

# Risk valuation using ProActive workflows

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## Value At Risk (VaR)

One-day 95% VaR of \$1 million  $\Leftrightarrow$  5% probability that the portfolio worst-case loss will exceed \$1 million over a one-day period

## Monte Carlo (MC) simulations

$$\bar{X}_n = \frac{1}{n} \sum_{i=1}^n X_i \xrightarrow{n \rightarrow +\infty} \mathbb{E} X$$

The Law of Large Numbers states for large  $n$ , the empirical average is very close to the expected value

## Estimating the VaR using MC simulations

$$\mathbb{P}(L_t > x) = \frac{1}{nb\_VaR} \sum_{i=1}^{nb\_VaR} \mathbb{1}_{L_t^i > x} = 1 - \alpha$$

$x$  the portfolio VaR

$L_t$  the portfolio loss at  $t$

$\alpha$  the VaR probability

$nb\_VaR$  the number of MC simulations

Estimates the Monte Carlo Value at Risk (MC VaR) of a portfolio. We use the geometric Brownian motion (GBM) method to simulate stock price paths, but more exotic assets can be integrated thanks to the Quantlib C++ lib.

Simulation

nbMC	<input type="text" value="10000"/>	The number of Monte Carlo simulations.
nbTimeSteps	<input type="text" value="255"/>	The number of time steps to the horizon.
horizon	<input type="text" value="1"/>	The horizon in year fraction.
assets_params_file_path_from_dataspace	<input type="text" value="assets.txt"/>	The relative path from the dataspace of the asset params file following the csv format.
assets_correlations_file_path_from_dataspace	<input type="text" value="assets_correlations.txt"/>	The relative path from the dataspace of the asset correlations file.

VaR

confidenceRate	<input type="text" value="0.99"/>	The confidence level rate.
nbBins	<input type="text" value="50"/>	The number of bins for the portfolio estimation distributions.

Parallelization

nbTasks	<input type="text" value="5"/>	The number of ProActive replicated tasks.
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Display

width_chart	<input type="text" value="1000"/>	The width of the chart in pixels.
height_chart	<input type="text" value="500"/>	The height of the chart in pixels.

chart\_message\_to\_append

<start price>, <riskless rate>, <volatility rate>,<weight>  
20.16,0.2312,0.2116,0.3  
40,0.115,0.254,0.3  
110,0.6,0.4,0.4

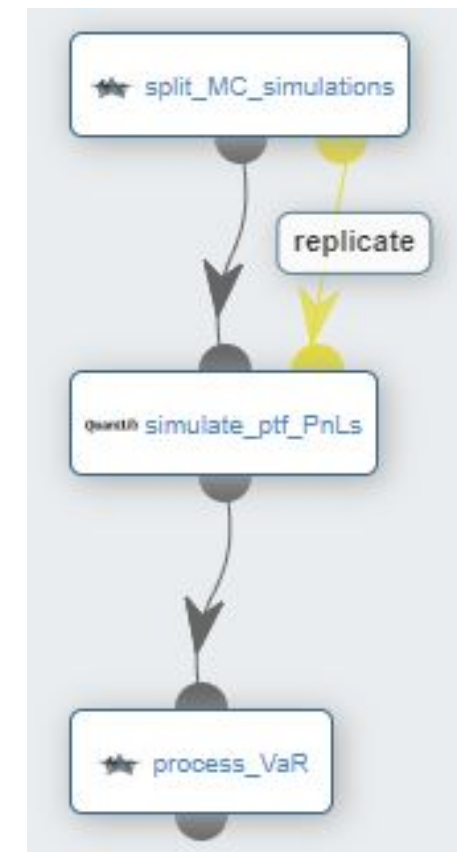
1 0 0  
0 1 0  
0 0 1



Estimates the number of MC simulations per replicated task. The tasks number does not necessary divide the total number of simulations

Using Quanlib, each replicated task proceses a subset of the MC simulations and deduces the PnL (profit and loss) of each simulated path (value at horizon of a simulation - value at start). On the task side, PnLs are saved into a dedicated file

This task gathers all the PnLs into a single array, sorts them, and retrieves the VaR at the VaR\_index corresponding to  $(1 - \text{confidenceRate}) * \text{nbMC}$ . Finally, it generates the corresponding frequencies bar chart and exposes it (view/download)



▼ Details

Tasks

Visualization

Users Sessions

Statistics

Usage

Tag

Filter

Auto-refresh

	Id	Status	Name	Tag	Duration	Nodes	Executions	N
▶	0	Finished	Split_MC_simulations		1s 668ms	1	0 / 2	
▶	1	Finished	simulate_ptf_PnLs		4s 800ms	1	0 / 2	
▶	2	Finished	process_VaR		3s 66ms	1	0 / 2	
▶	3	Finished	simulate_ptf_PnLs*1	REPLICATE-Split_M...	4s 562ms	1	0 / 2	
▶	4	Finished	simulate_ptf_PnLs*2	REPLICATE-Split_M...	4s 246ms	1	0 / 2	
▶	5	Finished	simulate_ptf_PnLs*3	REPLICATE-Split_M...	4s 720ms	1	0 / 2	
▶	6	Finished	simulate_ptf_PnLs*4	REPLICATE-Split_M...	3s 6ms	1	0 / 2	

