

PLUTUS:VaR

User Guide

Rev1.0.1
08/19/2024

- **New:** Bazel Backtesting Exceedance Report.
- **Fix:** Coupon generation for T-Bill and T-Note pricing.
- **Fix:** Time discretization of simulated interest rate paths.
- **Fix:** Vasicek/CIR interest rate model parameter calibration.

Rev1.0.0
06/04/2024

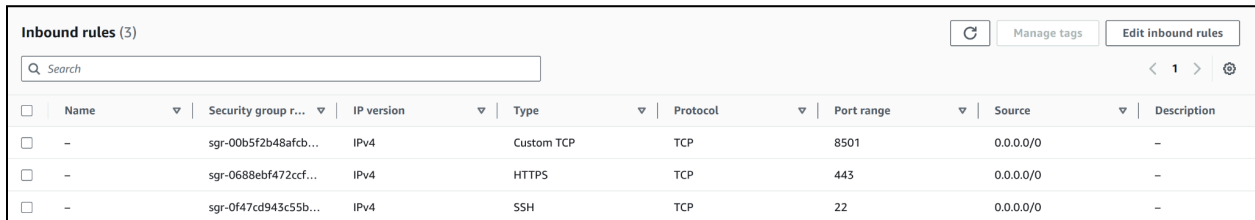
- **New:** Plutus:VaR Monte-Carlo option pricing engine with multiple GPUs support.
- **New:** Usage of Streamlit as the Web UI with HTTPS support.
- **New:** The user guide provides instructions on how to create a custom portfolio or using the default portfolio to run the VaR calculations.

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1. Launch Plutus:VaR With AWS EC2

1. Launch an AWS EC2 instance from the **Plutus:VaR** AMI found on AWS Marketplace.
 - a. The default username is **ubuntu**.
 - b. **Plutus:VaR** have been tested on p4d.24xlarge and g5.xxx instances. We recommend p4d.24xlarge instance to achieve the best performance.
2. Configure security group to the following:
 - a. [streamlit](#) Web UI is used by **Plutus:VaR** (default port: 8501).
 - b. (Optional) Please refer to the HTTPS support section.



The screenshot shows the 'Inbound rules (3)' configuration for a security group. It includes a search bar, 'Manage tags', and 'Edit inbound rules' buttons. The table below lists three rules:

Name	Security group r...	IP version	Type	Protocol	Port range	Source	Description
-	sgr-00b5f2b48afcb...	IPv4	Custom TCP	TCP	8501	0.0.0.0/0	-
-	sgr-0688ebf472ccf...	IPv4	HTTPS	TCP	443	0.0.0.0/0	-
-	sgr-0f47cd943c55b...	IPv4	SSH	TCP	22	0.0.0.0/0	-

3. Run Plutus:VaR in the instance

```
ubuntu@ip-172-31-68-162:~$ python3 var/run.py

You can now view your Streamlit app in your browser.

URL: http://0.0.0.0:8501
```

4. Open **Plutus:VaR** in the web browser
 - a. Enter <Public IP of the instance>:8501 into your browser. It takes a while for the first launch.
 - b. All browsers are supported but Firefox is recommended.

2. User Console Guide

The general workflow of **Plutus:VaR** is as follows:

- Users can upload their custom portfolio or choose from one of the provided default portfolios
- Users can directly edit portfolio data within the console to build and explore new portfolios
- Users can modify the Monte-Carlo simulation parameters used to generate the VaR distribution
- Users can download a zipped output file containing the results of their Value at Risk calculations

For general information on how to navigate the user console, please click on the help button located in the center of the console.

2.1. How To Prepare Portfolio

2.1.1. From YAML file

Users can upload a YAML file representing their portfolio in **Plutus:VaR**. To ensure recognition, the portfolio must include each of the following categories, adhering to the specified format:

1. Cash: Cash positions must be entered as a single numeric value with no punctuations including commas.

Unset

```
cash: 1000000
```

2. Long Option Positions: Long option positions must be entered as a list of dictionaries with each dictionary representing a single position.

