notebook-experiment-shocks

February 9, 2021

1 Experiment Analysis: Controller parameter stability search

Perform shocks of ETH price to test controller parameter stability, without stochastic processes.

- See `experiments/system_model_v3/experiment_shocks.py`

2 Setup and Dependencies

[1]:
```
# Set project root folder, to enable importing project files from subdirectories
from pathlib import Path
import os

path = Path().resolve()
root_path = str(path).split('notebooks')[0]
os.chdir(root_path)

# Force reload of project modules, sometimes necessary for Jupyter kernel
%load_ext autoreload
%autoreload 2

# Display framework versions for easy debugging
%pip show cadCAD
%pip show radcad
```

```
Name: cadCAD
Version: 0.4.23
Summary: cadCAD: a differential games based simulation software package for
research, validation, and         Computer Aided Design of economic systems
Home-page: https://github.com/cadCAD-org/cadCAD
Author: Joshua E. Jodesty
Author-email: joshua@block.science
License: LICENSE.txt
Location: /home/bscholtz/workspace/reflexer/venv/lib/python3.8/site-packages
Requires: fn, funcy, pandas, pathos
Required-by:
Note: you may need to restart the kernel to use updated packages.
Name: radcad
Version: 0.5.4
```

```
Summary: A cadCAD implementation, for dynamical systems modelling & simulation
Home-page: None
Author: Benjamin Scholtz
Author-email: ben@bitsofether.com
License: None
Location: /home/bscholtz/workspace/reflexer/venv/lib/python3.8/site-packages
Requires: ray, pandas, tables, boto3, pathos
Required-by:
Note: you may need to restart the kernel to use updated packages.
```

[2]:
```
# Import all shared dependencies and setup
from shared import *

import plotly.express as px
import plotly.graph_objects as go
from plotly.subplots import make_subplots
# import plotly.io as pio
# pio.renderers.default = "png"
from pprint import pprint
```

[3]:
```
# Update dataframe display settings
pd.set_option('display.max_columns', 100)
pd.set_option('display.max_rows', 50)
```

3 Load Results

Using the experiment logs, select the experiment of interest from the specific HDF5 store file (these datasets are very large, and won't be committed to repo):

[4]:
```
# experiment_results = 'experiments/system_model_v3/experiment_controller_sweep/
 ↪experiment_results.hdf5'
experiment_results = 'experiments/system_model_v3/experiment_shocks/
 ↪experiment_results.hdf5'
```

[5]:
```
experiment_results_keys = []
with pd.HDFStore(experiment_results) as store:
    experiment_results_keys = list(filter(lambda x: "results" in x, store.
 ↪keys()))
    exceptions_keys = list(filter(lambda x: "exceptions" in x, store.keys()))
```

[6]:
```
# A list of all experiment result keys
experiment_results_keys
```

[6]:
```
['/processed_results_2021-02-08T19:20:25.053328',
 '/processed_results_2021-02-08T19:45:15.538863',
 '/processed_results_2021-02-08T20:05:35.827550',
 '/processed_results_2021-02-08T22:54:43.005952',
```

```
 '/processed_results_2021-02-08T23:20:54.834451',
 '/processed_results_2021-02-09T09:43:01.154807',
 '/processed_results_2021-02-09T11:59:26.345803',
 '/results_2021-02-08T19:11:14.829535',
 '/results_2021-02-08T19:20:25.053328',
 '/results_2021-02-08T19:45:15.538863',
 '/results_2021-02-08T20:05:35.827550',
 '/results_2021-02-08T22:54:43.005952',
 '/results_2021-02-08T23:20:54.834451',
 '/results_2021-02-09T09:43:01.154807',
 '/results_2021-02-09T11:44:24.150805',
 '/results_2021-02-09T11:48:54.447990',
 '/results_2021-02-09T11:56:55.060726',
 '/results_2021-02-09T11:59:26.345803',
 '/results_2021-02-09T15:57:01.325820']
```

[7]:
```
# A list of all experiment result exception keys
exceptions_keys
```

[7]:
```
['/exceptions_2021-02-08T19:11:14.829535',
 '/exceptions_2021-02-08T19:20:25.053328',
 '/exceptions_2021-02-08T19:45:15.538863',
 '/exceptions_2021-02-08T20:05:35.827550',
 '/exceptions_2021-02-08T22:54:43.005952',
 '/exceptions_2021-02-08T23:20:54.834451',
 '/exceptions_2021-02-09T09:43:01.154807',
 '/exceptions_2021-02-09T11:44:24.150805',
 '/exceptions_2021-02-09T11:48:54.447990',
 '/exceptions_2021-02-09T11:56:55.060726',
 '/exceptions_2021-02-09T11:59:26.345803',
 '/exceptions_2021-02-09T15:57:01.325820']
```

[8]:
```
# Copy a results_ key from the above keys to select the experiment
experiment_results_key = 'results_2021-02-09T15:57:01.325820' # Or select last␣
 ↪result: experiment_results_keys[-1]
experiment_timestamp = experiment_results_key.strip('results_')
exceptions_key = 'exceptions_' + experiment_timestamp
experiment_timestamp
```

[8]:
```
'2021-02-09T15:57:01.325820'
```

[9]:
```
df_raw = pd.read_hdf(experiment_results, experiment_results_key)
df_raw.tail()
```