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Job Info

Task Info

Output

Server Logs

Preview

Remote Visualization

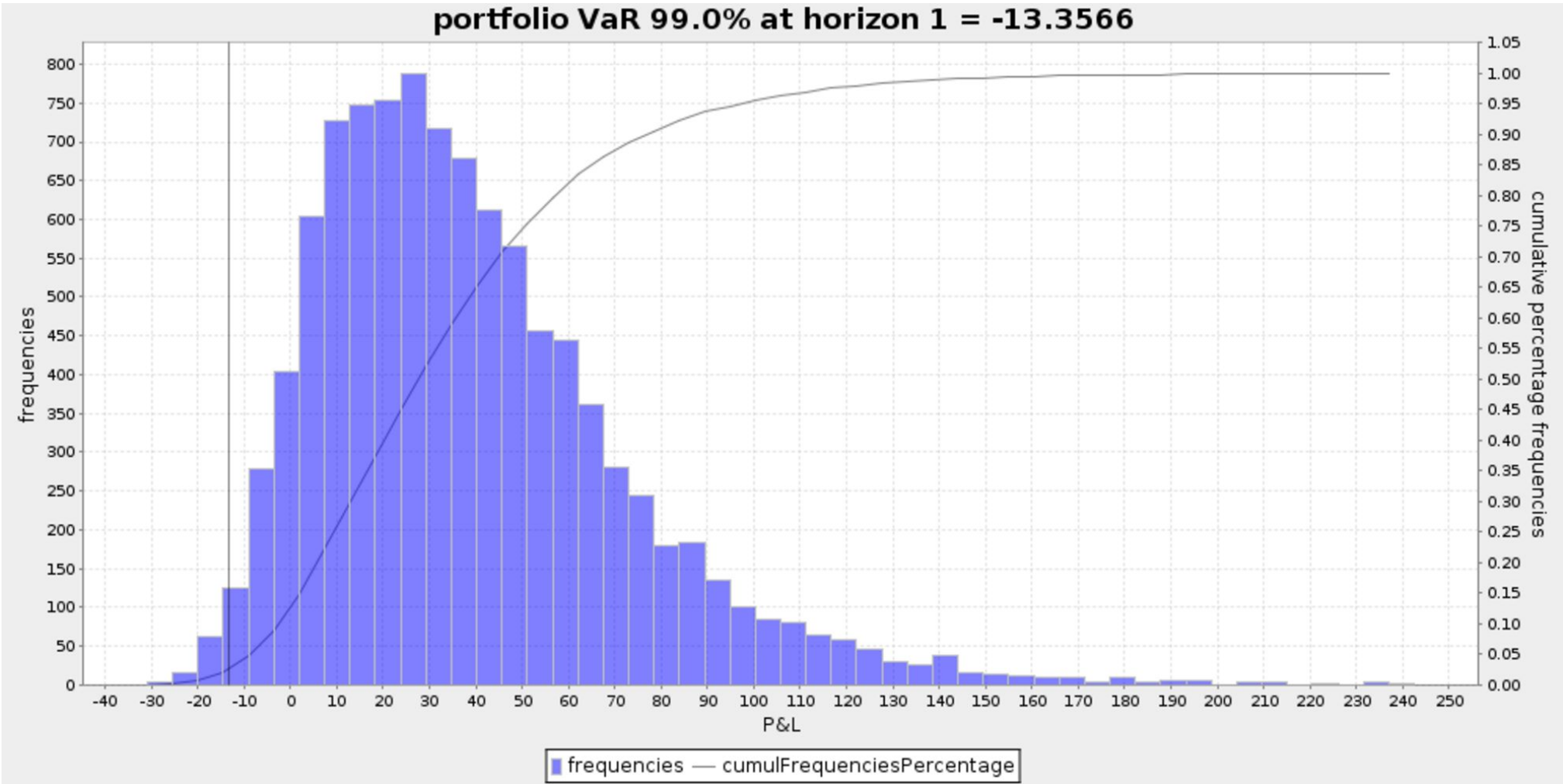
Remote visualization is disabled. Please toggle streaming in output view for a job in order to enable the remote visualization.

Task Result

Task process\_VaR (id: 2) from job MCVaR (id: 1)

Open in browser

Save as file





The interactive version of the Monte\_Carlo\_VaR\_portfolio workflow allows the user to add more MC simulations to the current results, for a more accurate VaR. “The estimated VaR can be refined incrementally.”

Submit a JobLaunch a ServiceManage Files▼Manage Third-Party Credentials

TreeFlat viewMy jobsAllNameAnyProjectAnyUserAny

PastCurrentPendingOnly Jobs with Issues

JIDWorkflowSubmittedStateInformation & Actions

93Monte\_Carlo\_VaR\_Portfolio\_Interactive\_ControlRisk Valuation Workflowsbenguigui01/31/2023 09:39:14STALLED81%19s

43Incremental\_Monte\_Carlo\_VaR\_Each\_Portfolio\_AssetRisk Valuation Workflowsbenguigui01/31/2023 08:59:49FINISHED

ResultsOutput

ResultsOutput

Actions▼

→ Terminate\_Job

→ Add\_more\_MC\_simulations

The user will be asked to specify the new MC simulation number to be aggregated to the VaR estimation.

You are about to send signal `Add_more_MC_simulations` to Job Id `6`, Workflow named `Monte_Carlo_VaR_Portfolio_MC_Interactive_Control`

Main Variables

nb\_MC10000

nb\_tasks5

TARGETED\_PA\_NODE\_SOURCE\_NAMEOn-Prem-Server-Static-Nodes▼

The number of Monte Carlo simulations.

The number of ProActive replicated tasks.

The node source where the job will be executed.



Estimates the incremental VaR (iVaR) for each asset of the portfolio. iVaR quantifies the risk a position (or sub-portfolio) is adding to a portfolio. The iVaR related to an asset Y, is the difference between the portfolio VaR with and without Y.

