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: tables, pathos, boto3, ray, pandas
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',
 '/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']
```

[61]:

```
# A list of all experiment result exception keys
exceptions_keys
```

[61]:

```
['/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']
```

[62]:

```
# Copy a results_ key from the above keys to select the experiment
experiment_results_key = 'results_2021-02-09T09:43:01.154807' # Or select last␣
 ↪result: experiment_results_keys[-1]
experiment_timestamp = experiment_results_key.strip('results_')
exceptions_key = 'exceptions_' + experiment_timestamp
experiment_timestamp
```

[62]:

```
'2021-02-09T09:43:01.154807'
```

[63]:

```
df_raw = pd.read_hdf(experiment_results, experiment_results_key)
df_raw.tail()
```

[63]:

```
                                              cdp_metrics optimal_values  \
769414  {'cdp_count': 1, 'open_cdp_count': 1, 'closed_...             {}
769415  {'cdp_count': 1, 'open_cdp_count': 1, 'closed_...             {}
769416  {'cdp_count': 1, 'open_cdp_count': 1, 'closed_...             {}
769417  {'cdp_count': 1, 'open_cdp_count': 1, 'closed_...             {}
769418  {'cdp_count': 1, 'open_cdp_count': 1, 'closed_...             {}

       sim_metrics  timedelta  cumulative_time           timestamp  \
769414          {}       3600          3589200 2017-02-11 13:00:00
769415          {}       3600          3589200 2017-02-11 13:00:00
769416          {}       3600          3589200 2017-02-11 13:00:00
769417          {}       3600          3589200 2017-02-11 13:00:00
769418          {}       3600          3589200 2017-02-11 13:00:00

        blockheight  eth_price  liquidity_demand  liquidity_demand_mean  \
769414            0      300.0               0.0          7.466109e-301
769415            0      300.0               0.0          7.466109e-301
769416            0      300.0               0.0          7.466109e-301
769417            0      300.0               0.0          7.466109e-301
769418            0      300.0               0.0          7.466109e-301

                                                     cdps  eth_collateral  \
769414     open  time         locked         drawn    …    66110.592512
769415     open  time         locked         drawn    …    66110.592512
769416     open  time         locked         drawn    …    66110.592512
769417     open  time         locked         drawn    …    66110.592512
769418     open  time         locked         drawn    …    66110.592512

           eth_locked     eth_freed  eth_bitten  principal_debt     rai_drawn  \
769414  154827.528922  88716.936409         0.0    1.584718e+07  2.684323e+07
769415  154827.528922  88716.936409         0.0    1.584718e+07  2.684352e+07
769416  154827.528922  88716.936409         0.0    1.584747e+07  2.684352e+07
769417  154827.528922  88716.936409         0.0    1.584747e+07  2.684352e+07
769418  154827.528922  88716.936409         0.0    1.584747e+07  2.684352e+07

           rai_wiped  rai_bitten  accrued_interest  interest_dripped  \
769414  1.099606e+07         0.0       7887.068526                 0
769415  1.099606e+07         0.0       7887.068526                 0
769416  1.099606e+07         0.0       7887.068526                 0
769417  1.099606e+07         0.0       7887.068526                 0
769418  1.099606e+07         0.0       7887.068526                 0

        interest_wiped  interest_bitten       w_1  w_2  w_3  system_revenue  \
769414               0                0  0.000165  0.0  0.0             0.0
769415               0                0  0.000165  0.0  0.0             0.0
769416               0                0  0.000165  0.0  0.0             0.0
769417               0                0  0.000165  0.0  0.0             0.0
769418               0                0  0.000165  0.0  0.0             0.0

        stability_fee  market_price  market_price_twap  target_price  \
769414   1.585490e-10      1.283732           1.284012      0.863091
769415   1.585490e-10      1.283732           1.284012      0.863091
769416   1.585490e-10      1.283732           1.284012      0.863091
769417   1.585490e-10      1.283732           1.284012      0.863091
769418   1.585490e-10      1.283732           1.284012      0.863091

         target_rate  eth_return  eth_gross_return  expected_market_price  \
769414 -5.068893e-09         0.0               1.0                1.32113
769415 -5.068893e-09         0.0               1.0                1.32113
769416 -5.068893e-09         0.0               1.0                1.32113
769417 -5.068893e-09         0.0               1.0                1.32113
769418 -5.068893e-09         0.0               1.0                1.32113
```

```
        expected_debt_price  error_star  error_star_integral  \
769414                 3.14   -0.032507        -34660.235438   
769415                 3.14   -0.032507        -34660.235438   
769416                 3.14   -0.032507        -34660.235438   
769417                 3.14   -0.032507        -34660.235438   
769418                 3.14   -0.032507        -34660.235438   

        secondary_market_slippage  RAI_balance   ETH_balance  UNI_supply  \
769414                          0  1.584747e+07  67810.507448  10000000.0   
769415                          0  1.584747e+07  67810.507448  10000000.0   
769416                          0  1.584747e+07  67810.507448  10000000.0   
769417                          0  1.584747e+07  67810.507448  10000000.0   
769418                          0  1.584747e+07  67810.507448  10000000.0   