[9]:
```
                                          cdp_metrics optimal_values  \
3240120  {'cdp_count': 1, 'open_cdp_count': 1, 'closed_…             {}
3240121  {'cdp_count': 1, 'open_cdp_count': 1, 'closed_…             {}
```

```
3240122  {'cdp_count': 1, 'open_cdp_count': 1, 'closed_…             {}
3240123  {'cdp_count': 1, 'open_cdp_count': 1, 'closed_…             {}
3240124  {'cdp_count': 1, 'open_cdp_count': 1, 'closed_…             {}

        sim_metrics  timedelta  cumulative_time  timestamp  blockheight  \
3240120          {}       3600          5184000 2017-03-02            0
3240121          {}       3600          5184000 2017-03-02            0
3240122          {}       3600          5184000 2017-03-02            0
3240123          {}       3600          5184000 2017-03-02            0
3240124          {}       3600          5184000 2017-03-02            0

         eth_price  liquidity_demand  liquidity_demand_mean  \
3240120      300.0               0.0                    0.0
3240121      300.0               0.0                    0.0
3240122      300.0               0.0                    0.0
3240123      300.0               0.0                    0.0
3240124      300.0               0.0                    0.0

                                                    cdps  eth_collateral  \
3240120     open  time         locked         drawn    …   105925.122117
3240121     open  time         locked         drawn    …   105925.122117
3240122     open  time         locked         drawn    …   105925.122117
3240123     open  time         locked         drawn    …   105925.122117
3240124     open  time         locked         drawn    …   105925.122117

           eth_locked     eth_freed  eth_bitten  principal_debt  \
3240120  154827.528922  48902.406805         0.0    1.012023e+07
3240121  154827.528922  48902.406805         0.0    1.012023e+07
3240122  154827.528922  48902.406805         0.0    1.012023e+07
3240123  154827.528922  48902.406805         0.0    1.012023e+07
3240124  154827.528922  48902.406805         0.0    1.012023e+07

           rai_drawn     rai_wiped  rai_bitten  accrued_interest  \
3240120  1.753607e+07  7.415836e+06         0.0       8310.947187
3240121  1.753607e+07  7.415836e+06         0.0       8310.947187
3240122  1.753607e+07  7.415836e+06         0.0       8310.947187
3240123  1.753607e+07  7.415836e+06         0.0       8310.947187
3240124  1.753607e+07  7.415836e+06         0.0       8310.947187

         interest_dripped  interest_wiped  interest_bitten  w_1  w_2  w_3  \
3240120                 0               0                0  0.0  0.0  0.0
3240121                 0               0                0  0.0  0.0  0.0
3240122                 0               0                0  0.0  0.0  0.0
3240123                 0               0                0  0.0  0.0  0.0
3240124                 0               0                0  0.0  0.0  0.0

         system_revenue  stability_fee  market_price  market_price_twap  \
```

```
3240120            0.0   1.585490e-10      3.139079           3.139079
3240121            0.0   1.585490e-10      3.139079           3.139079
3240122            0.0   1.585490e-10      3.139079           3.139079
3240123            0.0   1.585490e-10      3.139079           3.139079
3240124            0.0   1.585490e-10      3.139079           3.139079

         target_price  target_rate  eth_return  eth_gross_return  \
3240120      2.165517          0.0         0.0               1.0
3240121      2.165517          0.0         0.0               1.0
3240122      2.165517          0.0         0.0               1.0
3240123      2.165517          0.0         0.0               1.0
3240124      2.165517          0.0         0.0               1.0

         expected_market_price  expected_debt_price  error_star  \
3240120               3.230577                 3.14    0.000921
3240121               3.230577                 3.14    0.000921
3240122               3.230577                 3.14    0.000921
3240123               3.230577                 3.14    0.000921
3240124               3.230577                 3.14    0.000921

         error_star_integral  market_slippage   RAI_balance    ETH_balance  \
3240120           445.315323              0.0  1.012023e+07  105894.055592
3240121           445.315323              0.0  1.012023e+07  105894.055592
3240122           445.315323              0.0  1.012023e+07  105894.055592
3240123           445.315323              0.0  1.012023e+07  105894.055592
3240124           445.315323              0.0  1.012023e+07  105894.055592

         UNI_supply                                      uniswap_oracle  \
3240120  10000000.0  <models.system_model_v3.model.parts.uniswap_or…
3240121  10000000.0  <models.system_model_v3.model.parts.uniswap_or…
3240122  10000000.0  <models.system_model_v3.model.parts.uniswap_or…
3240123  10000000.0  <models.system_model_v3.model.parts.uniswap_or…
3240124  10000000.0  <models.system_model_v3.model.parts.uniswap_or…

         simulation  subset  run  substep  timestep  events
3240120           0      24    5       14      1440     NaN
3240121           0      24    5       15      1440     NaN
3240122           0      24    5       16      1440     NaN
3240123           0      24    5       17      1440     NaN
3240124           0      24    5       18      1440     NaN
```

Get experiment exceptions, tracebacks, and simulation metadata for further analysis:

[10]:
```
exceptions_df = pd.read_hdf(experiment_results, exceptions_key)
exceptions_df.head()
```

[10]:
```
   exception traceback  simulation  run  subset  timesteps  \
0       None       None           0    0       0       1440
1       None       None           0    0       1       1440
2       None       None           0    0       2       1440
3       None       None           0    0       3       1440
4       None       None           0    0       4       1440

                                              parameters  \
0  {"0":{"debug":false,"raise_on_assert":true,"fr…
1  {"0":{"debug":false,"raise_on_assert":true,"fr…
2  {"0":{"debug":false,"raise_on_assert":true,"fr…
3  {"0":{"debug":false,"raise_on_assert":true,"fr…
4  {"0":{"debug":false,"raise_on_assert":true,"fr…

                                        initial_state
0  {'cdp_metrics': {}, 'optimal_values': {}, 'sim…
1  {'cdp_metrics': {}, 'optimal_values': {}, 'sim…
2  {'cdp_metrics': {}, 'optimal_values': {}, 'sim…
3  {'cdp_metrics': {}, 'optimal_values': {}, 'sim…
4  {'cdp_metrics': {}, 'optimal_values': {}, 'sim…
```

[11]:
```
# Print the first 5 exceptions - indicating failed simulations
pprint(list(exceptions_df['exception'])[:5])
```

```
[None, None, None, None, None]
```

4 Post Process Results

[12]:
```
from experiments.system_model_v3.post_process import post_process_results
from experiments.system_model_v3.experiment_shocks import params,␣
↪SIMULATION_TIMESTEPS
```

```
* Number of timesteps: 1440 / 60.0 days
* Number of MC runs: 5
* Timestep duration: 0.004 seconds
* Control parameters: ['kp', 'ki']
* Number of parameter combinations: 25
* Expected experiment duration: 12.0 minutes / 0.2 hours
```

Remove substeps, add `set_params` to dataframe, and add post-processing columns:

[13]:
```
df = post_process_results(df_raw, params, set_params=['ki', 'kp',␣
↪'liquidation_ratio'])
df
```