<u>Simulation</u>		
nbMC	<input type="text" value="10000"/>	The number of Monte Carlo simulations per VaR estimation.
nbTimeSteps	<input type="text" value="255"/>	The number of time steps to the horizon.
horizon	<input type="text" value="1"/>	The horizon in year fraction.
assets_params_file_path_from_dataspace	<input type="text" value="assets.txt"/>	The relative path from the dataspace of the asset params file following the csv format.
assets_correlations_file_path_from_dataspace	<input type="text" value="assets_correlations.txt"/>	The relative path from the dataspace of the asset correlations file.
<u>VaR</u>		
confidenceRate	<input type="text" value="0.99"/>	The confidence level rate.
nbBins	<input type="text" value="50"/>	The number of bins for the portfolio estimation distributions.
<u>Parallelization</u>		
nbTasksPerVaR	<input type="text" value="4"/>	The number of ProActive replicated tasks per VaR estimation.
<u>Display</u>		
width_chart	<input type="text" value="1000"/>	The width of the chart in pixels.
height_chart	<input type="text" value="500"/>	The height of the chart in pixels.



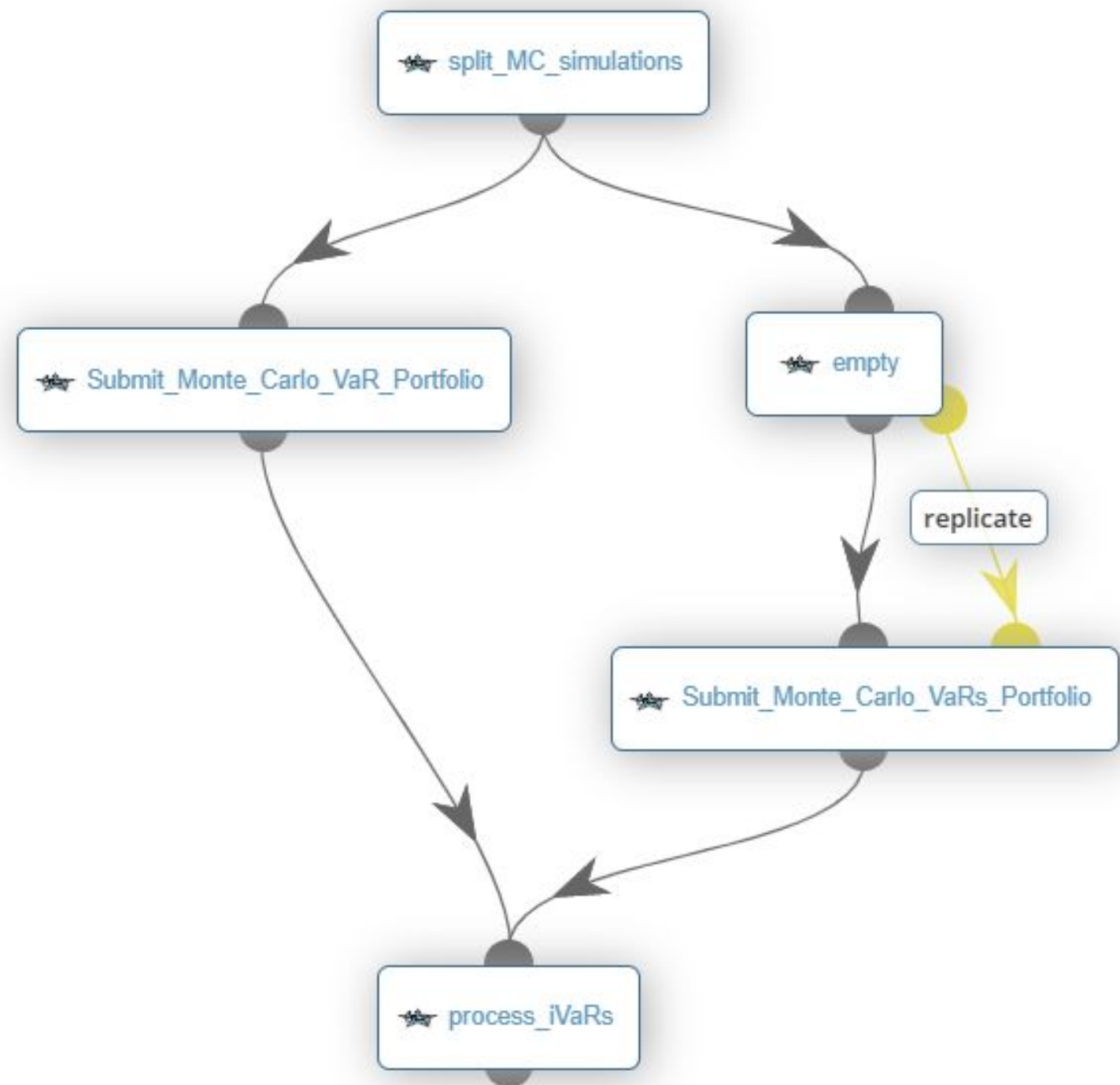
Estimates the number of MC simulations per replicated task for each VaR (right branch and left branch). The tasks number must divide the total number of simulations

(left branch) This task submits the Monte\_Carlo\_VaR\_portfolio wkw by considering all assets specified by the user

(right branch) **1st level of replicated tasks:** a replicated task per asset (Y)

(right branch) Each replicated task instantiates an asset params files, by excluding an asset from the portfolio, ie setting to 0 the asset weight. Then each task submits the Monte\_Carlo\_VaR\_portfolio wkw (**2nd inner level of replicated tasks**) with an instantiated asset params file as input.

