PRIM

September 2, 2020

[1]:
```
from IPython import get_ipython

# DICE SM - PRIM (recovered --> master)
```

Setup & Initialisation of levers and uncertainties

[2]:
```
import time
get_ipython().run_line_magic('matplotlib', 'inline')
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
import seaborn as sns
sns.set_style('white')
import statsmodels.api as sm
from sklearn import preprocessing
import ema_workbench.em_framework.evaluators


import os
from dest_directories import gz_path, fig_path
from dicemodel.specs import change_fontsize
from dicemodel.noDICE_v7 import PyDICE
model_version = 'v7'
```

[3]:
```
from ema_workbench import (perform_experiments, Model, Policy, Scenario,␣
↪ReplicatorModel, RealParameter, IntegerParameter, TimeSeriesOutcome,␣
↪ScalarOutcome, ArrayOutcome, Constant, ema_logging, SequentialEvaluator,␣
↪MultiprocessingEvaluator, IpyparallelEvaluator)
from ema_workbench import save_results, load_results

from ema_workbench.analysis import prim, cart
from ema_workbench.analysis import scenario_discovery_util as sdutil
from ema_workbench.analysis import pairs_plotting, plotting, plotting_util

import ema_workbench.em_framework.evaluators
from dicemodel.specs import change_fontsize
# from ema_workbench.analysis import feature_scoring
# from ema_workbench.em_framework.salib_samplers import get_SALib_problem
```

```python
# from SALib.analyze import sobol

ema_logging.log_to_stderr(ema_logging.INFO)
```

[3]: <Logger EMA (DEBUG)>

[4]:
```python
if __name__ == '__main__':
    ema_logging.log_to_stderr(ema_logging.INFO)


    model = PyDICE()
    dice_sm = Model('dicesmEMA', function=model)

    dice_sm.uncertainties = [
                             RealParameter('tfp_gr',  0.07, 0.09),
                             RealParameter('sigma_gr', -0.012, -0.008),
                             RealParameter('pop_gr', 0.1, 0.15),
                             RealParameter('fosslim',  4000.0, 13649),
                             IntegerParameter('cback', 100, 600),
                             RealParameter('emdd', -0.1, 0.99),
                            ]

    dice_sm.levers = [RealParameter('sr', 0.1, 0.5),
                      RealParameter('prtp_con',  0.001, 0.015),
                      RealParameter('emuc',  1.01, 2.00),
                      IntegerParameter('vd_switch', 0, 1),
                      IntegerParameter('periodfullpart', 10, 58),
                      IntegerParameter('miu_period', 10, 58)
                      ]

    dice_sm.outcomes = [
                        TimeSeriesOutcome('Atmospheric Temperature'),
                        TimeSeriesOutcome('Total Output'),
                        TimeSeriesOutcome('Per Capita Consumption'),
                        TimeSeriesOutcome('Consumption Growth'),
                        TimeSeriesOutcome('Utility of Consumption'),
                        TimeSeriesOutcome('Per Capita Damage'),
                        TimeSeriesOutcome('Damage Growth'),
                        TimeSeriesOutcome('Disutility of Damage'),
                        TimeSeriesOutcome('Welfare'),
                        # TimeSeriesOutcome('Undiscounted Period Welfare'),
                        TimeSeriesOutcome('Consumption SDR'),
                        TimeSeriesOutcome('Damage SDR'),
                        TimeSeriesOutcome('SCC')
                        ]
```

[5]:
```
n_scenarios = 2000
n_policies = 50
run = '30_OE'
```

[6]:
```
## Load results
results = load_results(os.path.join(gz_path,'30_OE2000s_50p_.tar.gz'))
experiments, outcomes = results
```

```
[MainProcess/INFO] results loaded succesfully from
E:\Year_2_Quarter_4\Thesis\06_Code\results\gz_files\30_OE2000s_50p_.tar.gz
```

[7]:
```
# for x: Clean experiments (keep only levers, remove policy, scenario, model␣
↪columns)
cleaned_experiments = experiments.drop(labels=[l.name for l in dice_sm.
↪uncertainties], axis=1)
cleaned_experiments = experiments.drop(labels= ['policy', 'model',] , axis=1)
# type(cleaned_experiments)
# cleaned_experiments
x = cleaned_experiments
#  For y: outcomes is nd-array, PRIM needs 1D
```

[8]:
```
# dropping first two steps (warm up) and last five steps(cooldown)
cleaned_outcome = {}
for key, value in outcomes.items():
    cleaned_outcome[key] = value[:,2:-5]
cleaned_outcome['Welfare'].shape
```

[8]:
```
(100000, 58)
```

[9]:
```
# values for 2300
end_outcome = {}
for key, value in outcomes.items():
    end_outcome[key] = value[:, -1]

# np.mean(end_outcome['Damage Growth'], axis =0)
```

