redeemAmount.
713          *  Note: The mToken must handle variations between ERC-20
                  and GLMR underlying.
714          *  On success, the mToken has redeemAmount less of cash.
715          *  doTransferOut reverts if anything goes wrong, since we
                  can't be sure if side effects occurred.
716          */
717         doTransferOut(redeemer, vars.redeemAmount);
718
719         return uint(Error.NO_ERROR);
```

Risk Level:

Likelihood - 4
Impact - 3

Recommendation:

The supported tokens should be white-listed to ensure that no hijacking mechanism could be implemented, such as ERC777. Furthermore, check-effect-interactions should be controlled properly to avoid any re-entrancy issue.

Remediation Plan:

SOLVED: Moonwell Team solved this issue by implementing Reentrancy Guard and better check-effect-interaction design to Comptroller.sol contract.

Commit ID: **65407b94e6da45a320f00819b59a92a38dc57eba**

3.2 (HAL-02) USE OF DEPRECATED CHAINLINK API - MEDIUM

Description:

The ChainlinkOracle contract uses Chainlink's deprecated API latestAnswer(). Such functions might suddenly stop working if Chainlink stopped supporting deprecated APIs. This method will return the last value, but it is possible to check if the data is fresh.

Code Location:

Listing 2: ChainlinkOracle.sol (Lines 57,59)

```
52 function getChainlinkPrice(AggregatorV2V3Interface feed) internal
       view returns (uint) {
53         // Chainlink USD-denominated feeds store answers at 8
               decimals
54         uint decimalDelta = uint(18).sub(feed.decimals());
55         // Ensure that we don't multiply the result by 0
56         if (decimalDelta > 0) {
57             return uint(feed.latestAnswer()).mul(10**decimalDelta)
                   ;
58         } else {
59             return uint(feed.latestAnswer());
60         }
61     }
```

Risk Level:

Likelihood - 3
Impact - 3

Recommendation:

It is recommended to use latestRoundData() method instead of latestAnswer(). This method allows executing some extra validations as shown as below:

Listing 3: Extra Validations (Lines 2,3,4)

```
1 (roundId, rawPrice, , updateTime, answeredInRound) =
    AggregatorV3Interface(feed).latestRoundData();
2         require(rawPrice > 0, "Chainlink price cannot be lower
              than 0");
3         require(updateTime != 0, "Round is in incompleted state");
4         require(answeredInRound >= roundId, "Stale price");
```

Remediation Plan:

SOLVED: This issue was solved by implementing better ChainLink Oracle API call (latestRoundData()).

Commit ID: **d7fe59cc8c810189dfd4754d8ebdd08863c59f52**

3.3 (HAL-03) ASSETS MAY LOCKED DOWN ON GOVERNORALPHA CONTRACT - MEDIUM

Description:

Eth sent to Timelock will be locked in current implementation.

Code Location:

Listing 4: GovernorAlpha.sol (Lines 205)

```
200 function execute(uint proposalId) external {
201         require(state(proposalId) == ProposalState.Queued, "
                GovernorAlpha::execute: proposal can only be executed
                if it is queued");
202         Proposal storage proposal = proposals[proposalId];
203         proposal.executed = true;
204         for (uint i = 0; i < proposal.targets.length; i++) {
205             timelock.executeTransaction(proposal.targets[i],
                    proposal.values[i], proposal.signatures[i],
                    proposal.calldatas[i], proposal.eta);
206         }
207         emit ProposalExecuted(proposalId);
208     }
```

Proof Of Concept:

- Set up the governance contracts (GovernanceAlpha, Timelock).
- Send eth to timelock contract.
- Set up a proposal to send 0.1 eth out. Code snippet in ether.js below. proxy refers to GovernorAlpha.

Listing 5

```
1     await proxy.propose(
2       [signers[3].address],
3       [ethers.utils.parseEther("0.1")],
4       [""],
```

```
5       [ethers.BigNumber.from(0)],
6       "Send funds to 3rd signer"
7     );
```

Listing 6

```
1 await proxy.execute(2);  // this fails
2 await proxy.execute(2, {value: ethers.utils.parseEther("0.1")})
      // this would work
```

Risk Level:

Likelihood - 3
Impact - 3

Recommendation:

Consider applying the following changes.

Listing 7

```
1     function execute(uint proposalId) external {
2         require(state(proposalId) == ProposalState.Queued, "
              GovernorAlpha::execute: proposal can only be executed
              if it is queued");
3         Proposal storage proposal = proposals[proposalId];
4         proposal.executed = true;
5         for (uint i = 0; i < proposal.targets.length; i++) {
6             timelock.executeTransaction(proposal.targets[i],
                  proposal.values[i], proposal.signatures[i],
                  proposal.calldatas[i], proposal.eta);
```