Unset

```
long option positions: [  
{ticker: SPY, style: american, put: false, strike: atm, time to maturity: 1.00, quantity: 20}  
]
```

Field	Descriptions	Example
ticker	Ticker symbol (from Yahoo finance)	SPY, ^DJI, etc.
style	Option style	american or european
put	“true” if option is a PUT and “false” if option is a CALL	true or false
strike	Strike price could be either a numeric value or at-the-money (atm) strike price +/- its percentage.	100.0, 200.0, etc. atm, atm+3%, atm-3%, etc.
time to maturity	The time to maturity in years.	1.00, 2.00, etc.
quantity	The number of option contracts purchased	10, 20, etc.

3. Short Option Positions: Short option positions must be entered as a list of dictionaries with each dictionary representing a single position. They follow the same format as long option positions.

Unset

```
short option positions: [  
{ticker: SPY, style: american, put: true, strike: atm, time to maturity: 0.20, quantity: 10}  
]
```

4. Long Stock Positions: Long stock positions must be entered as a list of dictionaries with each dictionary representing a single stock.

Unset

```
long stock positions: [{ticker: SPY, quantity: 1000}]
```

Field	Descriptions	Example
ticker	Ticker symbol (from Yahoo finance)	SPY, ^DJI, etc.

quantity	The number of stocks purchased	1000, 2000, etc.
----------	--------------------------------	------------------

5. Short Stock Positions: Short stock positions must be entered as a list of dictionaries with each dictionary representing a single stock. They follow the same format as long stock positions.

Unset

```
short stock positions: [{ticker: ^DJI, quantity: 100}]
```

6. Treasuries: Treasury bonds must be entered as a list of dictionaries with each dictionary representing a single position.

Unset

```
treasury: [{maturity: 3mo, total face value: 500000}]
```

Field	Descriptions	Example
maturity	The period of time until the bond's maturity from the current date, with 'mo' for months and 'y' for years.	3mo, 1y, etc.
total face value	The price of the bond at maturity	500000, 150000, etc.

7. Example of Portfolios

[American Portfolio]

Unset

```
# All tickers must be valid for Yahoo! Finance
```

```
cash: 0
```

```
long stock positions: [
  {ticker: SPY, quantity: 1000},
  {ticker: QQQ, quantity: 500},
]
```

```
short stock positions: [{ticker: ^DJI, quantity: 100},]
```

```
long option positions: [
  {ticker: SPY, style: american, put: false, strike: atm, time to maturity: 1.00, quantity: 20},
  {ticker: AAPL, style: american, put: false, strike: atm, time to maturity: 1.00, quantity: 1},
  {ticker: AMZN, style: american, put: false, strike: atm, time to maturity: 1.00, quantity: 1},
  {ticker: GOOG, style: american, put: false, strike: atm, time to maturity: 1.00, quantity: 1},
  {ticker: META, style: american, put: false, strike: atm, time to maturity: 1.00, quantity: 1},
  {ticker: MSFT, style: american, put: false, strike: atm, time to maturity: 1.00, quantity: 1},
  {ticker: NVDA, style: american, put: false, strike: atm, time to maturity: 1.00, quantity: 1},
  {ticker: TSLA, style: american, put: false, strike: atm, time to maturity: 1.00, quantity: 1},
]
```

```
short option positions: [
  {ticker: SPY, style: american, put: true, strike: atm, time to maturity: 1.00, quantity: 10},
]
```

```
treasuries: [
  {maturity: 3mo, total face value: 500000},
  {maturity: 1y, total face value: 250000},
]
```

```
{maturity: 2y, total face value: 150000},  
]
```

[Covered Call Portfolio]