[13]:

	index	cdp_metrics
0	0	{}
1	18	{'cdp_count': 1, 'open_cdp_count': 1, 'closed_…
2	36	{'cdp_count': 1, 'open_cdp_count': 1, 'closed_…
3	54	{'cdp_count': 1, 'open_cdp_count': 1, 'closed_…
4	72	{'cdp_count': 1, 'open_cdp_count': 1, 'closed_…
…	…	…
180120	3240052	{'cdp_count': 1, 'open_cdp_count': 1, 'closed_…
180121	3240070	{'cdp_count': 1, 'open_cdp_count': 1, 'closed_…
180122	3240088	{'cdp_count': 1, 'open_cdp_count': 1, 'closed_…
180123	3240106	{'cdp_count': 1, 'open_cdp_count': 1, 'closed_…
180124	3240124	{'cdp_count': 1, 'open_cdp_count': 1, 'closed_…

	optimal_values	sim_metrics	timedelta	cumulative_time
0	{}	{}	0	0
1	{}	{}	3600	3600
2	{}	{}	3600	7200
3	{}	{}	3600	10800
4	{}	{}	3600	14400
…	…	…	…	…
180120	{}	{}	3600	5169600
180121	{}	{}	3600	5173200
180122	{}	{}	3600	5176800
180123	{}	{}	3600	5180400
180124	{}	{}	3600	5184000

	timestamp	blockheight	eth_price	liquidity_demand
0	2017-01-01 00:00:00	0	294.069151	1.0
1	2017-01-01 01:00:00	0	300.000000	0.0
2	2017-01-01 02:00:00	0	300.000000	-0.0
3	2017-01-01 03:00:00	0	300.000000	0.0
4	2017-01-01 04:00:00	0	300.000000	-0.0
…	…	…	…	…
180120	2017-03-01 20:00:00	0	300.000000	-0.0
180121	2017-03-01 21:00:00	0	300.000000	-0.0
180122	2017-03-01 22:00:00	0	300.000000	0.0
180123	2017-03-01 23:00:00	0	300.000000	0.0
180124	2017-03-02 00:00:00	0	300.000000	0.0

	liquidity_demand_mean
0	1.0000
1	0.5000
2	0.2500
3	0.1250
4	0.0625
…	…
180120	0.0000

```
180121                0.0000
180122                0.0000
180123                0.0000
180124                0.0000

                                                    cdps  eth_collateral  \
0                                                   None   154827.528922
1                                                   None   154827.528922
2                                                   None   105925.122117
3                                                   None   105925.122117
4                                                   None   105925.122117
…                                                    …            …
180120                                              None   105925.122117
180121                                              None   105925.122117
180122                                              None   105925.122117
180123    open  time         locked         drawn    …   105925.122117
180124    open  time         locked         drawn    …   105925.122117

          eth_locked     eth_freed  eth_bitten  principal_debt     rai_drawn  \
0       154827.528922      0.000000         0.0    1.000000e+07  1.000000e+07
1       154827.528922      0.000000         0.0    1.450000e+07  1.450000e+07
2       154827.528922  48902.406805         0.0    1.012023e+07  1.450000e+07
3       154827.528922  48902.406805         0.0    1.012023e+07  1.450000e+07
4       154827.528922  48902.406805         0.0    1.012023e+07  1.450000e+07
…                 …           …          …             …           …
180120  154827.528922  48902.406805         0.0    1.012023e+07  1.753607e+07
180121  154827.528922  48902.406805         0.0    1.012023e+07  1.753607e+07
180122  154827.528922  48902.406805         0.0    1.012023e+07  1.753607e+07
180123  154827.528922  48902.406805         0.0    1.012023e+07  1.753607e+07
180124  154827.528922  48902.406805         0.0    1.012023e+07  1.753607e+07

          rai_wiped  rai_bitten  accrued_interest  interest_dripped  \
0       0.000000e+00         0.0          0.000000                 0
1       0.000000e+00         0.0          5.707764                 0
2       4.379765e+06         0.0         11.484158                 0
3       4.379765e+06         0.0         17.260556                 0
4       4.379765e+06         0.0         23.036956                 0
…                 …          …                 …                 …
180120  7.415836e+06         0.0       8287.822681                 0
180121  7.415836e+06         0.0       8293.603802                 0
180122  7.415836e+06         0.0       8299.384927                 0
180123  7.415836e+06         0.0       8305.166055                 0
180124  7.415836e+06         0.0       8310.947187                 0

        interest_wiped  interest_bitten           w_1  w_2  w_3  \
0                    0                0  0.000000e+00  0.0  0.0
1                    0                0  8.276258e+00  0.0  0.0
```

```
2                    0                0  4.723892e-06  0.0  0.0
3                    0                0  2.696510e-12  0.0  0.0
4                    0                0  0.000000e+00  0.0  0.0
…                  …                …             …  …  …
180120               0                0  0.000000e+00  0.0  0.0
180121               0                0  0.000000e+00  0.0  0.0
180122               0                0  0.000000e+00  0.0  0.0
180123               0                0  0.000000e+00  0.0  0.0
180124               0                0  0.000000e+00  0.0  0.0

        system_revenue  stability_fee  market_price  market_price_twap  \
0                  0.0   1.585490e-10      3.140000           0.000000
1                  0.0   1.585490e-10      3.140000           0.000000
2                  0.0   1.585490e-10      1.525000           0.000000
3                  0.0   1.585490e-10      3.133425           0.000000
4                  0.0   1.585490e-10      3.133425           0.000000
…                  …             …             …                  …
180120             0.0   1.585490e-10      3.139079           3.139079
180121             0.0   1.585490e-10      3.139079           3.139079
180122             0.0   1.585490e-10      3.139079           3.139079
180123             0.0   1.585490e-10      3.139079           3.139079
180124             0.0   1.585490e-10      3.139079           3.139079

        target_price  target_rate  eth_return  eth_gross_return  \
0           3.140000          0.0    0.000000               0.0
1           2.165517          0.0    0.020168               1.0
2           2.165517          0.0    0.000000               1.0
3           2.165517          0.0    0.000000               1.0
4           2.165517          0.0    0.000000               1.0
…              …            …          …                  …
180120      2.165517          0.0    0.000000               1.0
180121      2.165517          0.0    0.000000               1.0
180122      2.165517          0.0    0.000000               1.0
180123      2.165517          0.0    0.000000               1.0
180124      2.165517          0.0    0.000000               1.0

        expected_market_price  expected_debt_price  error_star  \
0                    3.140000                 3.14    0.000000
1                    3.231683                 3.14    3.140000
2                    1.569093                 3.14    3.140000
3                    3.224303                 3.14    3.140000
4                    3.224444                 3.14    3.140000
…                       …                    …          …
180120               3.230576                 3.14    0.000921
180121               3.230576                 3.14    0.000921
180122               3.230577                 3.14    0.000921
180123               3.230577                 3.14    0.000921
```

```
180124              3.230577                3.14    0.000921

        error_star_integral  market_slippage   RAI_balance    ETH_balance  \
0                  0.000000         0.000000  1.000000e+07  106777.606153
1               5652.000000         0.000000  1.450000e+07   73708.353400
2              16932.000000         0.514331  1.012023e+07  105703.331685
3              28166.000000        -1.054705  1.012023e+07  105703.331685
4              39354.000000         0.000000  1.012023e+07  105703.331685
…                       …                …             …             …
180120           441.315323         0.000000  1.012023e+07  105894.055592
180121           442.315323         0.000000  1.012023e+07  105894.055592
180122           443.315323         0.000000  1.012023e+07  105894.055592
180123           444.315323         0.000000  1.012023e+07  105894.055592
180124           445.315323         0.000000  1.012023e+07  105894.055592

        UNI_supply                                        uniswap_oracle  \
0       10000000.0                                                  None
1       10000000.0                                                  None
2       10000000.0                                                  None
3       10000000.0                                                  None
4       10000000.0                                                  None
…            …                                                      …
180120  10000000.0                                                  None
180121  10000000.0                                                  None
180122  10000000.0                                                  None
180123  10000000.0  <models.system_model_v3.model.parts.uniswap_or…
180124  10000000.0  <models.system_model_v3.model.parts.uniswap_or…

        simulation  subset  run  substep  timestep  events  \
0                0       0    1        0         0     NaN
1                0       0    1       18         1     NaN
2                0       0    1       18         2     NaN
3                0       0    1       18         3     NaN
4                0       0    1       18         4     NaN
…              …     …  …       …        …     …
180120           0      24    5       18      1436     NaN
180121           0      24    5       18      1437     NaN
180122           0      24    5       18      1438     NaN
180123           0      24    5       18      1439     NaN
180124           0      24    5       18      1440     NaN

        eth_collateral_value  collateralization_ratio           ki  \
0               4.553000e+07                 1.450000 -5.000000e-09
1               4.644826e+07                 1.479244 -5.000000e-09
2               3.177754e+07                 1.450000 -5.000000e-09
3               3.177754e+07                 1.450000 -5.000000e-09
4               3.177754e+07                 1.450000 -5.000000e-09
```

```
…                    …                    …           …
180120          3.177754e+07                 1.450000 -2.000000e-10
180121          3.177754e+07                 1.450000 -2.000000e-10
180122          3.177754e+07                 1.450000 -2.000000e-10
180123          3.177754e+07                 1.450000 -2.000000e-10
180124          3.177754e+07                 1.450000 -2.000000e-10

                  kp  liquidation_ratio  target_price_scaled
0       2.000000e-07                1.45                4.553
1       2.000000e-07                1.45                3.140
2       2.000000e-07                1.45                3.140
3       2.000000e-07                1.45                3.140
4       2.000000e-07                1.45                3.140
…              …                   …                   …
180120  5.000000e-06                1.45                3.140
180121  5.000000e-06                1.45                3.140
180122  5.000000e-06                1.45                3.140
180123  5.000000e-06                1.45                3.140
180124  5.000000e-06                1.45                3.140

[180125 rows x 56 columns]
```