[10]:
```
y = cleaned_outcome
```

[11]:
```
y_welfare = end_outcome['Welfare'] < np.percentile(end_outcome['Welfare'], 10)
```

[12]:
```
# the meaning of peel_alpha is the percentile of the data that is to be removed
# The peeling alpha determines how much data is peeled off in each iteration of␣
↪the algorithm. The lower the value, the less data is removed in each␣
↪iteration. Controls the leniency of the algorithm, the higher the less␣
↪lenient.
# from ema_workbench.analysis import prim
x = cleaned_experiments
```

```
y = y_welfare

prim_alg = prim.Prim(x, y, threshold=0.5, peel_alpha=0.1) #0.1
```

[13]:
```
box1 = prim_alg.find_box()
```

```
[MainProcess/INFO] 100000 points remaining, containing 10000 cases of interest
[MainProcess/INFO] mean: 1.0, mass: 0.05625, coverage: 0.5625, density: 1.0
restricted_dimensions: 4
```

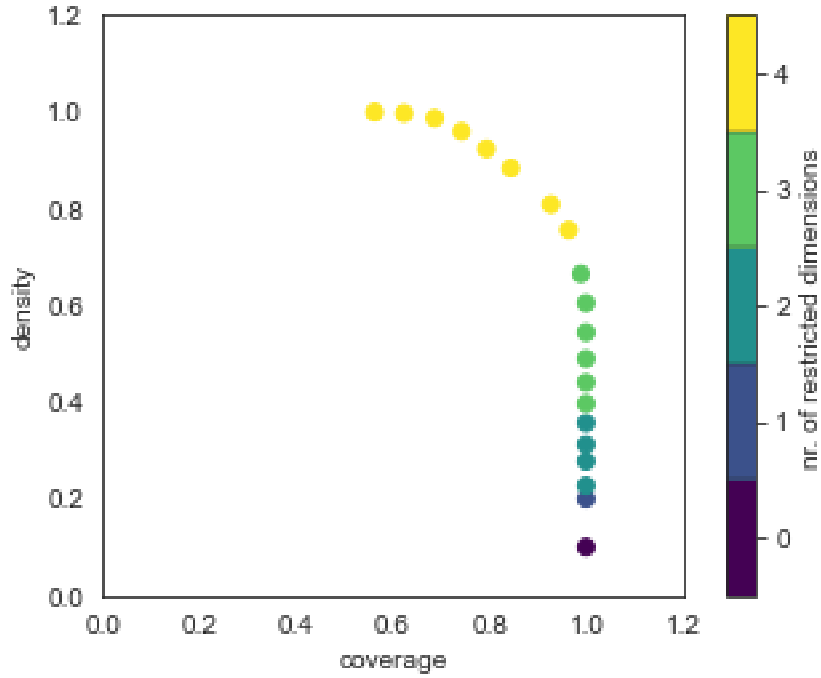
[14]:
```
box1.peeling_trajectory
```

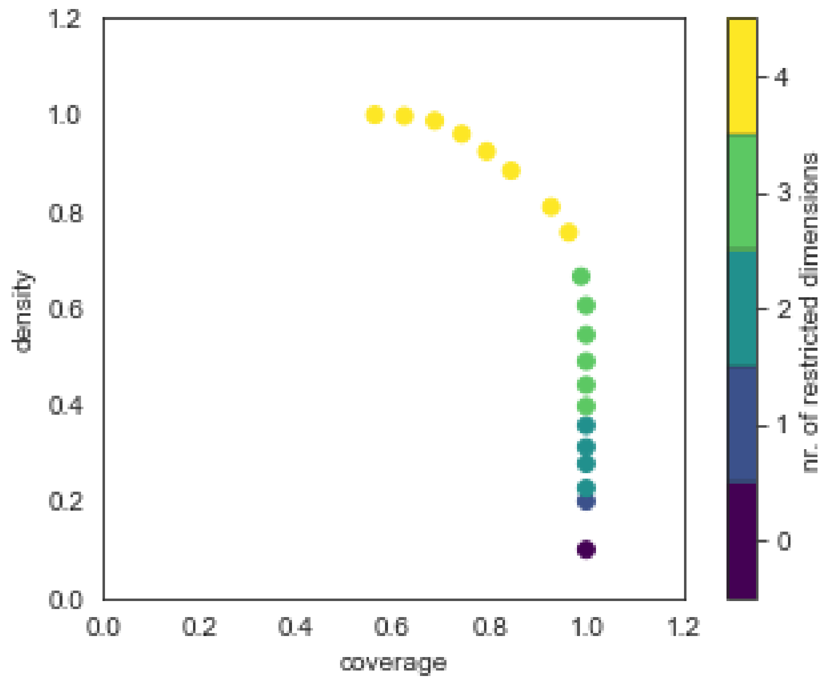
[14]:

	coverage	density	id	mass	mean	res_dim
0	1.0000	0.100000	0	1.00000	0.100000	0
1	1.0000	0.200000	1	0.50000	0.200000	1
2	1.0000	0.227273	2	0.44000	0.227273	2
3	1.0000	0.277778	3	0.36000	0.277778	2
4	1.0000	0.312500	4	0.32000	0.312500	2
5	1.0000	0.357143	5	0.28000	0.357143	2
6	1.0000	0.396825	6	0.25200	0.396825	3
7	1.0000	0.440917	7	0.22680	0.440917	3
8	1.0000	0.489908	8	0.20412	0.489908	3
9	1.0000	0.544425	9	0.18368	0.544425	3
10	0.9999	0.605266	10	0.16520	0.605266	3
11	0.9893	0.665389	11	0.14868	0.665389	3
12	0.9641	0.756513	12	0.12744	0.756513	4
13	0.9275	0.809337	13	0.11460	0.809337	4
14	0.8446	0.884398	14	0.09550	0.884398	4
15	0.7939	0.924214	15	0.08590	0.924214	4
16	0.7424	0.960414	16	0.07730	0.960414	4
17	0.6865	0.987770	17	0.06950	0.987770	4
18	0.6235	0.997600	18	0.06250	0.997600	4
19	0.5625	1.000000	19	0.05625	1.000000	4

[15]:
```
box1.show_tradeoff()
```

[15]:

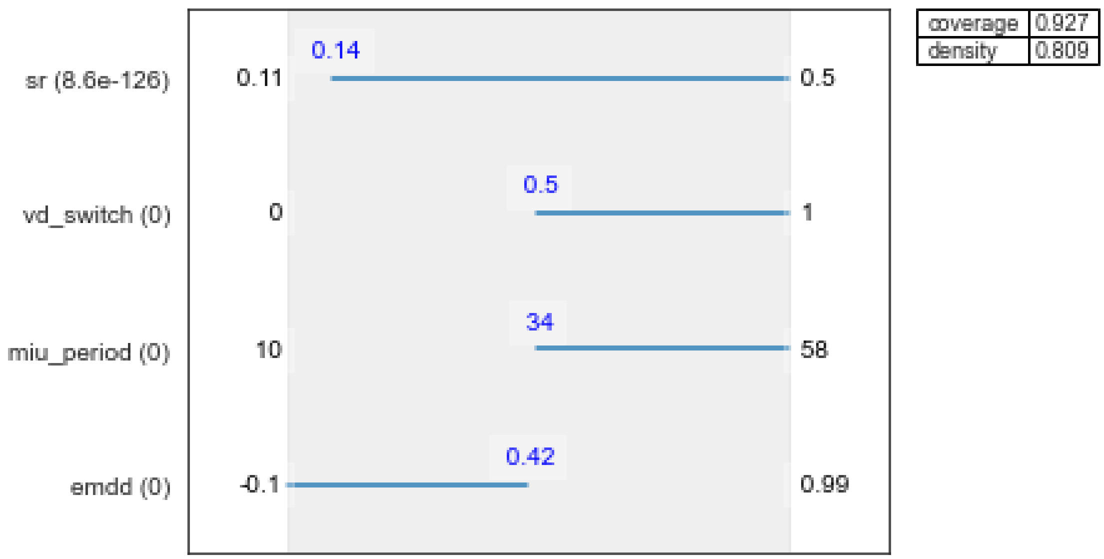




[16]:
```
box1.inspect(13)
```

```
coverage      0.9275
density     0.809337
id                13
mass          0.1146
mean        0.809337
res_dim            4
Name: 13, dtype: object

               box 13
                  min        max                         qp values
emdd        -0.099951   0.420299                       [-1.0, 0.0]
miu_period  34.000000  58.000000                       [0.0, -1.0]
vd_switch    0.500000   1.000000                       [0.0, -1.0]
sr           0.142786   0.497152  [8.560486100703134e-126, -1.0]
```