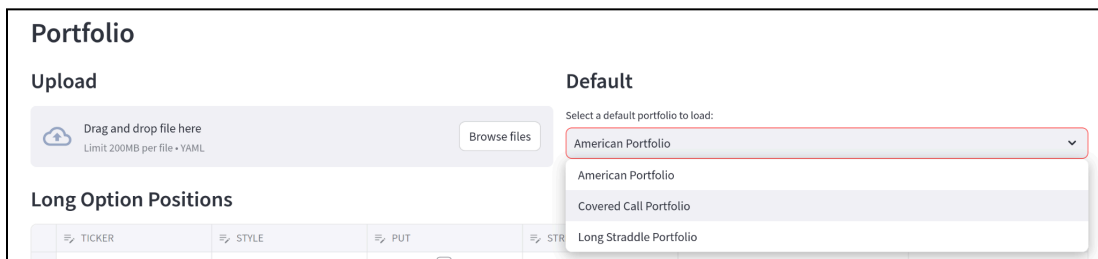
```
Unset  
cash: 0  
long stock positions: [{ticker: META, quantity: 1000},]  
short stock positions: []  
long option positions: []  
short option positions: [  
  {ticker: META, style: american, put: false, strike: 445, time to maturity: 0.833, quantity: 10},  
]  
treasuries: []
```

[Long Straddle Portfolio]

```
Unset  
cash: 0  
long stock positions: []  
short stock positions: []  
long option positions: [  
  {ticker: TSLA, style: american, put: false, strike: atm + 3%, time to maturity: 0.1, quantity: 1},  
  {ticker: TSLA, style: american, put: true, strike: atm - 3%, time to maturity: 0.1, quantity: 1},  
]  
short option positions: []  
treasuries: []
```

2.1.2. From Defaults

Plutus:VaR offers three default portfolios (American, Covered Call, Long Straddle). The American Portfolio will be automatically selected when launched, but users can select from any of these options using the dropdown menu.



2.1.3. From Web UI

Users have the ability to manually enter, edit, and remove data to personalize their portfolio before initiating the VaR calculations. Upon uploading the YAML file or choosing the default portfolio, the table in the Web UI will dynamically update accordingly.

1. Adding New Entries to a Data Table
 - a. Hover over the top-right corner of the data table and click on the plus (+) sign, or
 - b. Click on any of the plus (+) signs at the bottom of the data table

- c. NOTE: new entries will not be included in the portfolio if any columns are missing data

Long Option Positions						
TICKER	STYLE	PUT	STRIKE	TIME TO MATURITY (Y)	QUANTITY	
SPY	american	<input type="checkbox"/>	atm	1	20	
None	None		None	None	None	
+						

2. Removing Entries From a Data Table

- Select the row to remove using the checkboxes on the left side of the data table
- Hover over the top-right corner of the data table and click on the trash sign

Long Option Positions						
TICKER	STYLE	PUT	STRIKE	TIME TO MATURITY (Y)	QUANTITY	
<input checked="" type="checkbox"/>	SPY	american	<input type="checkbox"/>	atm	1	20

3. Editing Entries in a Data Table

- Double click to place your cursor in a specific cell and edit the data
- NOTE: new data must match required column data types

Long Option Positions						
TICKER	STYLE	PUT	STRIKE	TIME TO MATURITY (Y)	QUANTITY	
SPY	american	<input type="checkbox"/>	atm	1	20	

2.2. Run VaR

2.2.1. Simulation Settings

- Number of Scenarios - the number of randomized scenarios to simulate using Monte-Carlo
 - Range of accepted values: [1, 1000000]
 - more scenarios -> more accuracy
 - less scenarios -> less time
- Time Horizon (Days) - the number of days over which to price the given portfolio positions
 - Range of accepted values: [1, 2520]