[14]:
```
%%capture
# Save the processed results to the same HDF5 store file
df.to_hdf(experiment_results, key=f'processed_results_{experiment_timestamp}')
```

5 Control Parameters

[15]:
```
from radcad.core import generate_parameter_sweep

param_sweep = generate_parameter_sweep(params)
```

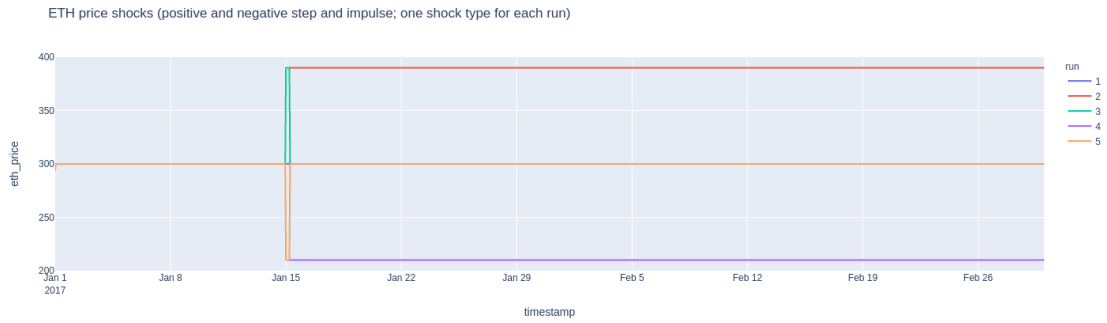
[16]:
```
df_control_parameters = df[['subset', 'kp', 'ki']]

df_control_parameters = df_control_parameters.drop_duplicates(subset=['kp',␣
↪'ki'])
df_control_parameters
```

[16]:
```
        subset            kp            ki
0            0  2.000000e-07 -5.000000e-09
1441         1  2.000000e-07 -3.000000e-09
2882         2  2.000000e-07 -1.000000e-09
4323         3  2.000000e-07 -6.000000e-10
5764         4  2.000000e-07 -2.000000e-10
7205         5  6.000000e-07 -5.000000e-09
8646         6  6.000000e-07 -3.000000e-09
```

```
10087       7  6.000000e-07 -1.000000e-09
11528       8  6.000000e-07 -6.000000e-10
12969       9  6.000000e-07 -2.000000e-10
14410      10  1.000000e-06 -5.000000e-09
15851      11  1.000000e-06 -3.000000e-09
17292      12  1.000000e-06 -1.000000e-09
18733      13  1.000000e-06 -6.000000e-10
20174      14  1.000000e-06 -2.000000e-10
21615      15  3.000000e-06 -5.000000e-09
23056      16  3.000000e-06 -3.000000e-09
24497      17  3.000000e-06 -1.000000e-09
25938      18  3.000000e-06 -6.000000e-10
27379      19  3.000000e-06 -2.000000e-10
28820      20  5.000000e-06 -5.000000e-09
30261      21  5.000000e-06 -3.000000e-09
31702      22  5.000000e-06 -1.000000e-09
33143      23  5.000000e-06 -6.000000e-10
34584      24  5.000000e-06 -2.000000e-10
```