[17]:
```python
box1.inspect(13, style='graph')
plt.show()
```



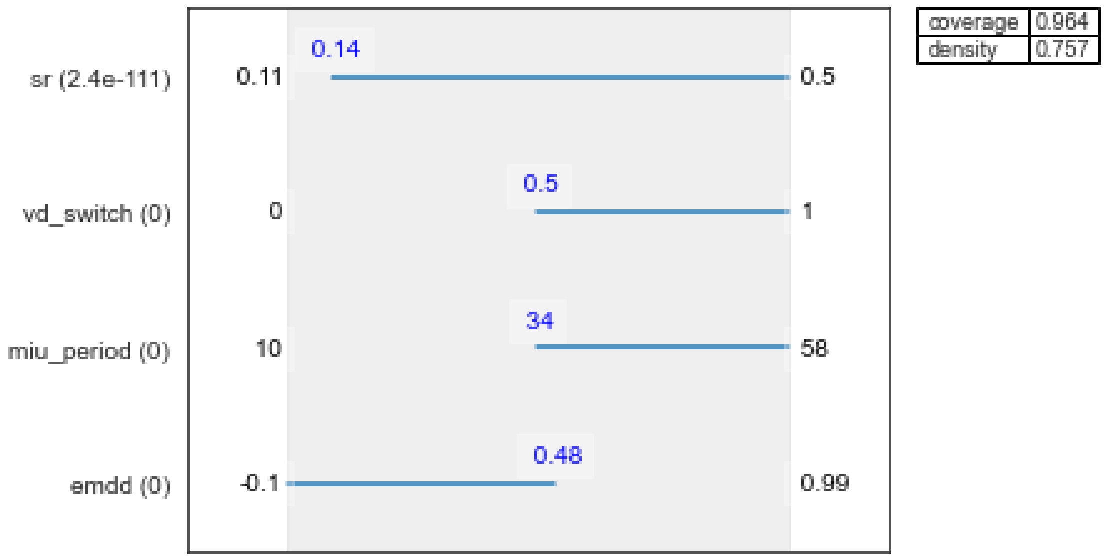
[19]:
```python
box1.inspect(12)
```

```
coverage      0.9641
density     0.756513
id                12
mass         0.12744
mean        0.756513
res_dim            4
Name: 12, dtype: object
```

```
              box 12
                 min        max                            qp values
emdd       -0.099951   0.478868                          [-1.0, 0.0]
miu_period 34.000000  58.000000                          [0.0, -1.0]
vd_switch   0.500000   1.000000                          [0.0, -1.0]
sr          0.142786   0.497152  [2.372474188954401e-111, -1.0]
```