Simulation Settings

Number of Scenarios

10000 - +

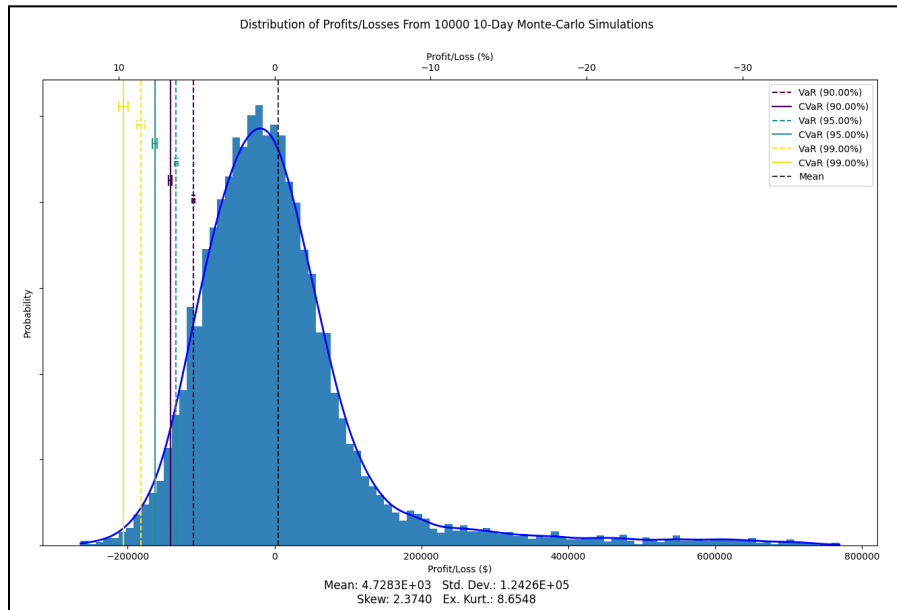
Time Horizon (Days)

10 - +

Run VaR

2.2.2. Results

1. Before running the VaR simulation, ensure that both your portfolio and simulation parameters are accurately entered. Then, simply click the 'Run VaR' button.
2. While the VaR engine processes your portfolio data and simulates the distribution of possible outcomes, a progress bar will be continuously updated.
3. When completed, the value-at-risk results are displayed as both a data table and a histogram of simulated profits/losses. These results include:
 - a. 90% VaR and CVaR
 - b. 95% VaR and CVaR
 - c. 99% VaR and CVaR
 - d. Mean and Standard Deviation
 - e. Skew and Kurtosis



Analysis

Confidence Level	Value at Risk	Conditional Value at Risk
0.90	-\$110,612.68	-\$143,971.84
0.95	-\$136,157.32	-\$165,589.40
0.99	-\$181,875.71	-\$206,071.77

4. Users will be able to download these results by clicking the Download button which appears only when the VaR engine has completed its calculations. Doing so will download a .zip file containing:
 - a. .csv of the portfolio used in the calculations
 - b. .png of the results histogram
 - c. .csv of the 90%, 95%, and 99% VaR and CVaR

3. Benchmarks

As a reference, we provide the following benchmarks for the speed of **Plutus:VaR**. The benchmarks were run with 10000 scenarios and a Time Horizon of 10 days on the three provided default portfolios for varying AWS instances.

Simulation Settings:

Number of scenarios: 10000

Time Horizon (days): 10

Instance / Portfolio	American	Covered Call	Long Straddle
g5.xlarge	1604.7 sec	147.8 sec	23.7 sec
g5.12xlarge	416.4 sec	43.8 sec	12.7 sec
p4d.24xlarge	19.6 sec	7.3 sec	2.1 sec

4. Underlying Assumptions

- Asset price changes follow a multivariate normal distribution.
- Asset volatilities and correlations are estimated from real world data via an exponentially-weighted moving average (EWMA).
 - These form the parameters of the asset price change distribution.
 - EWMA decay factor, λ , set to 0.94 (industry standard as set by RiskMetrics)
 - 25 lookback days
- Interest rates are modeled by a Cox-Ingersoll-Ross (CIR) model, fit to the current US Treasury yield curve.
- American options are priced via Monte-Carlo simulation on the GPUs, for higher accuracy compared to approximation formulas.

5. HTTPS support

In this section, we will show you how to enable HTTPS support for **Plutus:VaR**.