                                           uniswap_oracle  simulation  subset  \
769414  <models.system_model_v3.model.parts.uniswap_or…           0       8   
769415  <models.system_model_v3.model.parts.uniswap_or…           0       8   
769416  <models.system_model_v3.model.parts.uniswap_or…           0       8   
769417  <models.system_model_v3.model.parts.uniswap_or…           0       8   
769418  <models.system_model_v3.model.parts.uniswap_or…           0       8   

        run  substep  timestep  events  
769414    5       14       997     NaN  
769415    5       15       997     NaN  
769416    5       16       997     NaN  
769417    5       17       997     NaN  
769418    5       18       997     NaN  
```

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

[60]:
```
exceptions_df = pd.read_hdf(experiment_results, exceptions_key)
exceptions_df.head()
```

[60]:
```
                                 exception  \
0  underflow encountered in double_scalars   
1  underflow encountered in double_scalars   
2  underflow encountered in double_scalars   
3  underflow encountered in double_scalars   
4  underflow encountered in double_scalars   

                                           traceback  simulation  run  subset  \
0  Traceback (most recent call last):\n  File "/h…          0    0       0   
1  Traceback (most recent call last):\n  File "/h…          0    0       1   
2  Traceback (most recent call last):\n  File "/h…          0    0       2   
3  Traceback (most recent call last):\n  File "/h…          0    0       3   
4  Traceback (most recent call last):\n  File "/h…          0    0       4   
```

```
   timesteps                                         parameters  \
0       1440  {"0":{"debug":false,"raise_on_assert":true,"fr…
1       1440  {"0":{"debug":false,"raise_on_assert":true,"fr…
2       1440  {"0":{"debug":false,"raise_on_assert":true,"fr…
3       1440  {"0":{"debug":false,"raise_on_assert":true,"fr…
4       1440  {"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…
```

[59]:
```
# Print the first 5 exceptions - indicating failed simulations
pprint(list(exceptions_df['exception'])[:5])
```

```
[FloatingPointError('underflow encountered in double_scalars'),
 FloatingPointError('underflow encountered in double_scalars'),
 FloatingPointError('underflow encountered in double_scalars'),
 FloatingPointError('underflow encountered in double_scalars'),
 FloatingPointError('underflow encountered in double_scalars')]
```

4 Post Process Results

[11]:
```
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
* Timestep duration: 0.004 seconds
* Control parameters: ['kp', 'ki']
* Approx. number of values per parameter: 3
* Number of parameter combinations: 9
* Expected experiment duration: 0.8640000000000001 minutes /
0.014400000000000001 hours
```

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

[12]:
```
df = post_process_results(df_raw, params, set_params=['ki', 'kp',␣
 ↪'liquidation_ratio'])
df
```

[12]:

```
        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_…
…       …                                                …
42783  769346  {'cdp_count': 1, 'open_cdp_count': 1, 'closed_…
42784  769364  {'cdp_count': 1, 'open_cdp_count': 1, 'closed_…
42785  769382  {'cdp_count': 1, 'open_cdp_count': 1, 'closed_…
42786  769400  {'cdp_count': 1, 'open_cdp_count': 1, 'closed_…
42787  769418  {'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
…              …         …        …              …
42783             {}          {}       3600          3574800
42784             {}          {}       3600          3578400
42785             {}          {}       3600          3582000
42786             {}          {}       3600          3585600
42787             {}          {}       3600          3589200

                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
…                   …          …         …               …
42783 2017-02-11 09:00:00            0  300.000000               0.0
42784 2017-02-11 10:00:00            0  300.000000               0.0
42785 2017-02-11 11:00:00            0  300.000000              -0.0
42786 2017-02-11 12:00:00            0  300.000000               0.0
42787 2017-02-11 13:00:00            0  300.000000               0.0

       liquidity_demand_mean  \
0               1.000000e+00
1               5.000000e-01
2               2.500000e-01
3               1.250000e-01
4               6.250000e-02
…                      …
42783          1.194577e-299
```

```
42784          5.972887e-300
42785          2.986444e-300
42786          1.493222e-300
42787          7.466109e-301

                                                    cdps  eth_collateral  \
0                                                   None   154827.528922
1                                                   None   154827.528922
2                                                   None   105925.122117
3                                                   None   105925.122117
4                                                   None   105925.122117
…                                                  …             …
42783                                               None    66110.592512
42784                                               None    66110.592512
42785                                               None    66110.592512
42786                                               None    66110.592512
42787     open  time         locked         drawn    …    66110.592512

          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
…              …           …         …             …           …
42783  154827.528922  88716.936409         0.0    1.584631e+07  2.684237e+07
42784  154827.528922  88716.936409         0.0    1.584660e+07  2.684266e+07
42785  154827.528922  88716.936409         0.0    1.584689e+07  2.684294e+07
42786  154827.528922  88716.936409         0.0    1.584718e+07  2.684323e+07
42787  154827.528922  88716.936409         0.0    1.584747e+07  2.684352e+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
…             …         …               …               …
42783  1.099606e+07         0.0       7850.870783                 0
42784  1.099606e+07         0.0       7859.919964                 0
42785  1.099606e+07         0.0       7868.969315                 0
42786  1.099606e+07         0.0       7878.018836                 0
42787  1.099606e+07         0.0       7887.068526                 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
…               …              …           …  …  …
42783               0                0  1.645057e-04  0.0  0.0
42784               0                0  1.647442e-04  0.0  0.0
42785               0                0  1.647472e-04  0.0  0.0
42786               0                0  1.647502e-04  0.0  0.0
42787               0                0  1.650584e-04  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
…               …            …           …                …
42783             0.0   1.585490e-10      1.283918           1.284291
42784             0.0   1.585490e-10      1.283872           1.284151
42785             0.0   1.585490e-10      1.283825           1.284151
42786             0.0   1.585490e-10      1.283778           1.284151
42787             0.0   1.585490e-10      1.283732           1.284012