[20]:

```python
box1.inspect(12, style='graph')
plt.show()
```

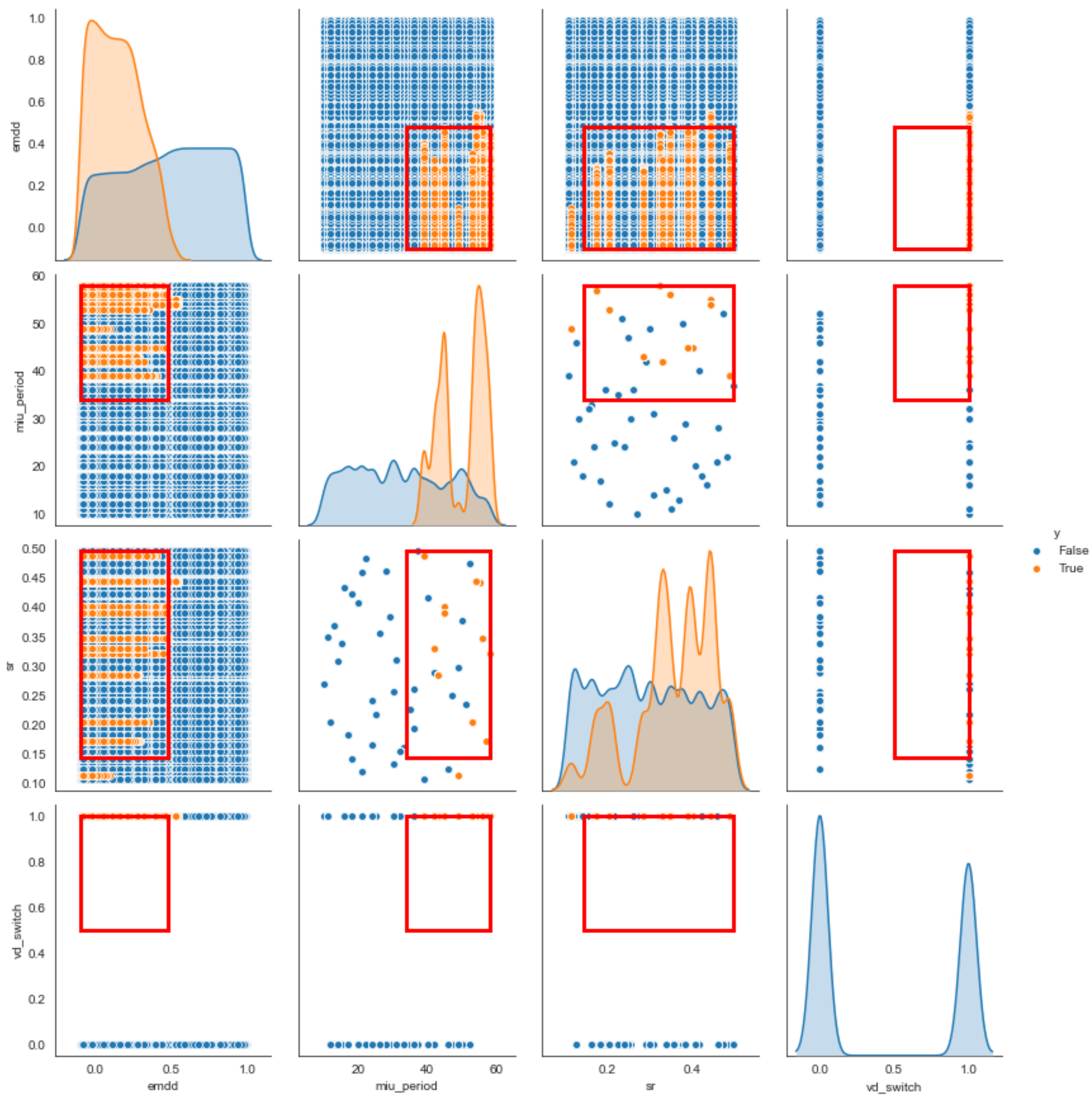


[21]:

```python
box1.select(12)
```

[22]:

```python
box1.show_pairs_scatter()
fig = plt.gcf()
fig.set_size_inches(12,12)
plt.show()
```




```
[23]: fig.savefig(os.path.join(fig_path,str(run) + '_PRIM_welfare_box1' + '.png'))
```

```
[24]: y_welfare = end_outcome['Welfare'] < np.percentile(end_outcome['Welfare'], 80)
```

```
[25]: y_welfare80 = end_outcome['Welfare'] < np.percentile(end_outcome['Welfare'], 80)
```

```
[26]: box2 = prim_alg.find_box()
```

```
[MainProcess/INFO] 87256 points remaining, containing 359 cases of interest
[MainProcess/INFO] box does not meet threshold criteria, value is
0.06241307371349096, returning dump box
```

```
[27]: box2.peeling_trajectory
```

[27]:

```
   coverage   density id     mass      mean res_dim
0    0.0359  0.004114  0  0.87256  0.004114       0
```

[29]:
```
box2.inspect()
```

```
coverage        0.0359
density     0.00411433
id                   0
mass           0.87256
mean        0.00411433
res_dim              0
Name: 0, dtype: object

Empty DataFrame
Columns: [(box 0, min), (box 0, max), (box 0, qp values)]
Index: []
```

[30]:
```
# the meaning of peel_alpha is the percentile of the data that is to be removed
# The peeling alpha determines how much data is peeled off in each iteration of␣
↪the algorithm. The lower the value, the less data is removed in each␣
↪iteration. Controls the leniency of the algorithm, the higher the less␣
↪lenient.
# from ema_workbench.analysis import prim
x = cleaned_experiments
y = y_welfare80

prim_alg = prim.Prim(x, y, threshold=0.5, peel_alpha=0.1) #0.1
```

[31]:
```
box1 = prim_alg.find_box()
box1.peeling_trajectory
```

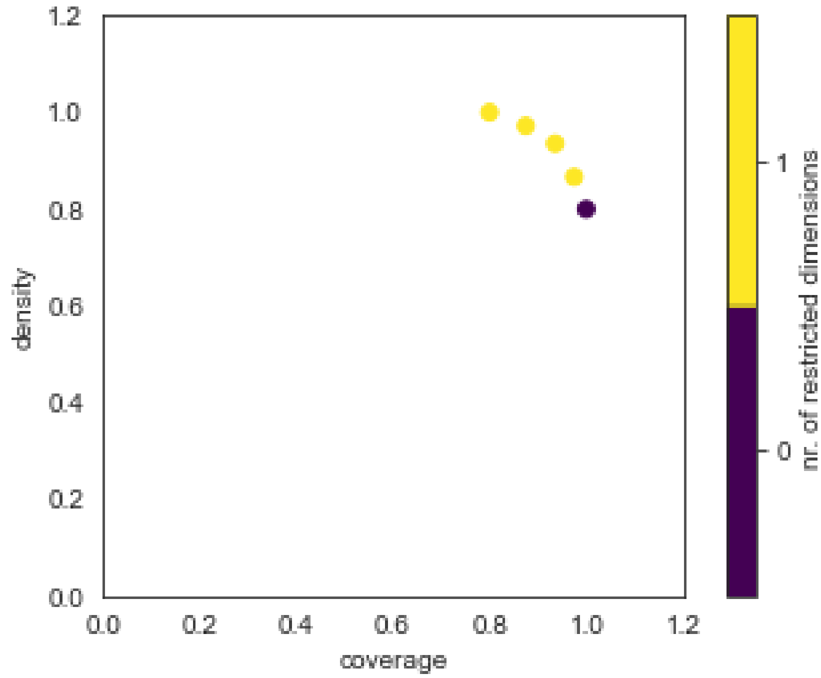
```
[MainProcess/INFO] 100000 points remaining, containing 80000 cases of interest
[MainProcess/INFO] mean: 1.0, mass: 0.64, coverage: 0.8, density: 1.0
restricted_dimensions: 1
```