```
        }
        emit ProposalExecuted(proposalId);
    }
```

Reference:

https://github.com/compound-finance/compound-protocol/pull/177/files

Remediation Plan:

SOLVED: This issue was solved by removing `payable` keyword and `call.value()` method from the `execute()` function on `GovernorAlpha.sol` contract.

Commit ID: **8b4c944db5dd3b2429d0dd8d13a22cceb6f23073**

3.4 (HAL-04) SHORT CIRCUIT IS NECESSARY FOR GAS OPTIMIZATION - LOW

Description:

If votes variable is equal to zero on GovernorAlpha.sol:_castVote() method contract should short circuit itself to consume less gas. The following lines will be executed even if votes amount is zero.

Listing 8: GovernorAlpha.sol

```
280 if (support) {
281             proposal.forVotes = add256(proposal.forVotes, votes);
282         } else {
283             proposal.againstVotes = add256(proposal.againstVotes,
                    votes);
284         }
285
286         receipt.hasVoted = true;
287         receipt.support = support;
288         receipt.votes = votes;
289
290         emit VoteCast(voter, proposalId, support, votes);
291     }
```

Basically, the contract will call more functions such as add256() even it is not necessary.

The same issue also exists on Well.sol:transferFrom() function. If rawAmount parameter is equal to zero, the contract should short-circuit itself to prevent gas consume. The following lines will be executed even if rawAmount is equal to zero.

Listing 9: Well.sol

```
162 if (spender != src && spenderAllowance != uint96(-1)) {
163             uint96 newAllowance = sub96(spenderAllowance, amount,
                    "Well::transferFrom: transfer amount exceeds
                    spender allowance");
164             allowances[src][spender] = newAllowance;
165
166             emit Approval(src, spender, newAllowance);
167         }
168
169         _transferTokens(src, dst, amount);
170         return true;
```

Code Location:

Listing 10: Vulnerable Functions

```
1 GovernorAlpha.sol:_castVote(address voter, uint proposalId, bool
      support)
2 Well.sol:transferFrom(address src, address dst, uint rawAmount)
```

Risk Level:

Likelihood - 3
Impact - 1

Recommendation:

It is suggested to apply the following implementations for functions above.

Listing 11: GovernorAlpha.sol

```
278 uint96 votes = well.getPriorVotes(voter, proposal.startBlock);
279 if (votes == 0) {
280     return;
281     }
282
283     . . .
```

Listing 12: Well.sol

```
165 uint96 amount = safe96(rawAmount, "Well::approve: amount exceeds
       96 bits");
166 if (amount == 0) {
167     emit Transfer(src, dst, 0); //emitting event is still
          necessary for following up the transfer standart.
168     return true;
169 }
170
171     . . .
```

Remediation Plan:

NOT APPLICABLE: This issue was marked as NOT APPLICABLE since the recommendation does not fit to intended behavior of Compound Protocol. Furthermore, Moonwell Team stay as close to the original contracts as possible, even if they are not completely optimal concerning gas efficiency, so that improvements to the original contracts may be adopted without significant refactoring, and the community can have better certainty that they function similarly to other contracts with the same code.

3.5 (HAL-05) GOVERNORALPHA DOES NOT CONTROL QUEUED PROPOSALS ON CANCEL METHOD - LOW

Description:

The cancel(uint proposalId) The cancel function is used to cancel the proposals. There is a check on the contract to do not cancel executed proposals. If the state of a proposal is not QUEUED yet, the contract will revert to cancel function. However, it will consume gas to achieve this. There is a missing control on the contract to only cancel QUEUED proposals.

Code Location:

Listing 13: GovernorAlpha.sol

```
210 function cancel(uint proposalId) public {
211         ProposalState state = state(proposalId);
212         require(state != ProposalState.Executed, "GovernorAlpha::
                cancel: cannot cancel executed proposal");
213
214         Proposal storage proposal = proposals[proposalId];
215         require(msg.sender == guardian || well.getPriorVotes(
                proposal.proposer, sub256(block.number, 1)) <
                proposalThreshold(), "GovernorAlpha::cancel: proposer
                above threshold");
216
217         proposal.canceled = true;
218         for (uint i = 0; i < proposal.targets.length; i++) {
219             timelock.cancelTransaction(proposal.targets[i],
                    proposal.values[i], proposal.signatures[i],
                    proposal.calldatas[i], proposal.eta);
220         }
221
222         emit ProposalCanceled(proposalId);
223     }
```

Risk Level:

Likelihood - 3
Impact - 1

Recommendation:

It is recommended to implement an additional check to control only QUEUED proposals are sent to this function.

Listing 14: GovernorAlpha.sol (Lines 212)