5.1 For Domains Registered With AWS Route 53

- 1) [Register](#) a domain name in AWS Route 53.
- 2) Create an [elastic IP](#) and associate the elastic IP address with **Plutus:VaR** instance.
- 3) [Route the traffic](#) from the domain to the **Plutus:VaR** instance by creating a record.
- 4) [Create a policy](#) of AWS Route 53 permissions for the certbot-dns-route53 plugin. Please update the following policy with your HostedZone ID.

```
Unset
```

```
{
```

```

"Version": "2012-10-17",
"Id": "certbot-dns-route53 sample policy",
"Statement": [
  {
    "Effect": "Allow",
    "Action": [
      "route53:ListHostedZones",
      "route53:GetChange"
    ],
    "Resource": [
      "*"
    ]
  },
  {
    "Effect" : "Allow",
    "Action" : [
      "route53:ChangeResourceRecordSets"
    ],
    "Resource" : [
      "arn:aws:route53::hostedzone/<HostedZone ID>"
    ]
  }
]
}

```

5) Please run the following commands to generate a letsencrypt certificate using certbot.

```

# sudo mode
sudo su

# AWS credential for certbot-dns-route53 plugin
export AWS_ACCESS_KEY_ID=XXX
export AWS_SECRET_ACCESS_KEY=XXX
export AWS_SESSION_TOKEN=XXX

# Generate a letsencrypt certificate (Dry run)
certbot certonly --dns-route53 -d <domain> -i nginx --dry-run --test-cert

# Generate a letsencrypt certificate
certbot certonly --dns-route53 -d <domain> -i nginx

```

You should see the following messages if the certificate is successfully issued.

```

Saving debug log to /var/log/letsencrypt/letsencrypt.log
Requesting a certificate for <domain>
Successfully received certificate.
Certificate is saved at: /etc/letsencrypt/live/<domain>/fullchain.pem
Key is saved at: /etc/letsencrypt/live/<domain>/privkey.pem
This certificate expires on 2024-09-04.
These files will be updated when the certificate renews.
Certbot has set up a scheduled task to automatically renew this certificate in the
background.

```

- 6) Update the nginx domain configuration file in the **Plutus:VaR** instance with the following configuration.

```
# Replace all the contents in the default
sudo nano /etc/nginx/sites-available/default
```

```
Unset
server {
    server_name <domain>;
    location / {
        proxy_pass http://0.0.0.0:8501/;
        proxy_set_header X-Forwarded-For $proxy_add_x_forwarded_for;
        proxy_set_header Host $http_host;
        proxy_redirect off;
        proxy_http_version 1.1;
        proxy_set_header Upgrade $http_upgrade;
        proxy_set_header Connection "upgrade";
    }
    listen 443 ssl;
    ssl_certificate /etc/letsencrypt/live/<domain>/fullchain.pem;
    ssl_certificate_key /etc/letsencrypt/live/<domain>/privkey.pem;
    include /etc/letsencrypt/options-ssl-nginx.conf;
    ssl_dhparam /etc/letsencrypt/ssl-dhparams.pem;
}
```

- 7) Restart the nginx service. If nginx doesn't show any errors, you should now be able to enter `https://<domain>` to access **Plutus:VaR** in your preferred web browser.

```
# Restart nginx service
sudo service nginx restart
sudo service nginx status
```

5.2 For Domains Registered With Other Websites

Follow the steps from (5)~(7) in the previous section to generate the certificate file using certbot without setting AWS credentials and dns-route53 flag.

6. Basel Backtesting Exceedance Report

The Basel Committee on Banking Supervision (BCBS) has established a standardized framework for backtesting to evaluate the accuracy of Value-at-Risk (VaR) models. Plutus:VaR adheres to these guidelines to ensure compliance and to maintain the integrity of its risk assessments. Backtesting requirements compare the value-at-risk measure calibrated to a one-day holding period against each of the actual P&L and hypothetical P&L over the prior 12 months.