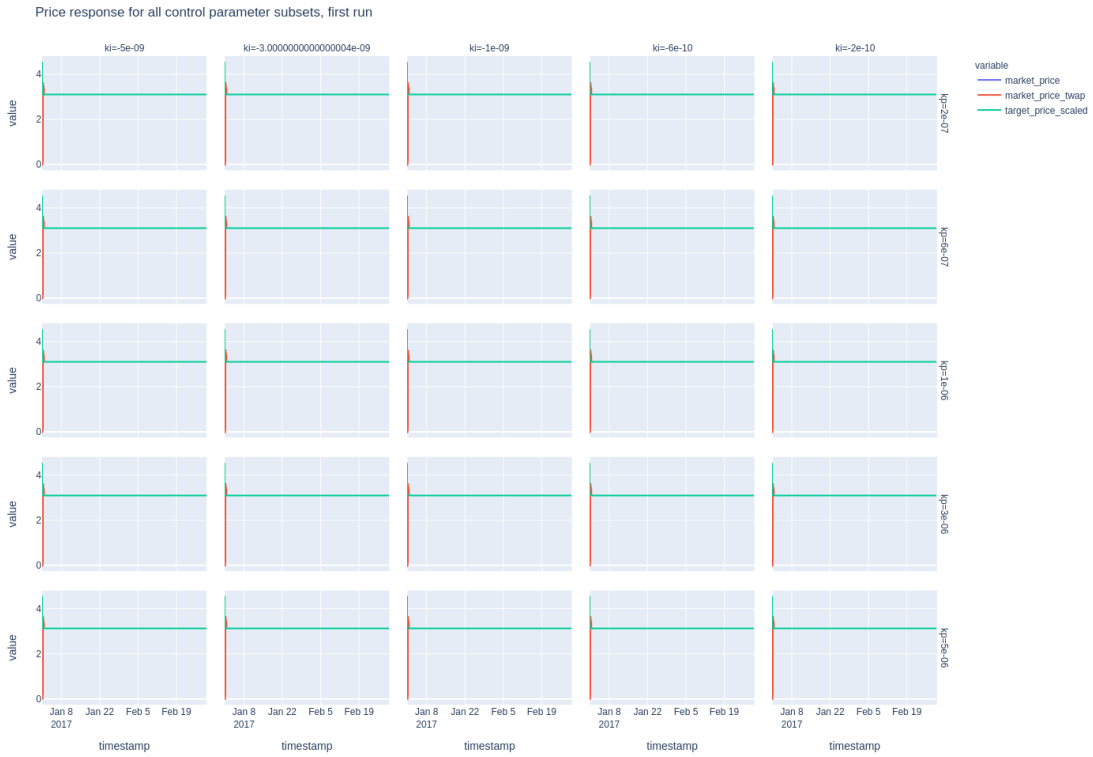
6 Simulation Analysis

[17]:
```
df.query('subset == 0')[['timestamp', 'eth_price', 'run']].plot(
    title="ETH price shocks (positive and negative step and impulse; one shock␣
 ↪type for each run)",
    x='timestamp',
    y='eth_price',
    color='run'
)
```



[18]:
```
fig = px.line(
    df.query('run == 1'),
    title="Price response for all control parameter subsets, first run",
    x="timestamp",
```

```
    y=["market_price", "market_price_twap", "target_price_scaled"],
    facet_col="ki",
    facet_row="kp",
    height=1000
)
fig.show()
```



Get the initial target price to test stability conditions:

[19]:
```
initial_target_price = df['target_price'].iloc[0]
initial_target_price
```

[19]:
```
3.14
```

Find all controller constant subsets where the price goes to zero:

[20]:
```
df_market_price_zero = df.query("market_price <= 0.1*@initial_target_price")
df_market_price_zero[['subset', 'kp', 'ki']].drop_duplicates(subset=['kp',␣
↪'ki'])
```

[20]:
```
Empty DataFrame
Columns: [subset, kp, ki]
Index: []
```

Find all controller constant subsets where the price goes to infinity:

[21]:
```
df_market_price_infinity = df.query("market_price > 10*@initial_target_price")
df_market_price_infinity[['subset', 'kp', 'ki']].drop_duplicates(subset=['kp',␣
↪'ki'])
```

[21]:
```
Empty DataFrame
Columns: [subset, kp, ki]
Index: []
```

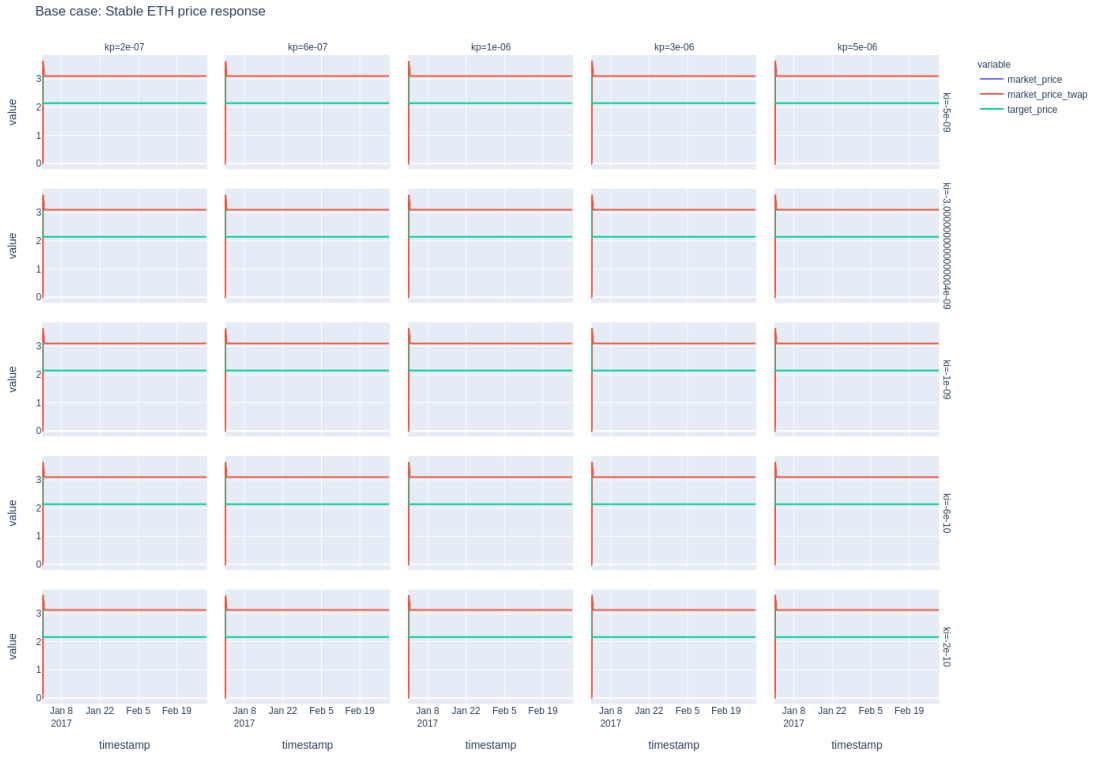
Create dataframe of stable simulation scenarios.