```
210 function cancel(uint proposalId) public {
211         ProposalState state = state(proposalId);
212         require(state == ProposalState.Queued, "GovernorAlpha::
                cancel: Current proposal is not queued.");
```

Remediation Plan:

NOT APPLICABLE: This issue was marked as NOT APPLICABLE since the recommendation does not fit to intended behavior of Compound Protocol.

> "A proposal is eligible to be cancelled at any time before its execution, including while queued in the Timelock, using this function."

3.6 (HAL-06) MISSING ZERO ADDRESS CHECKS - LOW

Description:

Moonwell-Core contracts have multiple input fields on their both public and private functions. Some of these inputs are required as address variable.
During the test, it has seen all of these inputs are not protected against using the address(0) as the target address. It is not recommended to use zero address as target addresses on the contracts.

Code Location:

Listing 15: Missing Zero Address Checks

```
1 ChainlinkOracle.setAdmin(address).newAdmin (contracts/Chainlink/
    ChainlinkOracle.sol#88)
2 Comptroller._setBorrowCapGuardian(address).newBorrowCapGuardian (
    contracts/Comptroller.sol#968)
3 Comptroller._setPauseGuardian(address).newPauseGuardian (contracts
    /Comptroller.sol#986)
4 Comptroller.setWellAddress(address).newWellAddress (contracts/
    Comptroller.sol#1351)
5 MErc20.initialize(address,ComptrollerInterface,InterestRateModel,
    uint256,string,string,uint8).underlying_ (contracts/MErc20.sol
    #21)
6 MToken._setPendingAdmin(address).newPendingAdmin (contracts/MToken
    .sol#1144)
7 MErc20Delegator.constructor(address,ComptrollerInterface,
    InterestRateModel,uint256,string,string,uint8,address,address,
    bytes).admin_ (contracts/MErc20Delegator.sol#31)
8 MErc20Delegator._setImplementation(address,bool,bytes).
    implementation_ (contracts/MErc20Delegator.sol#60)
9 MErc20Immutable.constructor(address,ComptrollerInterface,
    InterestRateModel,uint256,string,string,uint8,address).admin_ (
    contracts/MErc20Immutable.sol#29)
10 MGlimmer.constructor(ComptrollerInterface,InterestRateModel,
    uint256,string,string,uint8,address).admin_ (contracts/MGlimmer
    .sol#27)
```

```
11 Reservoir.constructor(uint256,EIP20Interface,address).target_ (
      contracts/Reservoir.sol#32)
12 Timelock.constructor(address,uint256).admin_ (contracts/Timelock.
      sol#26)
13 Timelock.executeTransaction(address,uint256,string,bytes,uint256).
      target (contracts/Timelock.sol#81)
14 Unitroller._setPendingImplementation(address).
      newPendingImplementation (contracts/Unitroller.sol#38)
15 Unitroller._setPendingAdmin(address).newPendingAdmin (contracts/
      Unitroller.sol#85)
```

Risk Level:

Likelihood - 2
Impact - 2

Recommendation:

It is recommended to implement additional zero address checks to avoid usage of zero addresses contracts.

Remediation Plan:

RISK ACCEPTED: The Moonwell Team accepts the risk of this finding. Except the ChainlinkOracle contract, all the contracts mentioned require the new admin key to execute the _acceptPendingAdmin function, which protects against accidental attempts to set the admin or guardian to the zero address. It was decided not to make any changes.

3.7 (HAL-07) MULTIPLE PRAGMA DEFINITION - INFORMATIONAL

Description:

Moonwell contracts use different pragma versions. Contracts should be deployed with the same compiler version and flags that they have been tested with thoroughly.
Locking the pragma helps to ensure that contracts do not accidentally get deployed using another pragma, for example, either an outdated pragma version that might introduce bugs that affect the contract system negatively or a recently released pragma version which has not been extensively tested. The latest pragma version (0.8.11) was released in December 2021. Many pragma versions have been lately released, going from version 0.7.x to the recently released version 0.8.x. in just few months.

Reference: Solidity Releases

In the Solidity GitHub repository, there is a JSON file with all bugs finding in the different compiler versions. It should be noted that pragma 0.6.12 and 0.7.6 are widely used by Solidity developers and have been extensively tested in many security audits.

Reference: Solidity bugs by version

Code Location:

Different pragma versions in use:

Listing 16