Gather the portfolio VaR over all assets (left branch) and all partial VaRs (right branch). Compute and print the iVaR related to each asset (portfolio VaR estimated by the left branch - portfolio VaR without the asset Y estimated by the right branch)







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Auto-refresh

Filters: Submitted Pending Current Past Error

	Id	Status	Name	Tag	Duration
▶	0	Finished	split_MC_simulations		900ms
▶	1	Finished	Submit_Monte_Carlo_VaR_Portfolio		17s 923ms
▶	2	Finished	empty		860ms
▶	3	Finished	Submit_Monte_Carlo_VaRs_Portfolio		23s 575ms
▶	4	Finished	process_iVaRs		1s 404ms
▶	5	Finished	Submit_Monte_Carlo_VaRs_Portfolio*1	REPLICATE-empty-1	20s 101ms
▶	6	Finished	Submit_Monte_Carlo_VaRs_Portfolio*2	REPLICATE-empty-2	24s 704ms

Job Info

Job Variables

Job Results

Task Info

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Result List:

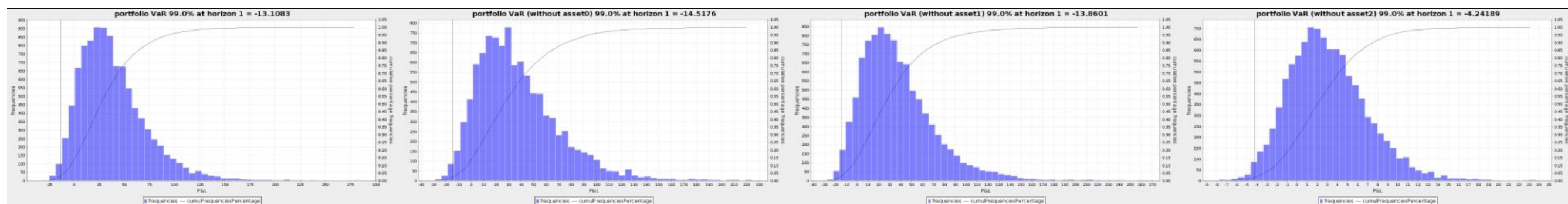
process\_iVaRs

Open in browser

Save as file

Result Map

No items to show.





Estimates the portfolio PnLs (Profits and Losses) over stressed risk free rates and volatilities.

Simulation

nb_MC_per_ptf_value	1000	The number of Monte Carlo simulations per portfolio estimation.
nb_time_steps	255	The number of time steps to the horizon.
stress_horizon	1	The stress horizon in year fraction.
assets_params_file_path_from_dataspace	assets.txt	The relative path from the dataspace of the asset params file following the csv format.
assets_correlations_file_path_from_dataspace	assets_correlations.txt	The relative path from the dataspace of the asset correlations file.
stressed_risk_free_rate_in_percent_range_min	-10	The min of the stressed risk free rate range.
stressed_risk_free_rate_in_percent_range_max	+10	The max of the stressed risk free rate range.
stressed_risk_free_rate_range_nb_steps	8	The step number of the stressed risk free rate range.
stressed_volatility_in_percent_range_min	-5	The min of the stressed volatility rate range.
stressed_volatility_in_percent_range_max	+5	The max of the stressed volatility rate range.
stressed_volatility_range_nb_steps	8	The step number of the stressed volatility rate range.

Parallelization

nb_replicated_tasks	4	The number of ProActive replicated tasks which must divide stressed_risk_free_rate_range_nb_steps x stressed_volatility_range_nb_steps.
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Others

DOCKER_ENABLED	<input checked="" type="radio"/> TRUE <input type="radio"/> FALSE	If true, the workflow tasks will be executed inside a docker container
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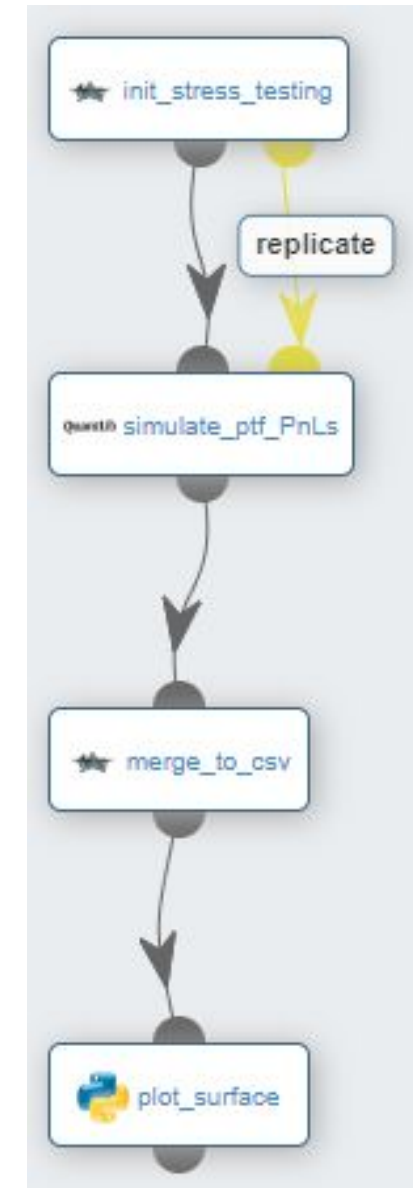


Generates all the combinations <stressed risk free rate, stressed volatility> according to their min,max,step user parameters. The number of replicated tasks must divide the number of combinations, i.e. the number of scenarios