       target_price   target_rate  eth_return  eth_gross_return  \
0          3.140000  0.000000e+00    0.000000               0.0
1          2.165517  0.000000e+00    0.020168               1.0
2          2.165517  0.000000e+00    0.000000               1.0
3          2.165517  0.000000e+00    0.000000               1.0
4          2.165517  0.000000e+00    0.000000               1.0
…             …           …         …               …
42783      0.863154 -5.059519e-09    0.000000               1.0
42784      0.863138 -5.059519e-09    0.000000               1.0
42785      0.863122 -5.059519e-09    0.000000               1.0
42786      0.863107 -5.068893e-09    0.000000               1.0
42787      0.863091 -5.068893e-09    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
…                      …                  …         …
42783               1.321322                 3.14   -0.032695
42784               1.321274                 3.14   -0.032578
42785               1.321226                 3.14   -0.032601
42786               1.321178                 3.14   -0.032624
```

```
42787               1.321130                 3.14   -0.032507

       error_star_integral  secondary_market_slippage   RAI_balance  \
0                 0.000000                          0  1.000000e+07
1              5652.000000                          0  1.450000e+07
2             16932.000000                          0  1.012023e+07
3             28166.000000                          0  1.012023e+07
4             39354.000000                          0  1.012023e+07
…                    …                        …           …
42783        -34764.662660                          0  1.584631e+07
42784        -34738.492828                          0  1.584660e+07
42785        -34712.323053                          0  1.584689e+07
42786        -34686.405119                          0  1.584718e+07
42787        -34660.235438                          0  1.584747e+07

         ETH_balance  UNI_supply  \
0      106777.606153  10000000.0
1       73708.353400  10000000.0
2      105703.331685  10000000.0
3      105703.331685  10000000.0
4      105703.331685  10000000.0
…              …         …
42783   67815.435562  10000000.0
42784   67814.204070  10000000.0
42785   67812.972601  10000000.0
42786   67811.741154  10000000.0
42787   67810.507448  10000000.0

                                          uniswap_oracle  simulation  subset  \
0                                                   None           0       0
1                                                   None           0       0
2                                                   None           0       0
3                                                   None           0       0
4                                                   None           0       0
…                                                  …         …     …
42783                                               None           0       8
42784                                               None           0       8
42785                                               None           0       8
42786                                               None           0       8
42787  <models.system_model_v3.model.parts.uniswap_or…           0       8

       run  substep  timestep  events  eth_collateral_value  \
0        1        0         0     NaN          4.553000e+07
1        1       18         1     NaN          4.644826e+07
2        1       18         2     NaN          3.177754e+07
3        1       18         3     NaN          3.177754e+07
4        1       18         4     NaN          3.177754e+07
```

```
…    …      …       …     …                   …
42783    5       18       993     NaN          1.983318e+07
42784    5       18       994     NaN          1.983318e+07
42785    5       18       995     NaN          1.983318e+07
42786    5       18       996     NaN          1.983318e+07
42787    5       18       997     NaN          1.983318e+07

       collateralization_ratio            ki            kp  liquidation_ratio  \
0                     1.450000 -1.000000e-09  1.000000e-07               1.45
1                     1.479244 -1.000000e-09  1.000000e-07               1.45
2                     1.450000 -1.000000e-09  1.000000e-07               1.45
3                     1.450000 -1.000000e-09  1.000000e-07               1.45
4                     1.450000 -1.000000e-09  1.000000e-07               1.45
…                          …           …            …                 …
42783                 1.450026 -1.000000e-07  1.000000e-05               1.45
42784                 1.450026 -1.000000e-07  1.000000e-05               1.45
42785                 1.450026 -1.000000e-07  1.000000e-05               1.45
42786                 1.450026 -1.000000e-07  1.000000e-05               1.45
42787                 1.450026 -1.000000e-07  1.000000e-05               1.45

       target_price_scaled
0                 4.553000
1                 3.140000
2                 3.140000
3                 3.140000
4                 3.140000
…                    …
42783             1.251573
42784             1.251550
42785             1.251528
42786             1.251505
42787             1.251482

[42788 rows x 56 columns]
```

[55]:

```
%%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
```

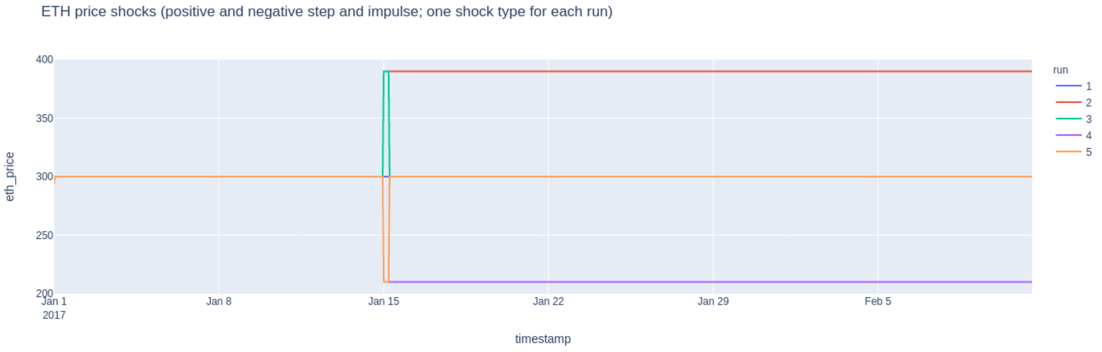
[16]:

```
      subset            kp            ki
0          0  1.000000e-07 -1.000000e-09
998        1  1.000000e-07 -1.000000e-08
1996       2  1.000000e-07 -1.000000e-07
2994       3  1.000000e-06 -1.000000e-09
3992       4  1.000000e-06 -1.000000e-08
4990       5  1.000000e-06 -1.000000e-07
5988       6  1.000000e-05 -1.000000e-09
6986       7  1.000000e-05 -1.000000e-08
7984       8  1.000000e-05 -1.000000e-07
```

6 Simulation Analysis

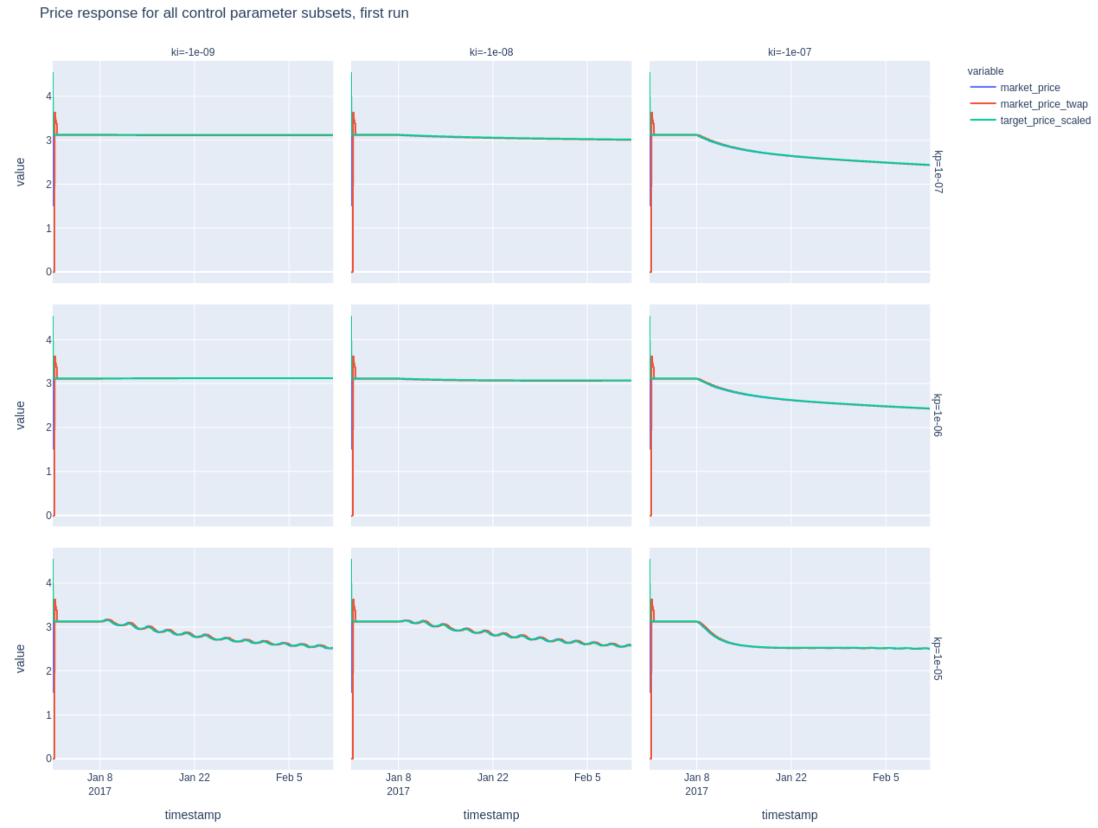
[58]:

```
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'
)
```



[54]:

```
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()
```


Price response for all control parameter subsets, first run

Get the initial target price to test stability conditions:

[20]:

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

[20]:

```
3.14
```

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

[38]:

```
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'])
```

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

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

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