```
DAIInterestRateModel.sol - Pragma Version 0.5.16
Other Contracts - Pragma Version 0.5.17
```

Risk Level:

Likelihood - 1
Impact - 1

Recommendation:

Consider locking and using a single pragma version without known bugs for the compiler version. If possible, consider using the latest stable pragma version that has been thoroughly tested to prevent potential undiscovered vulnerabilities, such as a pragma between 0.6.12 - 0.7.6, or the latest pragma 0.8.9 - 0.8.11. For example, after the Solidity v 0.8.x, arithmetic operations revert to underflow and overflow by default. By using this version, utility contracts like SafeMath.sol would not be needed.

Remediation Plan:

SOLVED: This issue was solved by the Moonwell Team. The DAIInterestRateModel.sol contract is not used by the Moonwell community, so this contract has been removed from the repository.

3.8 (HAL-08) UNUSED FUNCTION PARAMETERS - INFORMATIONAL

Description:

During the test, it was determined that a variable on the contract was not used for any purpose, although it was defined on the contract. This situation does not pose any risk in terms of security. But it is important for the readability and applicability of the code.

The baseRatePerYear parameter of updateJumpRateModel function on DAIInterestRateModelV3.sol contract is unused on that function.

Code Location:

Listing 17: DAIInterestRateModelV3.sol (Lines 51)

```
51 function updateJumpRateModel(uint baseRatePerYear, uint gapPerYear
       , uint jumpMultiplierPerYear, uint kink_) external {
52         require(msg.sender == owner, "only the owner may call this
               function.");
53         gapPerTimestamp = gapPerYear / timestampsPerYear;
54         updateJumpRateModelInternal(0, 0, jumpMultiplierPerYear,
              kink_);
55         poke();
56     }
```

Risk Level:

Likelihood - 1
Impact - 1

Recommendation:

It is recommended to review baseRatePerYear variable, and delete it from the contract if this variable will be remained unused in the future.

Remediation Plan:

SOLVED: This issue has was solved by the Moonwell Team. The DAIInterestRateModel.sol contract is not used by the Moonwell community, so this contract has been removed from the repository.

AUTOMATED TESTING

4.1 STATIC ANALYSIS REPORT

Description:

Halborn used automated testing techniques to enhance coverage of certain areas of the scoped contract. Among the tools used was Slither, a Solidity static analysis framework. After Halborn verified all the contracts in the repository and was able to compile them correctly into their ABI and binary formats. This tool can statically verify mathematical relationships between Solidity variables to detect invalid or inconsistent usage of the contracts' APIs across the entire code-base.

Results:

```
Comptroller._grantRewardInternal(uint256,address,uint256) (contracts/Comptroller.sol#1289-1305) sends eth to arbitrary user
        Dangerous calls:
        - user.transfer(amount) (contracts/Comptroller.sol#1300)
Maximillion.repayBehalfExplicit(address,MGlimmer) (contracts/Maximillion.sol#37-46) sends eth to arbitrary user
        Dangerous calls:
        - mGlimmer_.repayBorrowBehalf.value(borrows)(borrower) (contracts/Maximillion.sol#41)
Reference: https://github.com/crytic/slither/wiki/Detector-Documentation#functions-that-send-ether-to-arbitrary-destinations

GovernorAlpha.execute(uint256) (contracts/Governance/GovernorAlpha.sol#200-208) sends eth to arbitrary user
        Dangerous calls:
        - timelock.executeTransaction.value(proposal.values[i])(proposal.targets[i],proposal.values[i],proposal.signatures[i],proposal.calldatas[i],proposal.eta) (contracts/Governance/GovernorAlpha.sol#205
)
Reference: https://github.com/crytic/slither/wiki/Detector-Documentation#functions-that-send-ether-to-arbitrary-destinations

Comptroller (contracts/Comptroller.sol#15-1361) contract sets array length with a user-controlled value:
        - accountAssets[borrower].push(mToken) (contracts/Comptroller.sol#156)
Comptroller (contracts/Comptroller.sol#15-1361) contract sets array length with a user-controlled value:
        - allMarkets.push(MToken(mToken)) (contracts/Comptroller.sol#940)
Reference: https://github.com/crytic/slither/wiki/Detector-Documentation#array-length-assignment

MGlimmer.requireNoError(uint256,string) (contracts/MGlimmer.sol#156-175) uses a weak PRNG: "fullMessage[i + 3] = bytes1(uint8(48 + (errCode % 10))) (contracts/MGlimmer.sol#171)"
Reference: https://github.com/crytic/slither/wiki/Detector-Documentation#weak-PRNG