6.1 Basel Framework Overview

The framework for the supervisory interpretation of backtesting results for the bank-wide capital model encompasses a range of possible responses, depending on the strength of the signal generated from the backtesting. These responses are classified into three backtesting zones, distinguished by colors into a hierarchy of responses.

Green zone

This corresponds to results that do not themselves suggest a problem with the quality or accuracy of the model.

Amber zone

This encompasses results that do raise questions in this regard, for which such a conclusion is not definitive.

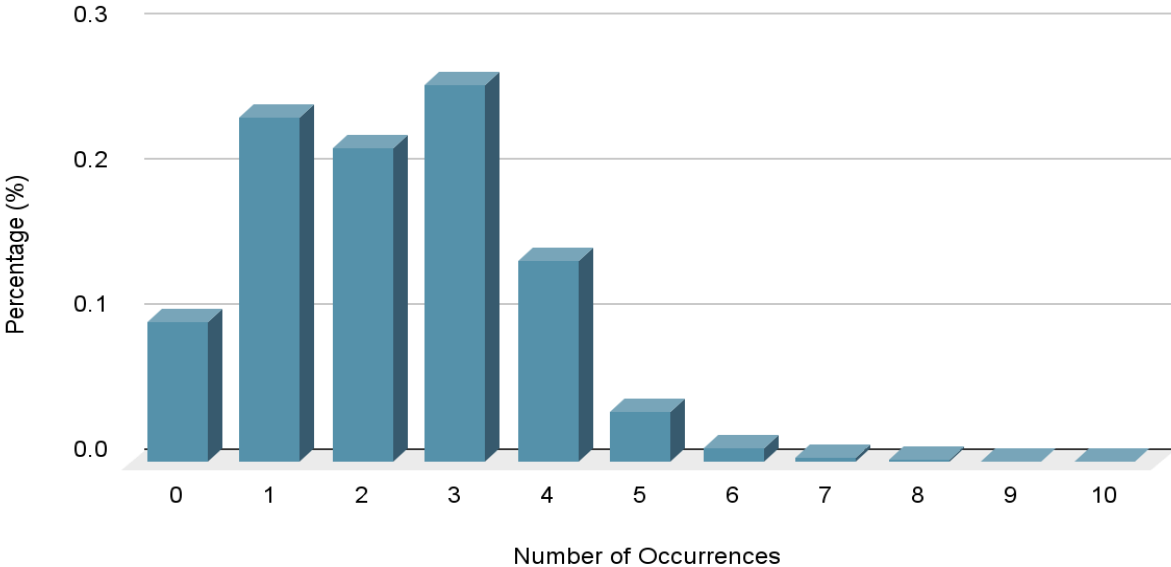
Red zone

This indicates a result that almost certainly suggests a problem with the risk model.

In accordance with Basel backtesting standards, we conducted 250 days of backtesting for at the 99th percentile confidence level for a wide range of portfolios including cash positions, bonds, options, and stocks. Tickers were sampled from a dataset of S&P 500 constituents. In total, 1000 such backtests were conducted and their results are shown below.

6.2 Backtesting Results

Plutus:VaR Backtesting Exceedances (99%)



Green Zone	Yellow zone	Red zone
95.06%	4.94%	0

The results obtained are consistent with the Basel Committee's guidelines and fully demonstrate the robustness of the Plutus:VaR engine under normal market conditions.

7. Resources

- [1] [Generating letsencrypt certificate using Certbot through certbot-dns-route53 plugin](#)
- [2] [Using Let's Encrypt to Enable HTTPS for a Streamlit Web Service](#)

8. Software Disclaimer

1) General Information

This software, including all its modules and features, databases, and functionalities, is provided for informational purposes only. The software is intended to provide general financial information and is not intended to provide complete or accurate financial or investment advice.

2) No Warranty

The software is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose. The entire risk as to the quality and performance of the software is with you.

3) Limitation of Liability

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