```
[37]:        subset            kp            ki
      19809       1  1.000000e-07 -1.000000e-08
      20447       2  1.000000e-07 -1.000000e-07
      23068       5  1.000000e-06 -1.000000e-07
```

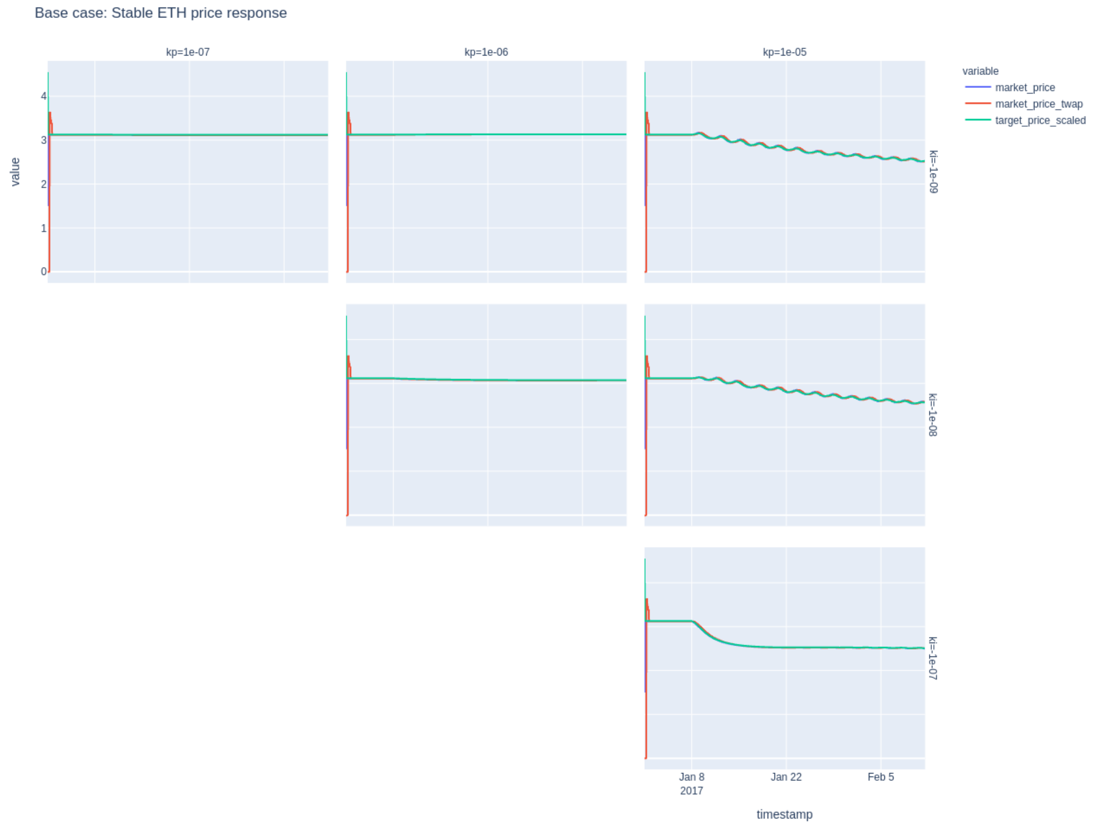
Create dataframe of stable simulation scenarios.

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

```
[21]: 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()
```

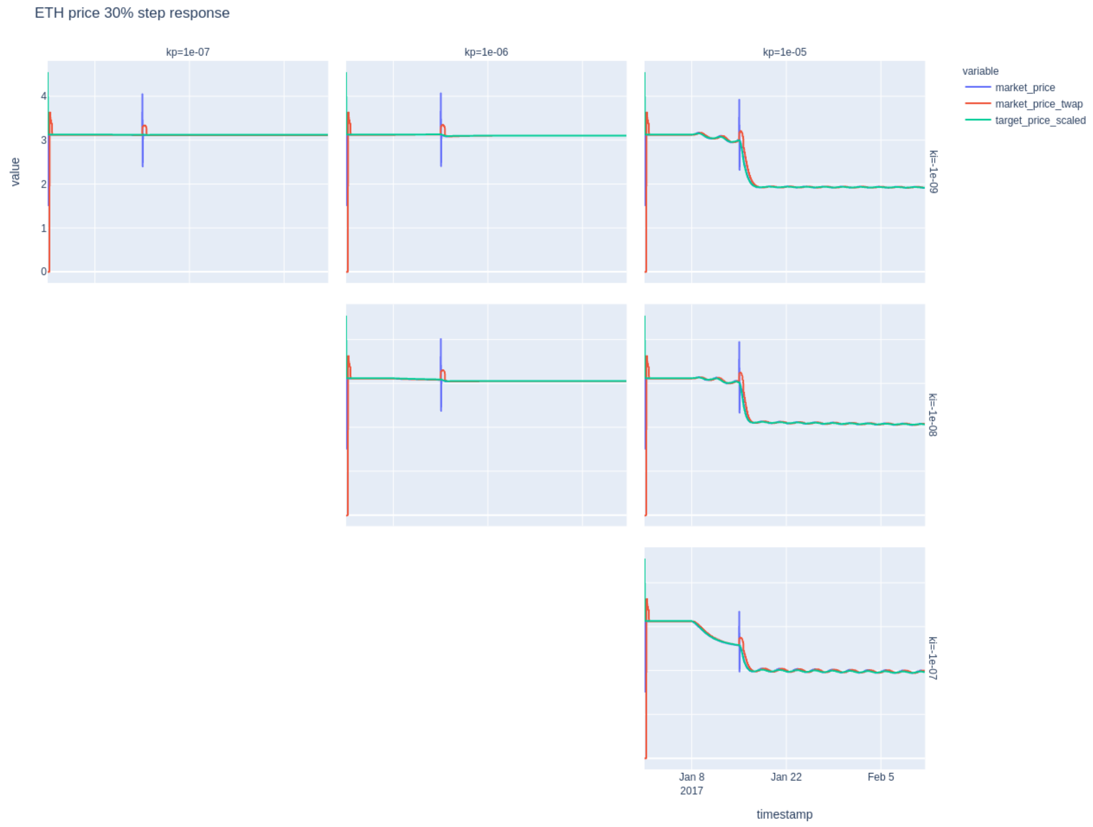
```
[21]: array([0, 3, 4, 6, 7, 8])
```