MErc20Delegator.delegateTo(address,bytes) (contracts/MErc20Delegator.sol#430-438) uses delegatecall to a input-controlled function id
        - (success,returnData) = callee.delegatecall(data) (contracts/MErc20Delegator.sol#431)
MErc20Delegator.fallback() (contracts/MErc20Delegator.sol#471-485) uses delegatecall to a input-controlled function id
        - (success) = implementation.delegatecall(msg.data) (contracts/MErc20Delegator.sol#475)
Unitroller.fallback() (contracts/Unitroller.sol#135-147) uses delegatecall to a input-controlled function id
        - (success) = comptrollerImplementation.delegatecall(msg.data) (contracts/Unitroller.sol#137)
PglStakingContractProxy.fallback() (contracts/staking/PglStakingContractProxy.sol#50-61) uses delegatecall to a input-controlled function id
        - (success) = implementation.delegatecall(msg.data) (contracts/staking/PglStakingContractProxy.sol#51)
Reference: https://github.com/crytic/slither/wiki/Detector-Documentation#controlled-delegatecall

PotLike is re-used:
        - contracts/MDaiDelegate.sol#184-190
        - contracts/DAIInterestRateModelV3.sol#113-121
Reference: https://github.com/crytic/slither/wiki/Detector-Documentation#name-reused

Comptroller._grantRewardInternal(uint256,address,uint256) (contracts/Comptroller.sol#1289-1305) ignores return value by well.transfer(user,amount) (contracts/Comptroller.sol#1294)
Reservoir.drip() (contracts/Reservoir.sol#66-67) ignores return value by token_.transfer(target_,toDrip_) (contracts/Reservoir.sol#64)
PglStakingContract.deposit(uint256) (contracts/staking/PglStakingContract.sol#29-43) ignores return value by pglToken.transferFrom(msg.sender,address(this),pglAmount) (contracts/staking/PglStakingContract.
sol#34)
PglStakingContract.redeem(uint256) (contracts/staking/PglStakingContract.sol#50-61) ignores return value by pglToken.transfer(msg.sender,pglAmount) (contracts/staking/PglStakingContract.sol#60)
PglStakingContract.claimErc20(uint256,address,uint256) (contracts/staking/PglStakingContract.sol#220-228) ignores return value by token.transfer(recipient,amount) (contracts/staking/PglStakingContract.sol#
227)
Reference: https://github.com/crytic/slither/wiki/Detector-Documentation#unchecked-transfer

UnitrollerAdminStorage.comptrollerImplementation (contracts/ComptrollerStorage.sol#20) is never initialized. It is used in:
        - Comptroller.adminOrInitializing() (contracts/Comptroller.sol#1049-1051)
Reference: https://github.com/crytic/slither/wiki/Detector-Documentation#uninitialized-state-variables
```

```
Comptroller.mintVerify(address,address,uint256,uint256) (contracts/Comptroller.sol#254-265) uses a Boolean constant improperly:
        -false (contracts/Comptroller.sol#262)
Comptroller.borrowVerify(address,address,uint256) (contracts/Comptroller.sol#389-399) uses a Boolean constant improperly:
        -false (contracts/Comptroller.sol#396)
Comptroller.repayBorrowVerify(address,address,address,uint256,uint256) (contracts/Comptroller.sol#437-454) uses a Boolean constant improperly:
        -false (contracts/Comptroller.sol#451)
Comptroller.liquidateBorrowVerify(address,address,address,address,uint256,uint256) (contracts/Comptroller.sol#504-523) uses a Boolean constant improperly:
        -false (contracts/Comptroller.sol#520)
Comptroller.seizeVerify(address,address,address,address,uint256) (contracts/Comptroller.sol#568-585) uses a Boolean constant improperly:
        -false (contracts/Comptroller.sol#582)
Comptroller.transferVerify(address,address,address,uint256) (contracts/Comptroller.sol#620-631) uses a Boolean constant improperly:
        -false (contracts/Comptroller.sol#628)
MErc20Delegate._becomeImplementation(bytes) (contracts/MErc20Delegate.sol#20-30) uses a Boolean constant improperly:
        -false (contracts/MErc20Delegate.sol#25)
MErc20Delegate._resignImplementation() (contracts/MErc20Delegate.sol#35-42) uses a Boolean constant improperly:
        -false (contracts/MErc20Delegate.sol#37)
Reference: https://github.com/crytic/slither/wiki/Detector-Documentation#misuse-of-a-boolean-constant