Each replicated task processes a subset of the scenarios and estimates per scenario, the mean/expected portfolio Profit and Loss (P&L) over the given number of MC simulations. These simulations are processed in C++/Quantlib. Each task writes into a dedicated file all its estimated P&Ls (a P&L per senario)

Merge all stressed PnLs into a single csv file

Plot a 3D representation of the stressed PnLs



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Auto-refresh

	Id	Status	Name	Tag	Duration	Nodes	Executions	Node Failures	Visu
▶	0	Finished	plot_surface		5s 2ms	1	0 / 2	0 / 2	
▶	1	Finished	init_stress_testing		2s 43ms	1	0 / 2	0 / 2	
▶	2	Finished	simulate_ptf_PnLs		2m 43s 788ms	1	0 / 2	0 / 2	
▶	3	Finished	merge_to_csv		1s 931ms	1	0 / 2	0 / 2	
▶	4	Finished	simulate_ptf_PnLs*1	REPLICATE-init_stre...	2m 43s 606ms	1	0 / 2	0 / 2	
▶	5	Finished	simulate_ptf_PnLs*2	REPLICATE-init_stre...	2m 42s 81ms	1	0 / 2	0 / 2	
▶	6	Finished	simulate_ptf_PnLs*3	REPLICATE-init_stre...	2m 43s 284ms	1	0 / 2	0 / 2	

Job Info

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Remote Visualization

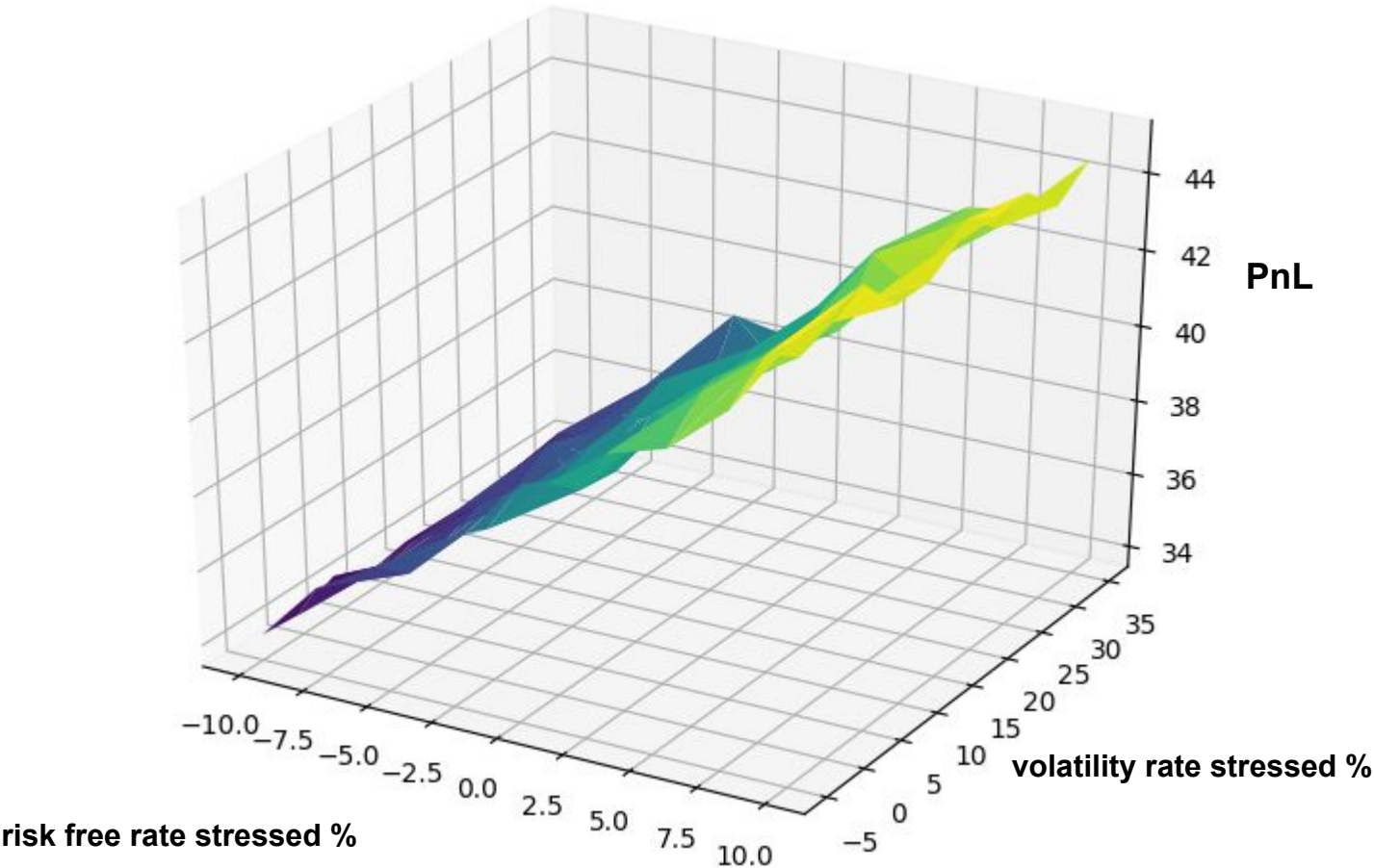
Remote visualization is disabled. Please toggle streaming in output view for a job in order to enable the remote visualization.