```
[50]: 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_scaled"],
          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()
```



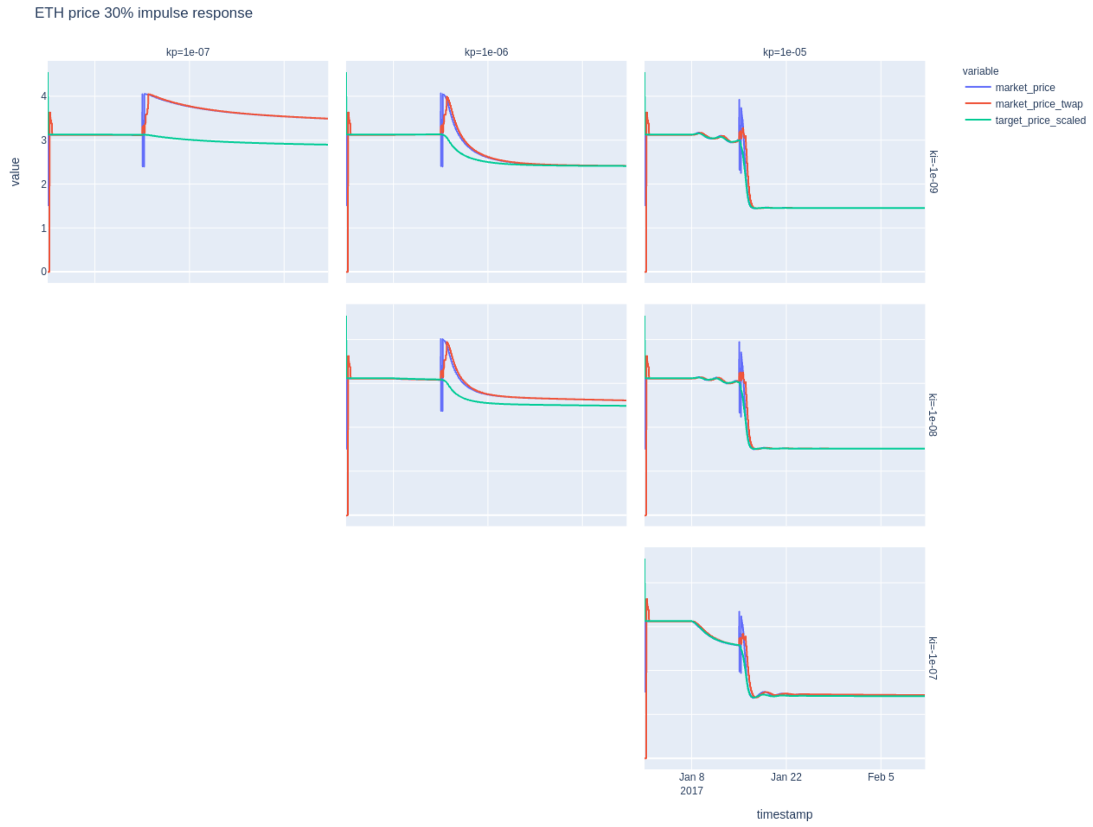
[33]:

```
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()
```



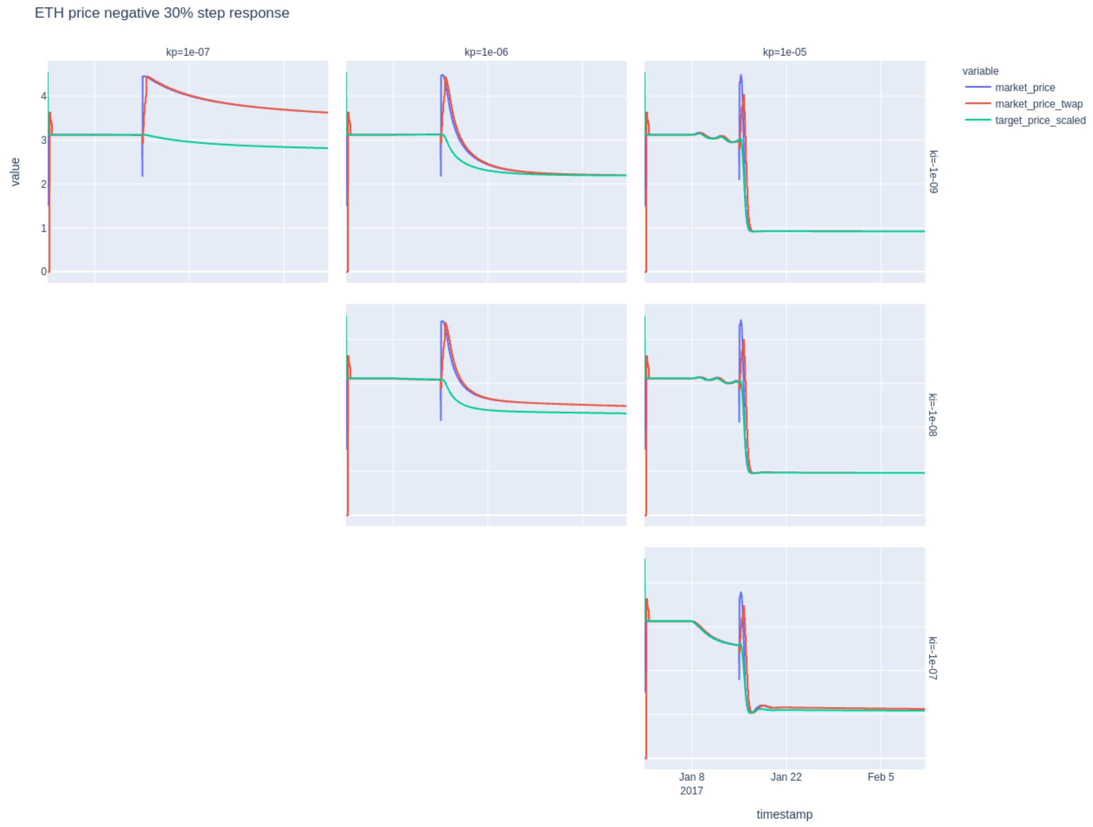
[32]:

```
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()
```



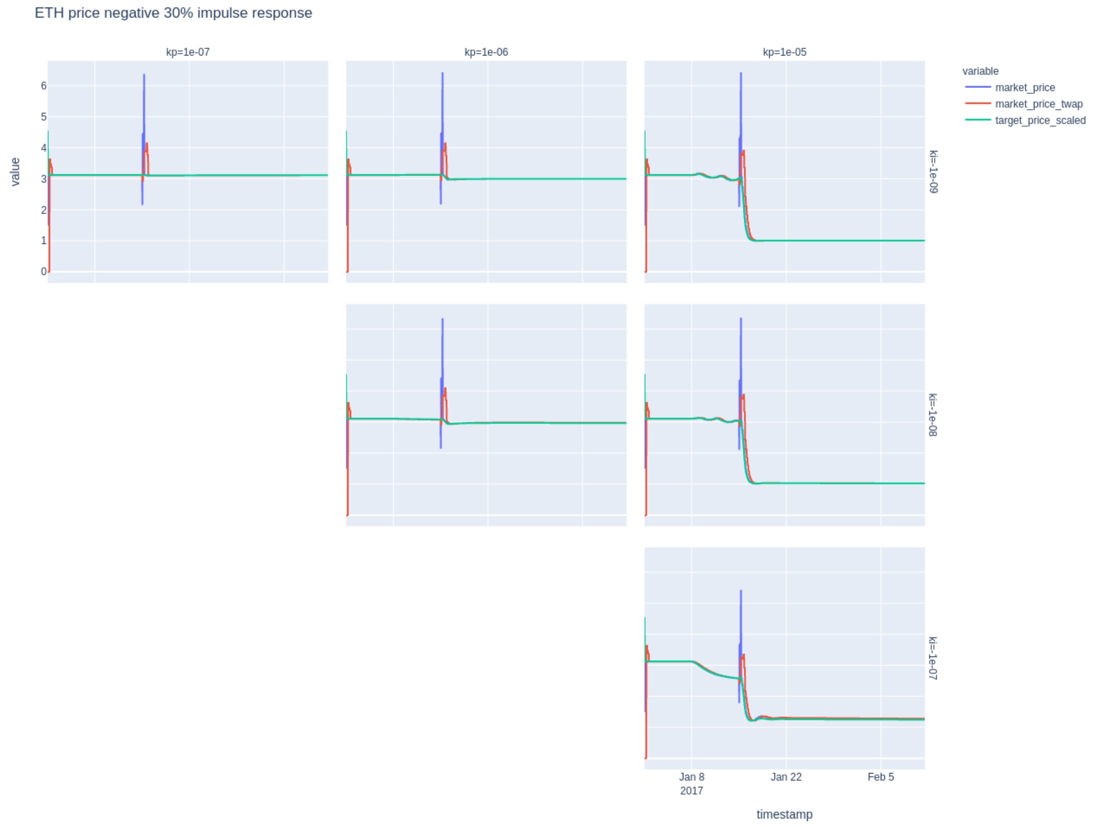
[31]:

```
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()
```



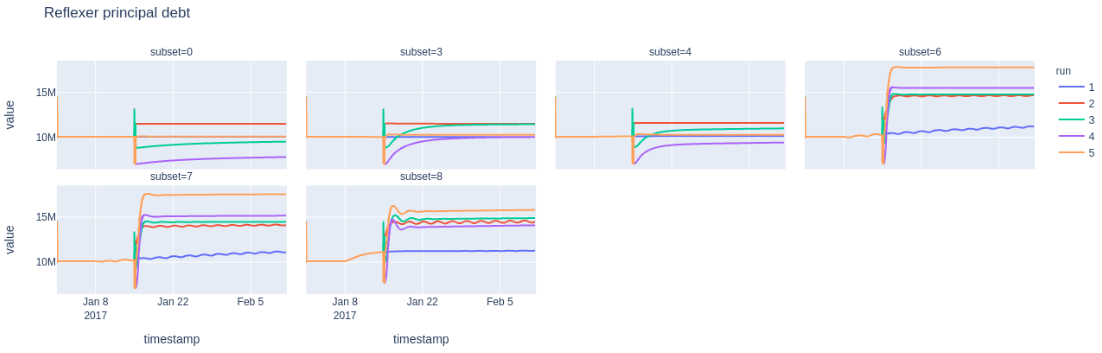
[30]:

```
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()
```

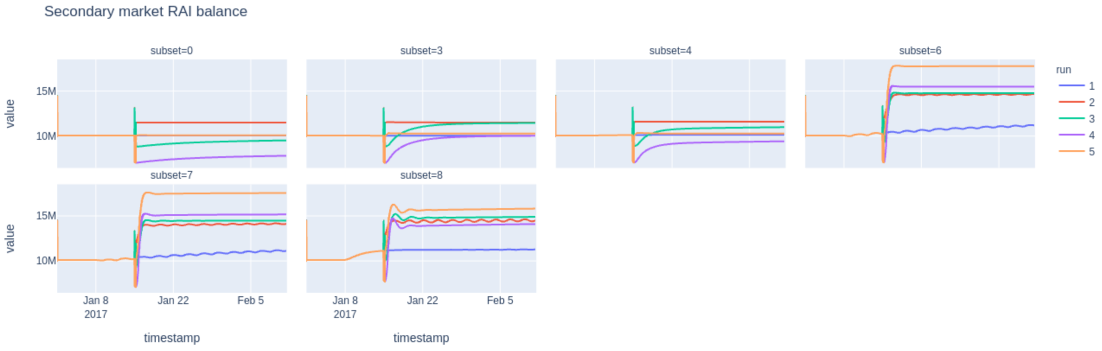


[44]:

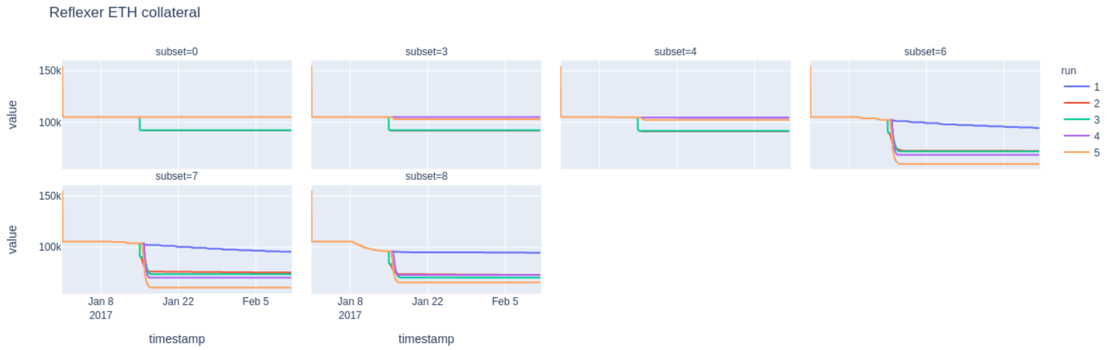
```
fig = px.line(
    df_stable_price,
    title="Reflexer principal debt",
    x="timestamp",
    y=["principal_debt"],
    color='run',
    facet_col="subset",
    facet_col_wrap=4
)
fig.show()
```



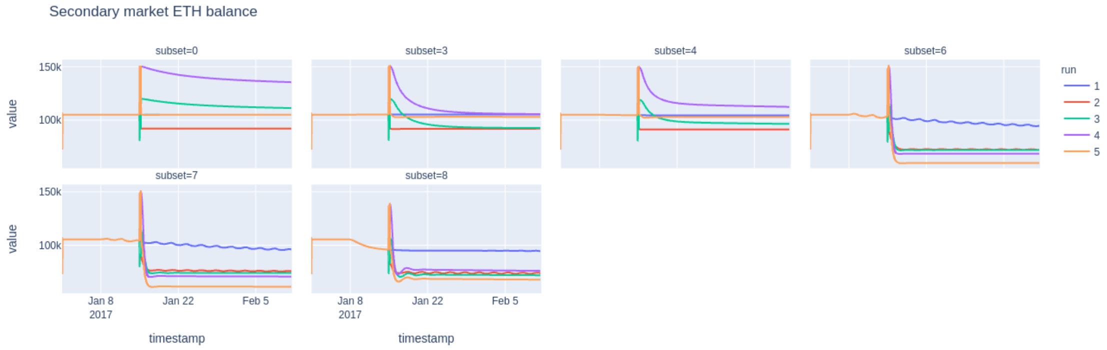
```
[42]: fig = px.line(
          df_stable_price,
          title="Secondary market RAI balance",
          x="timestamp",
          y=["RAI_balance"],
          color='run',
          facet_col="subset",
          facet_col_wrap=4
      )
      fig.show()
```



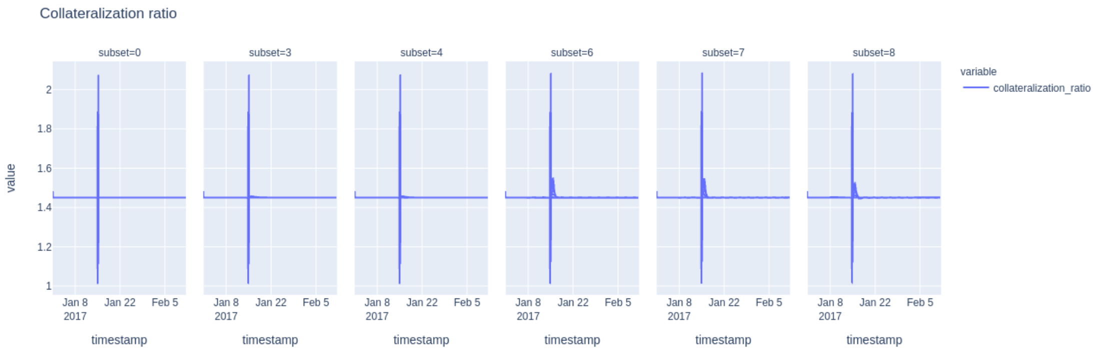
```
[45]: fig = px.line(
          df_stable_price,
          title="Reflexer ETH collateral",
          x="timestamp",
          y=["eth_collateral"],
          color='run',
          facet_col="subset",
          facet_col_wrap=4
      )
      fig.show()
```



```
[47]: fig = px.line(
          df_stable_price,
          title="Secondary market ETH balance",
          x="timestamp",
          y=["ETH_balance"],
          color='run',
          facet_col="subset",
          facet_col_wrap=4
      )
      fig.show()
```



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


Collateralization ratio
subset=0
subset=3
subset=4
subset=6
subset=7
subset=8
variable
collateralization_ratio
value
2
1.8
1.6
1.4
1.2
1
Jan 8
2017
Jan 22
Feb 5
timestamp