Stability is defined as: 1. The market price and scaled target price remaining within 0.1x and 10x the starting price, for all timesteps

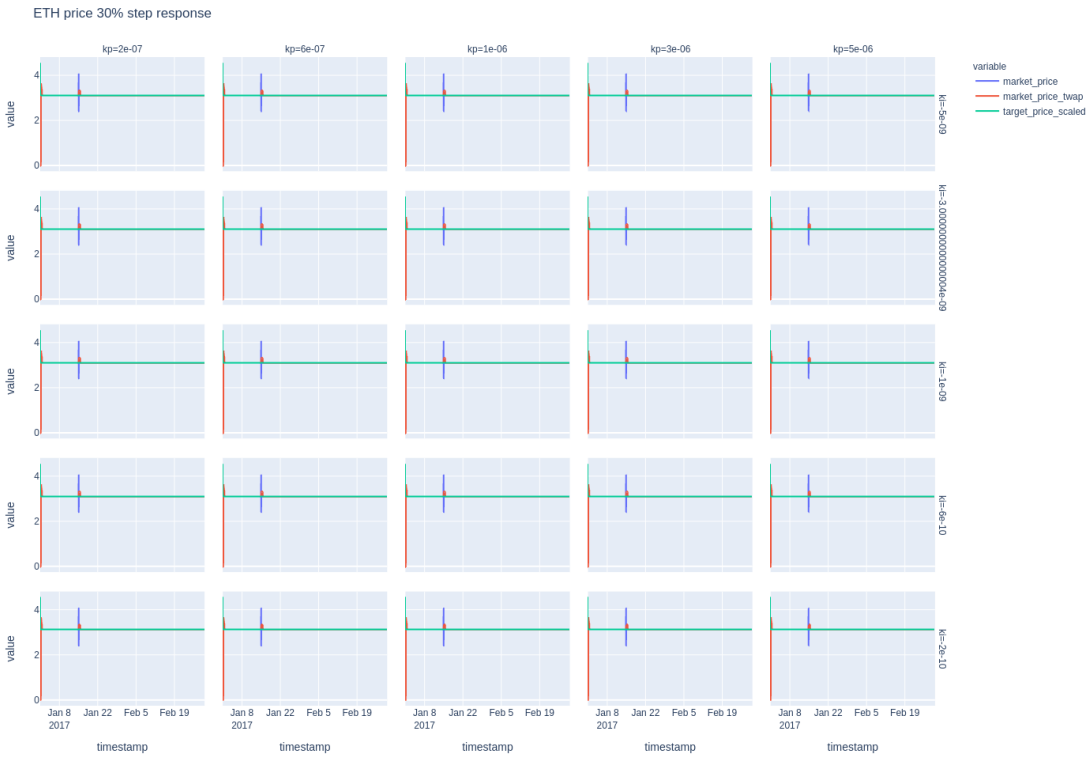
[22]:
```
df['stable_price'] = False
df.loc[df.eval("""
0.1*@initial_target_price < market_price <= 10*@initial_target_price and 0.
↪1*@initial_target_price < target_price_scaled <= 10*@initial_target_price
"""), 'stable_price'] = True
df_stable_price = df.groupby("subset").filter(lambda x: all(x.query('timestep >␣
↪24*2')['stable_price'])) #  and x['timestep'].max() == SIMULATION_TIMESTEPS
df_stable_price['subset'].unique()
```

[22]:
```
array([ 0,  1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15, 16,
       17, 18, 19, 20, 21, 22, 23, 24])
```

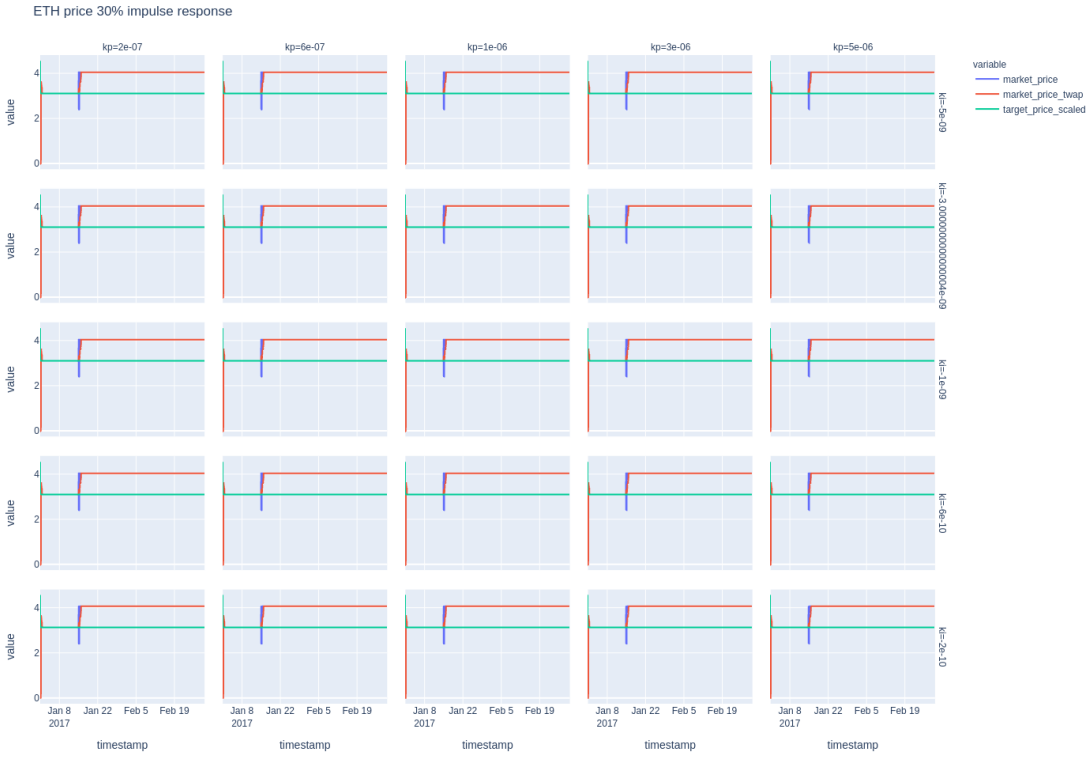
[23]:
```
fig = px.line(
    df_stable_price.query('run == 1'),
    title="Base case: Stable ETH price response",
    x="timestamp",
    y=["market_price", "market_price_twap", "target_price"],
    facet_col="kp",
    facet_row="ki",
    facet_col_wrap=2,
    height=1000
)
# fig.for_each_annotation(lambda a: a.update(text = f"kp={param_sweep[int(a.
↪text.split('=')[-1])]['kp']} ki={param_sweep[int(a.text.
↪split('=')[-1])]['ki']}"))
fig.show()
```