Task Result

Task plot\_surface (id: 0) from job stress\_testing\_Monte\_Carlo\_value\_portfolio (id: 21)

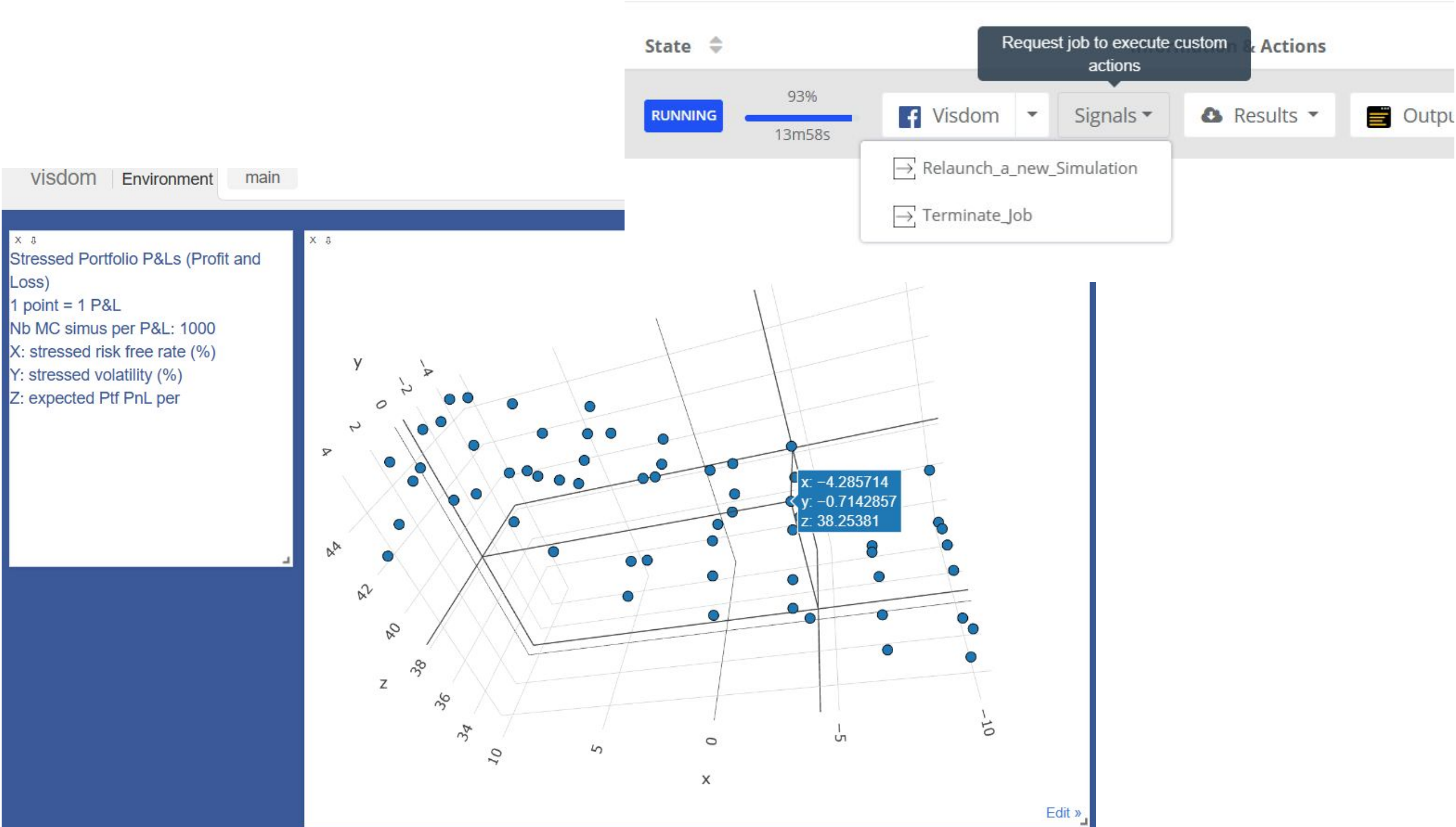
Open in browser

Save as file





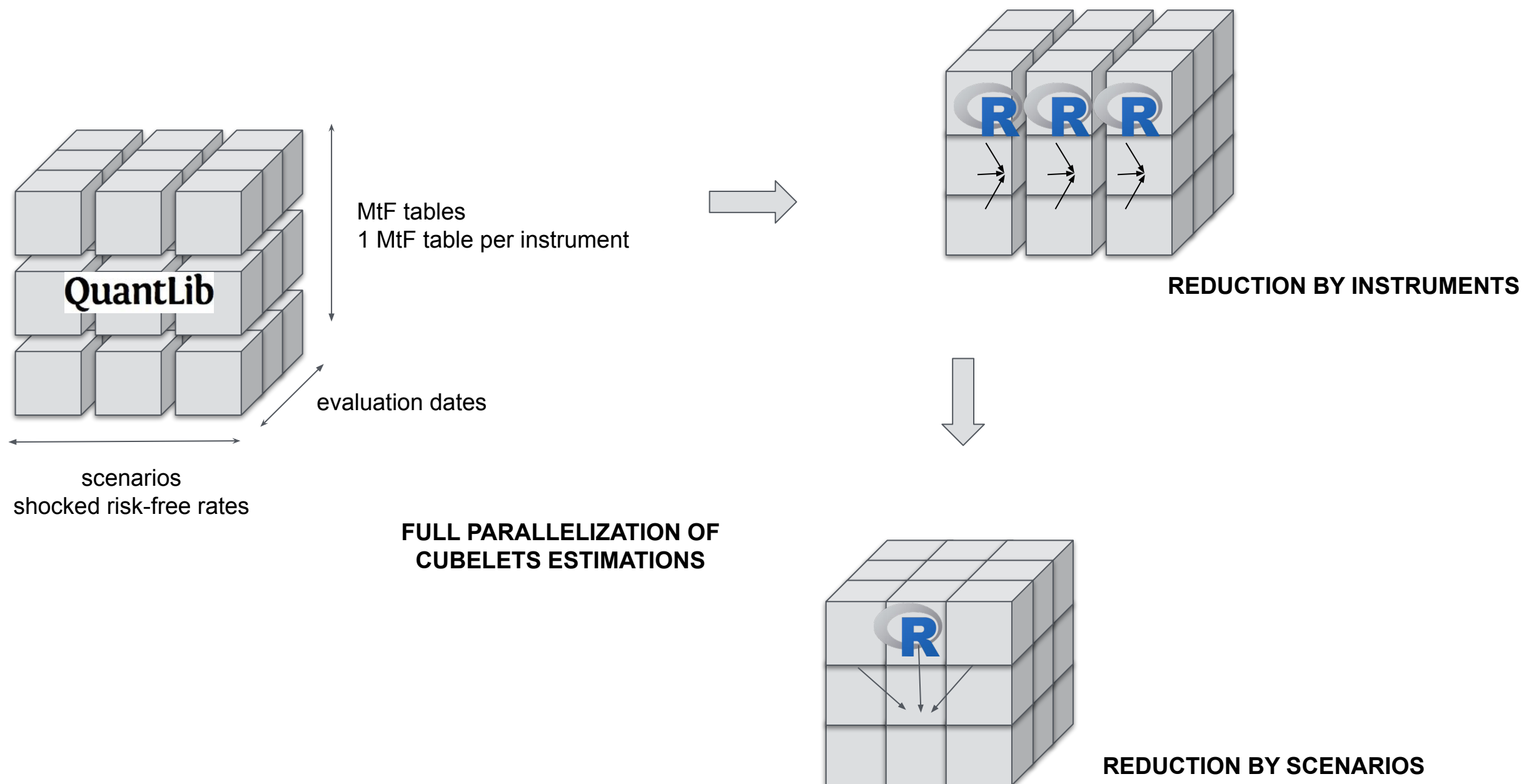
The interactive version of the Stress\_Testing\_Monte\_Carlo\_Value\_Portfolio workflow allows the user to stress test the portfolio by considering a new set of parameters.







Estimates a Mark-to-Future (MtF) cube of a bond portfolio. Each cell of the cube estimates the valuation of a bond at a specific time given a specific scenario. This can be easily extended to more exotic instruments thanks to the high maintainability of the implementation (C++ Quantlib for the pricing engine, inputs split in Java/Groovy, R for the cube/cubelet stats,...).





## Simulation

evaluation_date_start	<input type="text" value="01/12/2018"/>	The start date of the evaluation.
evaluation_date_end	<input type="text" value="20/12/2021"/>	The end date of the evaluation.
evaluation_frequency	<input type="text" value="biweekly"/>	The time discretization.
shocked_yield_start	<input type="text" value="0"/>	The start of the shocked yield range.
shocked_yield_end	<input type="text" value="0.1"/>	The end of the shocked yield range.
shocked_yield_delta	<input type="text" value="0.005"/>	The yield step of the shocked yield range.
bonds_params_file_path_from_dataspace	<input type="text" value="bonds.txt"/>	The relative path from the dataspace of the bond params file following the tsv format.

## Parallelization

nb_replicated_tasks	<input type="text" value="2"/>	The number of ProActive replicated tasks, each having in charge a cubelet, i.e. a subset of the scenarios.
nb_replicated_tasks_per_cubelet	<input type="text" value="2"/>	The number of ProActive replicated tasks, each having in charge a cubelet, i.e. a subset of the instruments.

## Hardware Resources

node_source_compute_memory_intensive_exclusive	<input type="radio"/> TRUE <input checked="" type="radio"/> FALSE	Exclusive usage or not of the targeted node sources.
node_source_compute_intensive	<input type="text"/>	Name of the targeted node source dedicated to compute intensive tasks.
node_source_memory_intensive	<input type="text"/>	Name of the targeted node source dedicated to memory intensive tasks.

## Others

data_dir_path	<input type="text" value="/tmp"/>	The path of the output files.
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Splits the scenarios and bonds over the replicated tasks