BaseJumpRateModelV2.getSupplyRate(uint256,uint256,uint256,uint256) (contracts/BaseJumpRateModelV2.sol#115-120) performs a multiplication on the result of a division:
        -rateToPool = borrowRate.mul(oneMinusReserveFactor).div(1e18) (contracts/BaseJumpRateModelV2.sol#118)
        -utilizationRate(cash,borrows,reserves).mul(rateToPool).div(1e18) (contracts/BaseJumpRateModelV2.sol#119)
DAIInterestRateModelV3.dsrPerTimestamp() (contracts/DAIInterestRateModelV3.sol#82-87) performs a multiplication on the result of a division:
        -pot.dsr().sub(1e27).div(1e9).mul(15) (contracts/DAIInterestRateModelV3.sol#83-86)
DAIInterestRateModelV3.poke() (contracts/DAIInterestRateModelV3.sol#92-107) performs a multiplication on the result of a division:
        -stabilityFeePerTimestamp = duty.add(jug.base()).sub(1e27).mul(1e18).div(1e27).mul(15) (contracts/DAIInterestRateModelV3.sol#94)
JumpRateModel.getSupplyRate(uint256,uint256,uint256,uint256) (contracts/JumpRateModel.sol#99-104) performs a multiplication on the result of a division:
        -rateToPool = borrowRate.mul(oneMinusReserveFactor).div(1e18) (contracts/JumpRateModel.sol#102)
        -utilizationRate(cash,borrows,reserves).mul(rateToPool).div(1e18) (contracts/JumpRateModel.sol#103)
WhitePaperInterestRateModel.getSupplyRate(uint256,uint256,uint256,uint256) (contracts/WhitePaperInterestRateModel.sol#79-84) performs a multiplication on the result of a division:
        -rateToPool = borrowRate.mul(oneMinusReserveFactor).div(1e18) (contracts/WhitePaperInterestRateModel.sol#82)
        -utilizationRate(cash,borrows,reserves).mul(rateToPool).div(1e18) (contracts/WhitePaperInterestRateModel.sol#83)
Reference: https://github.com/crytic/slither/wiki/Detector-Documentation#divide-before-multiply

EIP20NonStandardInterface (contracts/EIP20NonStandardInterface.sol#8-70) has incorrect ERC20 function interface:EIP20NonStandardInterface.transfer(address,uint256) (contracts/EIP20NonStandardInterface.sol#
34)
EIP20NonStandardInterface (contracts/EIP20NonStandardInterface.sol#8-70) has incorrect ERC20 function interface:EIP20NonStandardInterface.transferFrom(address,address,uint256) (contracts/EIP20NonStandardIn
terface.sol#48)
ERC20NS (contracts/FaucetToken.sol#24-28) has incorrect ERC20 function interface:ERC20NS.transfer(address,uint256) (contracts/FaucetToken.sol#25)
ERC20NS (contracts/FaucetToken.sol#24-28) has incorrect ERC20 function interface:ERC20NS.transferFrom(address,address,uint256) (contracts/FaucetToken.sol#27)
GemLike (contracts/MDaiDelegate.sol#192-196) has incorrect ERC20 function interface:GemLike.approve(address,uint256) (contracts/MDaiDelegate.sol#193)
Reference: https://github.com/crytic/slither/wiki/Detector-Documentation#incorrect-erc20-interface

Comptroller.getHypothenticalAccountLiquidityInternal(address,MToken,uint256,uint256) (contracts/Comptroller.sol#706-762) uses a dangerous strict equality:
        - vars.oraclePriceMantissa == 0 (contracts/Comptroller.sol#730)
Comptroller.liquidateBorrowAllowed(address,address,address,address,uint256) (contracts/Comptroller.sol#464-494) uses a dangerous strict equality:
        - shortfall == 0 (contracts/Comptroller.sol#482)
ExponentialNoError.mul_(uint256,uint256,string) (contracts/ExponentialNoError.sol#150-157) uses a dangerous strict equality:
        - a == 0 || b == 0 (contracts/ExponentialNoError.sol#151)
ExponentialNoError.mul_(uint256,uint256,string) (contracts/ExponentialNoError.sol#150-157) uses a dangerous strict equality:
        - require(bool,string)(c / a == b,errorMessage) (contracts/ExponentialNoError.sol#155)