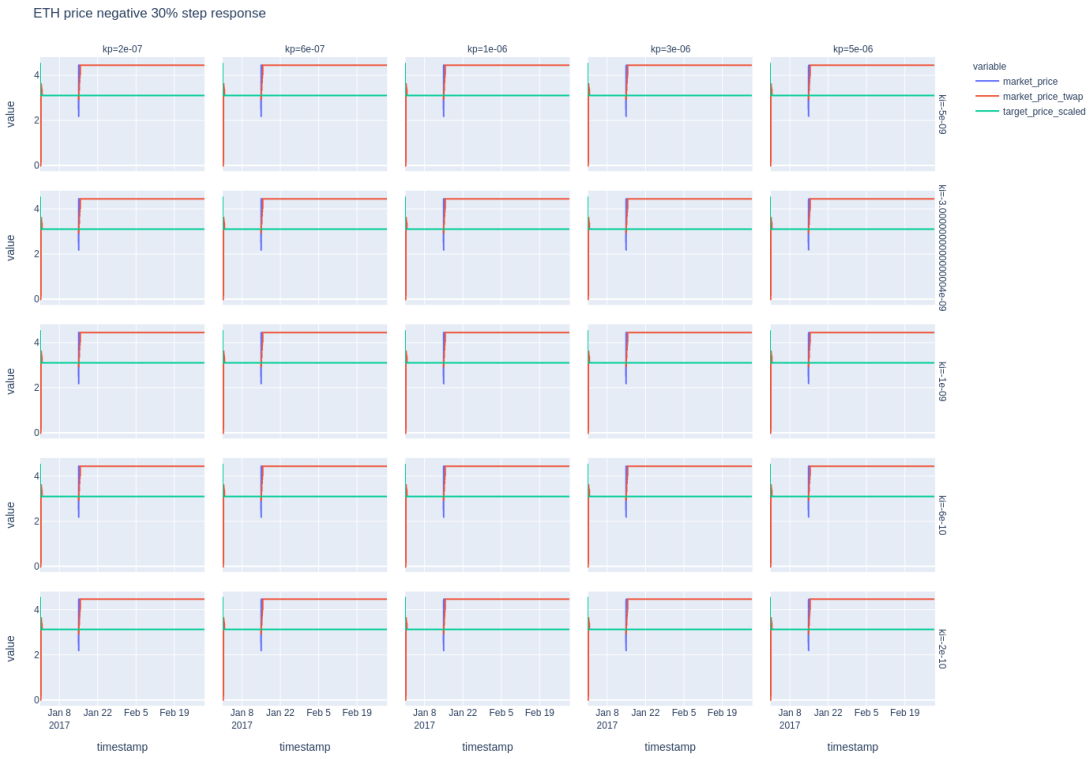
[24]:
```
fig = px.line(
    df_stable_price.query('run == 2'),
    title="ETH price 30% step response",
    x="timestamp",
    y=["market_price", "market_price_twap", "target_price_scaled"],
    facet_col="kp",
    facet_row="ki",
    facet_col_wrap=2,
    height=1000
)
fig.show()
```



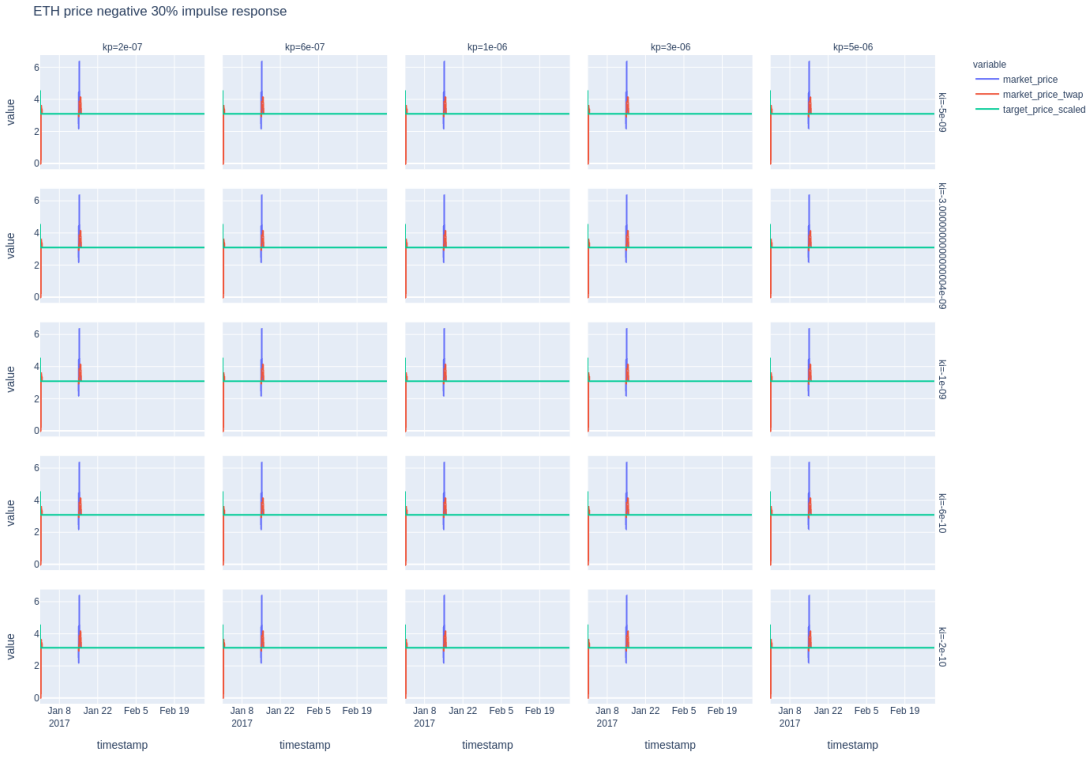
[25]:
```
fig = px.line(
    df_stable_price.query('run == 3'),
    title="ETH price 30% impulse response",
    x="timestamp",
    y=["market_price", "market_price_twap", "target_price_scaled"],
    facet_col="kp",
    facet_row="ki",
    facet_col_wrap=2,
    height=1000
)
fig.show()
```



[28]:
```
fig = px.line(
    df_stable_price.query('run == 4'),
    title="ETH price negative 30% step response",
    x="timestamp",
    y=["market_price", "market_price_twap", "target_price_scaled"],
    facet_col="kp",
    facet_row="ki",
    facet_col_wrap=2,
    height=1000
)
fig.show()
```



[29]:
```
fig = px.line(
    df_stable_price.query('run == 5'),
    title="ETH price negative 30% impulse response",
    x="timestamp",
    y=["market_price", "market_price_twap", "target_price_scaled"],
    facet_col="kp",
    facet_row="ki",
    facet_col_wrap=2,
    height=1000
)
fig.show()
```