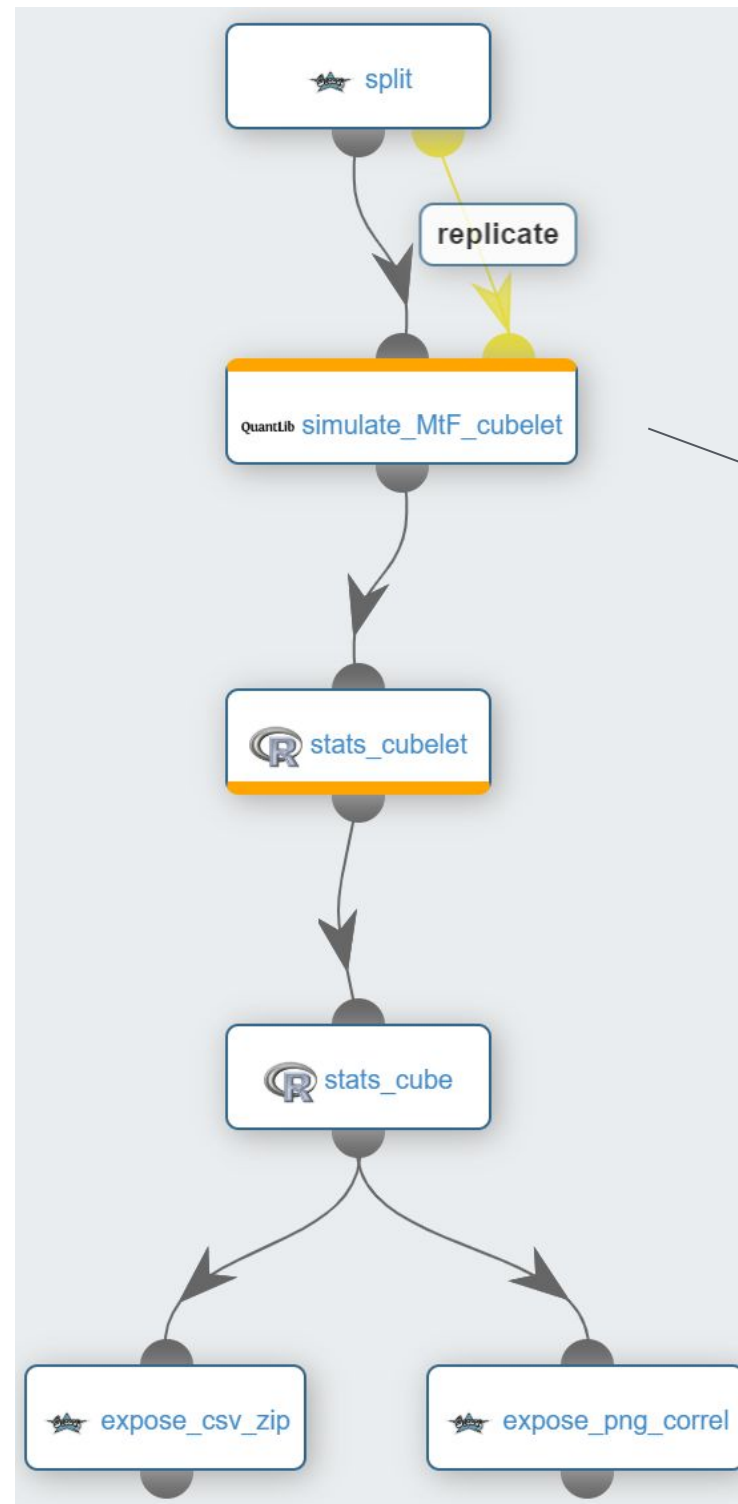
**1st level of replicated tasks:** a replicated task per subset of scenarios

Each replicated task pulls from the catalog and submits the cubelet simulation workflow

Computes the portfolio clean prices per scenario and per evaluation date (cubelets)

**Merges** the portfolio clean prices into a single csv file (cube). Computes portfolio prices time series for each scenario and creates a csv file. Computes correlations over scenarios and creates a csv file + heat map png file

Allows user to visualize/download the png/csv zip files

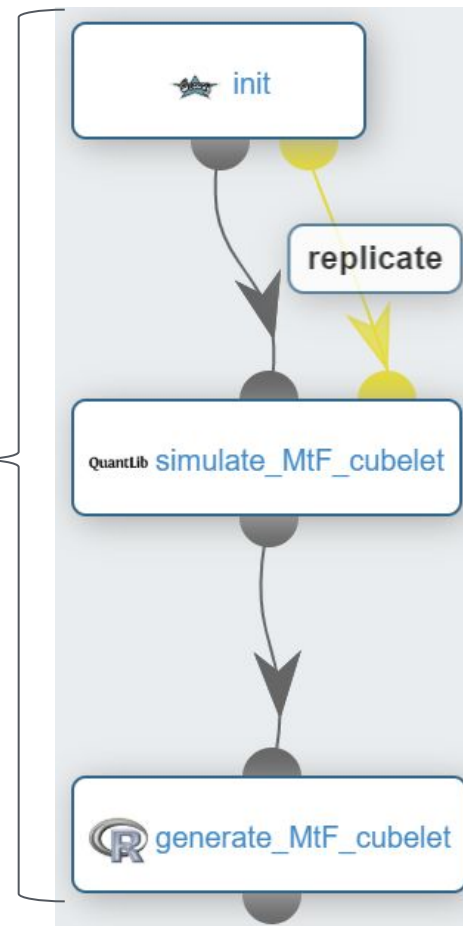


Init parameters

**2nd level of replicated tasks:** a replicated task per subset of bonds

Using Quanlib, each replicated task estimates a subset of the portfolio clean prices (cubelet)

**Merges** cubelets (bonds -> portfolio) and creates a csv file





Details

Tasks Visualization Users Sessions Statistics Usage

Tag  Filter ☒ Auto-refresh

	Id	Status	Name	Tag	Duration	Nodes	Executions
▶	0	Finished	split		2s 395ms	1	0 / 2
▶	1	Finished	simulate_MtF_cubelet		35s 107ms	1	1 / 2
▶	2	Finished	stats_cubelet		1s 304ms	1	0 / 2
▶	3	Finished	stats_cube		1s 842ms	1	0 / 2
▶	4	Finished	expose_csv_zip		2s 229ms	1	0 / 2
▶	5	Finished	expose_png_correl		1s 936ms	1	0 / 2
▶	6	Finished	simulate_MtF_cube...	REPLICATE-split-1	44s 471ms	1	1 / 2
▶	7	Finished	stats_cubelet*1	REPLICATE-split-1	1s 83ms	1	0 / 2

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**Remote Visualization**

Remote visualization is disabled. Please toggle streaming in output view for a job in order to enable the remote visualization.

**Task Result**

Task expose\_png\_correl (id: 5) from job Mark\_to\_Future\_cube\_stats (id: 36)

Open in browser

Save as file