Reentrancy in MErc20Delegator._setImplementation(address,bool,bytes) (contracts/MErc20Delegator.sol#60-73):
        External calls:
        - delegateToImplementation(abi.encodeWithSignature(_resignImplementation())) (contracts/MErc20Delegator.sol#64)
                - (success,returnData) = callee.delegatecall(data) (contracts/MErc20Delegator.sol#431)
        State variables written after the call(s):
        - implementation = implementation_ (contracts/MErc20Delegator.sol#68)
Reentrancy in MErc20Delegator.constructor(address,ComptrollerInterface,InterestRateModel,uint256,string,string,uint8,address,address,bytes) (contracts/MErc20Delegator.sol#24-52):
        External calls:
        - delegateToImplementation(_,abi.encodeWithSignature(initialize(address,address,address,uint256,string,string,uint8),underlying_,comptroller_,interestRateModel_,initialExchangeRateMantissa_,name_,s
ymbol_,decimals_)) (contracts/MErc20Delegator.sol#38-45)
                - (success,returnData) = callee.delegatecall(data) (contracts/MErc20Delegator.sol#431)
        - _setImplementation(implementation_,false,becomeImplementationData) (contracts/MErc20Delegator.sol#48)
                - (success,returnData) = callee.delegatecall(data) (contracts/MErc20Delegator.sol#431)
        State variables written after the call(s):
        - admin = admin_ (contracts/MErc20Delegator.sol#51)
Reentrancy in MToken.liquidateBorrowInternal(address,uint256,MTokenInterface) (contracts/MToken.sol#941-956):
        External calls:
        - error = mTokenCollateral.accrueInterest() (contracts/MToken.sol#948)
        - liquidateBorrowFresh(msg.sender,borrower,repayAmount,mTokenCollateral) (contracts/MToken.sol#955)
                - allowed = comptroller.repayBorrowAllowed(address(this),payer,borrower,repayAmount) (contracts/MToken.sol#866)
                - allowed = comptroller.liquidateBorrowAllowed(address(this),address(mTokenCollateral),liquidator,borrower,repayAmount) (contracts/MToken.sol#969)
                - allowed = comptroller.seizeAllowed(address(this),seizerToken,liquidator,borrower,seizeTokens) (contracts/MToken.sol#1075)
                - seizeError = mTokenCollateral.seize(liquidator,borrower,seizeTokens) (contracts/MToken.sol#1022)
        State variables written after the call(s):
        - liquidateBorrowFresh(msg.sender,borrower,repayAmount,mTokenCollateral) (contracts/MToken.sol#955)
                - totalBorrows = vars.totalBorrowsNew (contracts/MToken.sol#921)
        - liquidateBorrowFresh(msg.sender,borrower,repayAmount,mTokenCollateral) (contracts/MToken.sol#955)
                - totalReserves = vars.totalReservesNew (contracts/MToken.sol#1110)
Reentrancy in MToken.redeemFresh(address,uint256,uint256) (contracts/MToken.sol#614-720):
        External calls:
        - allowed = comptroller.redeemAllowed(address(this),redeemer,vars.redeemTokens) (contracts/MToken.sol#666)
        State variables written after the call(s):
        - accountTokens[redeemer] = vars.accountTokensNew (contracts/MToken.sol#710)
        - totalSupply = vars.totalSupplyNew (contracts/MToken.sol#709)
Reference: https://github.com/crytic/slither/wiki/Detector-Documentation#reentrancy-vulnerabilities-1

MToken._addReservesFresh(uint256).actualAddAmount (contracts/MToken.sol#1283) is a local variable never initialized
Comptroller.borrowAllowed(address,address,uint256).err_scope_0 (contracts/Comptroller.sol#368) is a local variable never initialized
MToken.redeemFresh(address,uint256,uint256).vars (contracts/MToken.sol#617) is a local variable never initialized
MToken.borrowFresh(address,uint256).vars (contracts/MToken.sol#766) is a local variable never initialized
MToken.mintFresh(address,uint256).vars (contracts/MToken.sol#509) is a local variable never initialized
MToken.seizeInternal(address,address,address,uint256).vars (contracts/MToken.sol#1085) is a local variable never initialized
MToken.repayBorrowFresh(address,address,uint256).vars (contracts/MToken.sol#876) is a local variable never initialized
Reference: https://github.com/crytic/slither/wiki/Detector-Documentation#uninitialized-local-variables

Comptroller._supportMarket(MToken) (contracts/Comptroller.sol#915-934) ignores return value by mToken.isMToken() (contracts/Comptroller.sol#924)
MDaiDelegate._becomeImplementation(address,address) (contracts/MDaiDelegate.sol#42-67) ignores return value by pot.drip() (contracts/MDaiDelegate.sol#63)
MDaiDelegate._resignImplementation() (contracts/MDaiDelegate.sol#72-92) ignores return value by pot.drip() (contracts/MDaiDelegate.sol#81)
MDaiDelegate.accrueInterest() (contracts/MDaiDelegate.sol#101-107) ignores return value by PotLike(potAddress).drip() (contracts/MDaiDelegate.sol#103)
MErc20.initialize(address,ComptrollerInterface,InterestRateModel,uint256,string,string,uint8) (contracts/MErc20.sol#21-34) ignores return value by EIP20Interface(underlying).totalSupply() (contracts/MErc20
.sol#33)
Reference: https://github.com/crytic/slither/wiki/Detector-Documentation#unused-return
```