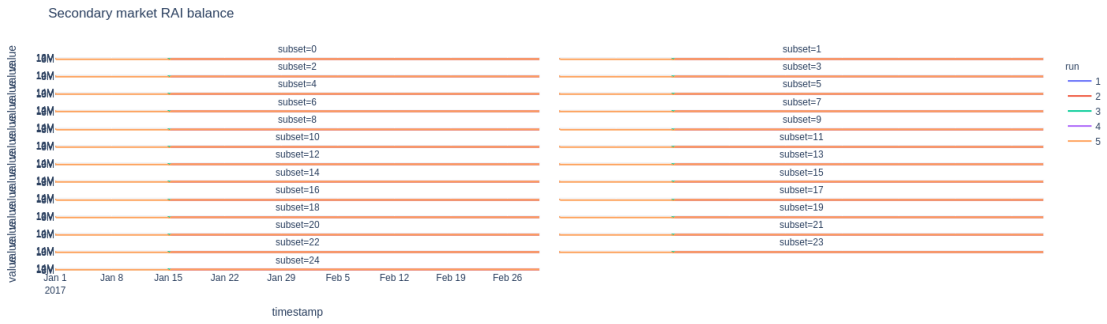


[35]:
```
fig = px.line(
    df_stable_price,
    title="Reflexer principal debt",
    x="timestamp",
    y=["principal_debt"],
    color='run',
    facet_col="subset",
    facet_col_wrap=2
)
fig.show()
```

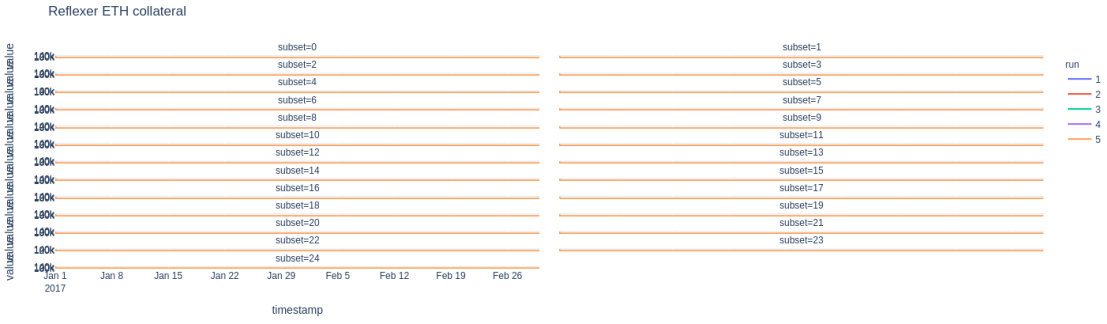
```
* Number of timesteps: 1440 / 60.0 days
* Number of MC runs: 5
* Timestep duration: 0.004 seconds
* Control parameters: ['kp', 'ki']
* Number of parameter combinations: 25
* Expected experiment duration: 12.0 minutes / 0.2 hours
```


Reflexer principal debt
subset=0
subset=1
subset=2
subset=3
subset=4
subset=5
subset=6
subset=7
subset=8
subset=9
subset=10
subset=11
subset=12
subset=13
subset=14
subset=15
subset=16
subset=17
subset=18
subset=19
subset=20
subset=21
subset=22
subset=23
subset=24
value
14M
12M
10M
8M
Jan 1
2017
Jan 8
Jan 15
Jan 22
Jan 29
Feb 5
Feb 12
Feb 19
Feb 26
timestamp
run
1
2
3
4
5

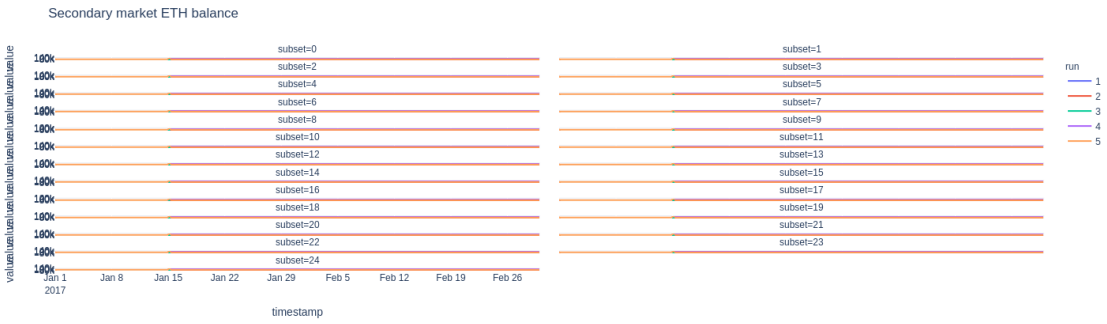
[31]:
```
fig = px.line(
    df_stable_price,
    title="Secondary market RAI balance",
    x="timestamp",
    y=["RAI_balance"],
    color='run',
    facet_col="subset",
    facet_col_wrap=2
)
fig.show()
```



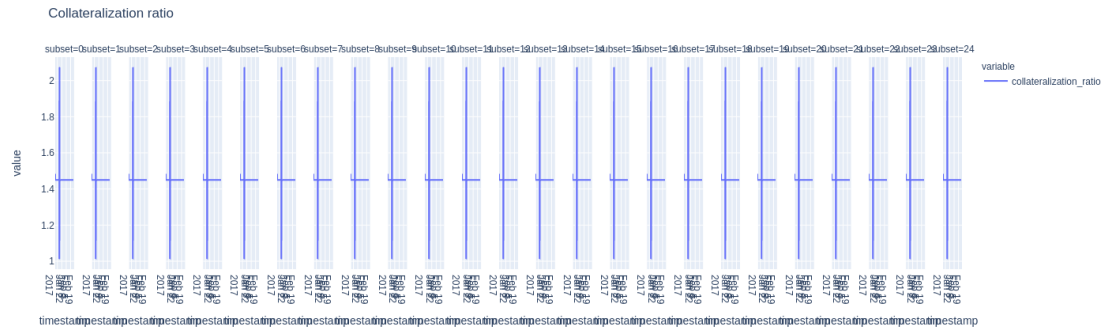
[32]:
```
fig = px.line(
    df_stable_price,
    title="Reflexer ETH collateral",
    x="timestamp",
    y=["eth_collateral"],
    color='run',
    facet_col="subset",
    facet_col_wrap=2
)
fig.show()
```



[33]:
```
fig = px.line(
    df_stable_price,
    title="Secondary market ETH balance",
    x="timestamp",
    y=["ETH_balance"],
    color='run',
    facet_col="subset",
    facet_col_wrap=2
)
fig.show()
```



[34]:
```
df_stable_price.plot(
    x='timestamp',
    y=['collateralization_ratio'],
    title='Collateralization ratio',
    facet_col="subset",
)
```



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