```
Reentrancy in MDaiDelegate._becomeImplementation(address,address) (contracts/MDaiDelegate.sol#42-67):
        External calls:
        - dai = daiJoin.dai() (contracts/MDaiDelegate.sol#46)
        - vat = daiJoin.vat() (contracts/MDaiDelegate.sol#47)
        State variables written after the call(s):
        - daiJoinAddress = daiJoinAddress_ (contracts/MDaiDelegate.sol#51)
        - potAddress = potAddress_ (contracts/MDaiDelegate.sol#52)
        - vatAddress = address(vat) (contracts/MDaiDelegate.sol#53)
Reentrancy in MDaiDelegate.accrueInterest() (contracts/MDaiDelegate.sol#101-107):
        External calls:
        - PotLike(potAddress).drip() (contracts/MDaiDelegate.sol#103)
        State variables written after the call(s):
        - super.accrueInterest() (contracts/MDaiDelegate.sol#106)
                - accrualBlockTimestamp = currentBlockTimestamp (contracts/MToken.sol#453)
        - super.accrueInterest() (contracts/MDaiDelegate.sol#106)
                - borrowIndex = borrowIndexNew (contracts/MToken.sol#454)
        - super.accrueInterest() (contracts/MDaiDelegate.sol#106)
                - totalBorrows = totalBorrowsNew (contracts/MToken.sol#455)
        - super.accrueInterest() (contracts/MDaiDelegate.sol#106)
                - totalReserves = totalReservesNew (contracts/MToken.sol#456)
Reentrancy in MToken.borrowFresh(address,uint256) (contracts/MToken.sol#749-813):
        External calls:
        - allowed = comptroller.borrowAllowed(address(this),borrower,borrowAmount) (contracts/MToken.sol#751)
        State variables written after the call(s):
        - accountBorrows[borrower].principal = vars.accountBorrowsNew (contracts/MToken.sol#801)
        - accountBorrows[borrower].interestIndex = borrowIndex (contracts/MToken.sol#802)
        - totalBorrows = vars.totalBorrowsNew (contracts/MToken.sol#803)
Reentrancy in PglStakingContract.deposit(uint256) (contracts/staking/PglStakingContract.sol#29-43):
        External calls:
        - pglToken.transferFrom(msg.sender,address(this),pglAmount) (contracts/staking/PglStakingContract.sol#34)
        State variables written after the call(s):
        - distributeReward(msg.sender) (contracts/staking/PglStakingContract.sol#39)
                - accrualBlockTimestamp = block.timestamp (contracts/staking/PglStakingContract.sol#165)
        - distributeReward(msg.sender) (contracts/staking/PglStakingContract.sol#39)
                - accruedReward[recipient][i] = accruedReward[recipient][i].add(accruedAmount) (contracts/staking/PglStakingContract.sol#195)
        - distributeReward(msg.sender) (contracts/staking/PglStakingContract.sol#39)
                - rewardIndex[i] = rewardIndex[i].add(accruedPerPGL) (contracts/staking/PglStakingContract.sol#180)
        - distributeReward(msg.sender) (contracts/staking/PglStakingContract.sol#39)
                - supplierRewardIndex[recipient][i] = rewardIndex[i] (contracts/staking/PglStakingContract.sol#196)
        - supplyAmount[msg.sender] = supplyAmount[msg.sender].add(depositedAmount) (contracts/staking/PglStakingContract.sol#42)
        - totalSupplies = totalSupplies.add(depositedAmount) (contracts/staking/PglStakingContract.sol#41)
Reentrancy in MToken.mintFresh(address,uint256) (contracts/MToken.sol#497-562):
        External calls:
        - allowed = comptroller.mintAllowed(address(this),minter,mintAmount) (contracts/MToken.sol#499)
        State variables written after the call(s):
        - accountTokens[minter] = vars.accountTokensNew (contracts/MToken.sol#551)
        - totalSupply = vars.totalSupplyNew (contracts/MToken.sol#550)
```

As a result of the tests completed with the Slither tool, some results were obtained and these results were reviewed by Halborn. In line with the reviewed results, it was decided that some vulnerabilities were false-positive and these results were not included in the report. The actual vulnerabilities found by Slither are already included in the findings on the report.

THANK YOU FOR CHOOSING

// HALBORN