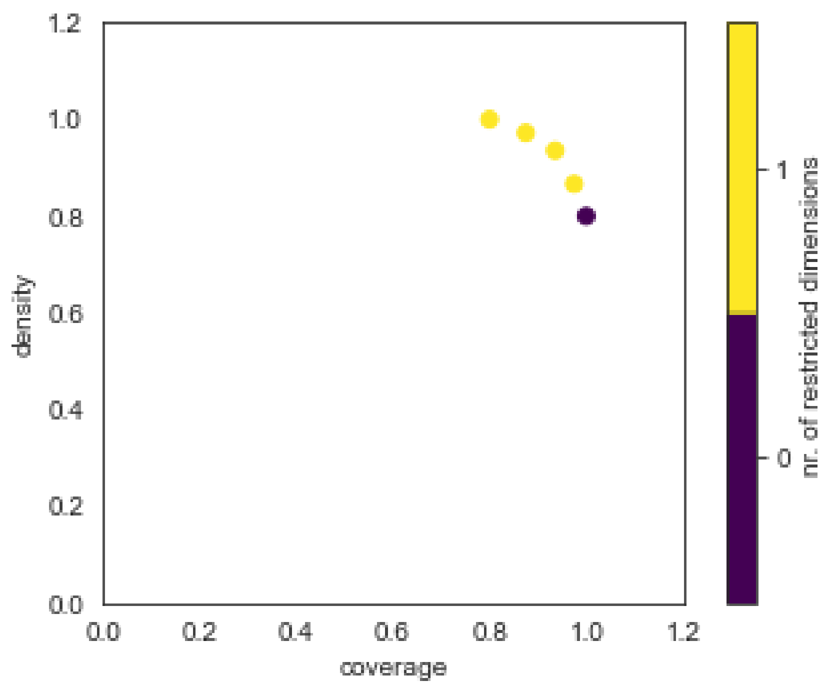
[31]:

```
   coverage   density id  mass      mean res_dim
0  1.000000  0.800000  0  1.00  0.800000       0
1  0.975000  0.866667  1  0.90  0.866667       1
2  0.935712  0.935712  2  0.80  0.935712       1
3  0.875000  0.972222  3  0.72  0.972222       1
4  0.800000  1.000000  4  0.64  1.000000       1
```

[32]:
```
box1.show_tradeoff()
```

[32]:





[33]:
```
box1.inspect(2)
```

```
coverage    0.935712
density     0.935712
id                 2
mass             0.8
mean        0.935712
res_dim            1
Name: 2, dtype: object

         box 2
           min     max    qp values
emuc  1.211436  1.9832  [0.0, -1.0]
```

[38]:
```
# Welfare
# y_welfare = end_outcome['Welfare'] < 5000
y_welfare20 = end_outcome['Welfare'] < np.percentile(end_outcome['Welfare'], 20)
```

[39]:
```
# the meaning of peel_alpha is the percentile of the data that is to be removed
# The peeling alpha determines how much data is peeled off in each iteration of␣
↪the algorithm. The lower the value, the less data is removed in each␣
↪iteration. Controls the leniency of the algorithm, the higher the less␣
↪lenient.
# from ema_workbench.analysis import prim
x = cleaned_experiments
y = y_welfare20

prim_alg = prim.Prim(x, y, threshold=0.5, peel_alpha=0.1) #0.1
```

[40]:
```
box1 = prim_alg.find_box()
box1.peeling_trajectory
```

```
[MainProcess/INFO] 100000 points remaining, containing 20000 cases of interest
[MainProcess/INFO] mean: 1.0, mass: 0.11808, coverage: 0.5904, density: 1.0
restricted_dimensions: 4
```

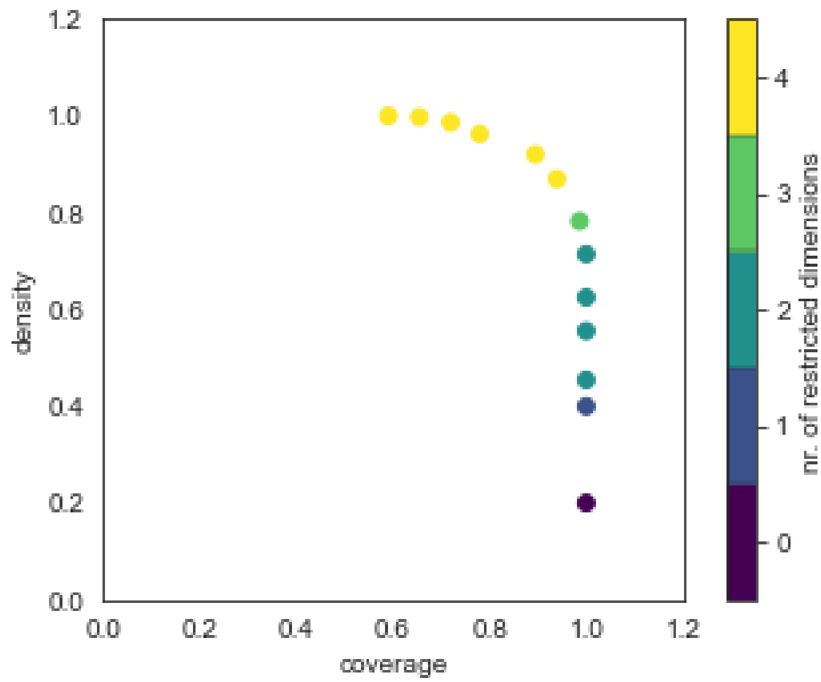
[40]:

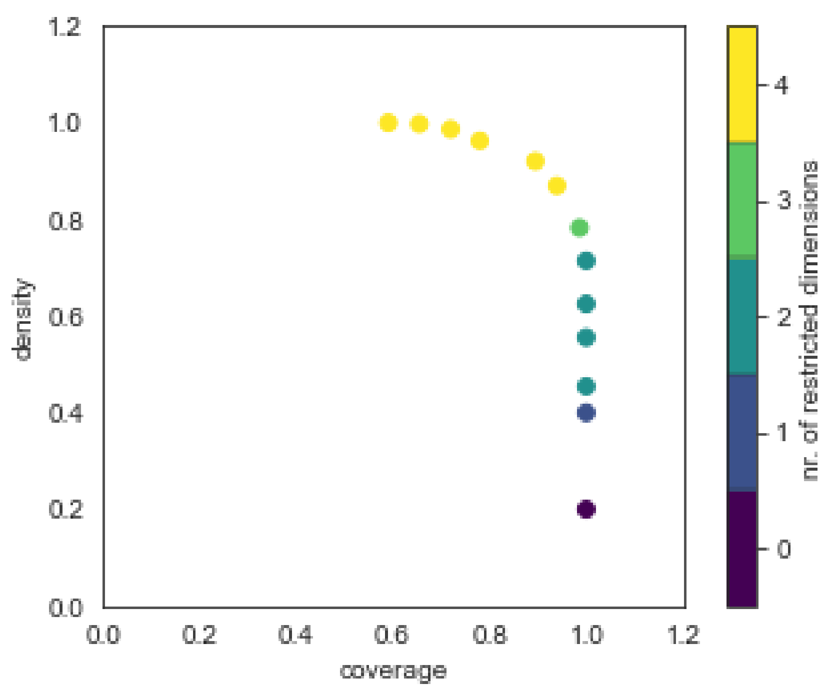
	coverage	density	id	mass	mean	res_dim
0	1.00000	0.200000	0	1.00000	0.200000	0
1	1.00000	0.400000	1	0.50000	0.400000	1
2	1.00000	0.454545	2	0.44000	0.454545	2
3	1.00000	0.555556	3	0.36000	0.555556	2
4	1.00000	0.625000	4	0.32000	0.625000	2
5	1.00000	0.714286	5	0.28000	0.714286	2
6	0.98620	0.782698	6	0.25200	0.782698	3
7	0.93935	0.869769	7	0.21600	0.869769	4
8	0.89485	0.920628	8	0.19440	0.920628	4
9	0.77990	0.962840	9	0.16200	0.962840	4
10	0.71950	0.986968	10	0.14580	0.986968	4

11	0.65460	0.997714	11	0.13122	0.997714	4
12	0.59040	1.000000	12	0.11808	1.000000	4

[41]:
```
box1.show_tradeoff()
```

[41]:

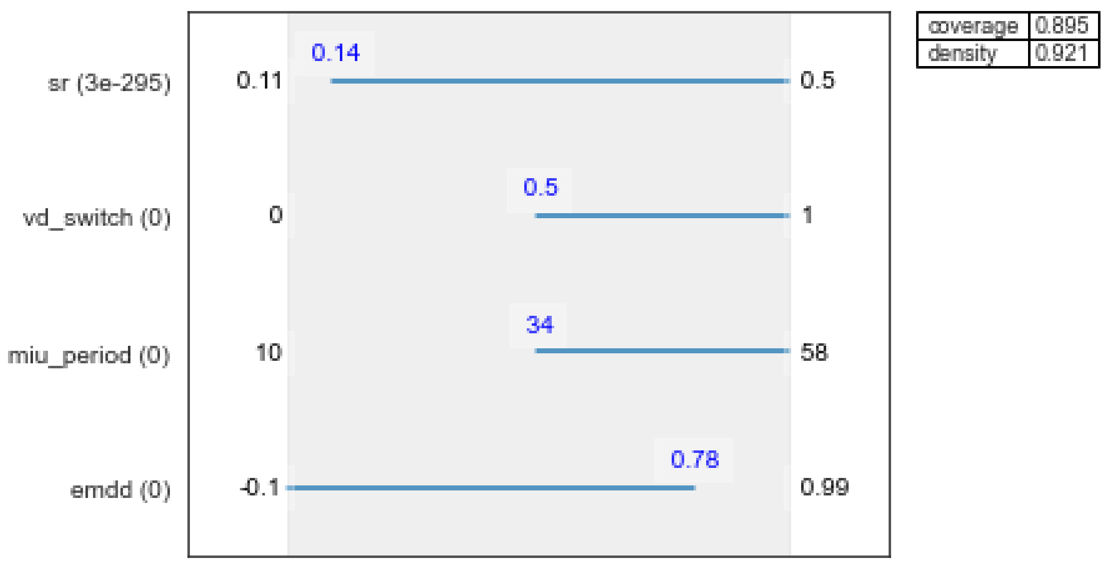




[42]:
```
box1.inspect(8)
```

```
coverage     0.89485
density     0.920628
id                 8
mass          0.1944
mean        0.920628
res_dim            4
Name: 8, dtype: object

                 box 8
                   min        max                          qp values
emdd         -0.099951   0.782662                         [-1.0, 0.0]
miu_period   34.000000  58.000000                         [0.0, -1.0]
vd_switch     0.500000   1.000000                         [0.0, -1.0]
sr            0.142786   0.497152  [2.99911058759791e-295, -1.0]
```

[43]:
```
box1.inspect(8, style='graph')
plt.show()
```



[44]:
```
box1.inspect(7)
```

```
coverage     0.93935
density     0.869769
id                 7
```

```
mass           0.216
mean        0.869769
res_dim            4
Name: 7, dtype: object

                box 7
                  min        max                            qp values
emdd        -0.099951   0.881150  [-1.0, 1.2880945432641185e-184]
miu_period  34.000000  58.000000                       [0.0, -1.0]
vd_switch    0.500000   1.000000                       [0.0, -1.0]
sr           0.142786   0.497152  [1.2212146580563432e-237, -1.0]
```

[45]:
```python
box2 = prim_alg.find_box()
```

```
[MainProcess/INFO] 88192 points remaining, containing 8192 cases of interest
[MainProcess/INFO] mean: 0.9211768979295314, mass: 0.05506, coverage: 0.2536,
density: 0.9211768979295314 restricted_dimensions: 5
```

[46]:
```python
box2.peeling_trajectory
```

[46]:

	coverage	density	id	mass	mean	res_dim
0	0.40960	0.092888	0	0.88192	0.092888	0
1	0.40960	0.214495	1	0.38192	0.214495	1
2	0.40960	0.239588	2	0.34192	0.239588	2
3	0.40960	0.290579	3	0.28192	0.290579	2
4	0.40960	0.338624	4	0.24192	0.338624	2
5	0.40960	0.405705	5	0.20192	0.405705	2
6	0.40960	0.505929	6	0.16192	0.505929	2
7	0.40960	0.577227	7	0.14192	0.577227	3
8	0.40780	0.639085	8	0.12762	0.639085	4
9	0.39420	0.687059	9	0.11475	0.687059	4
10	0.37495	0.726788	10	0.10318	0.726788	4
11	0.34050	0.790390	11	0.08616	0.790390	4
12	0.32000	0.825593	12	0.07752	0.825593	4
13	0.27315	0.892355	13	0.06122	0.892355	5
14	0.25360	0.921177	14	0.05506	0.921177	5

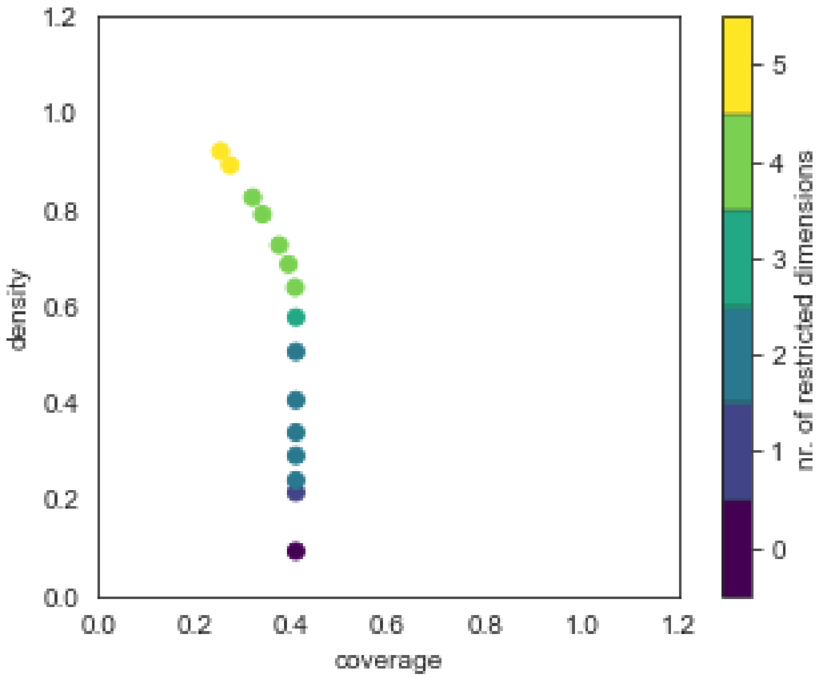
[47]:
```python
box2.inspect()
```

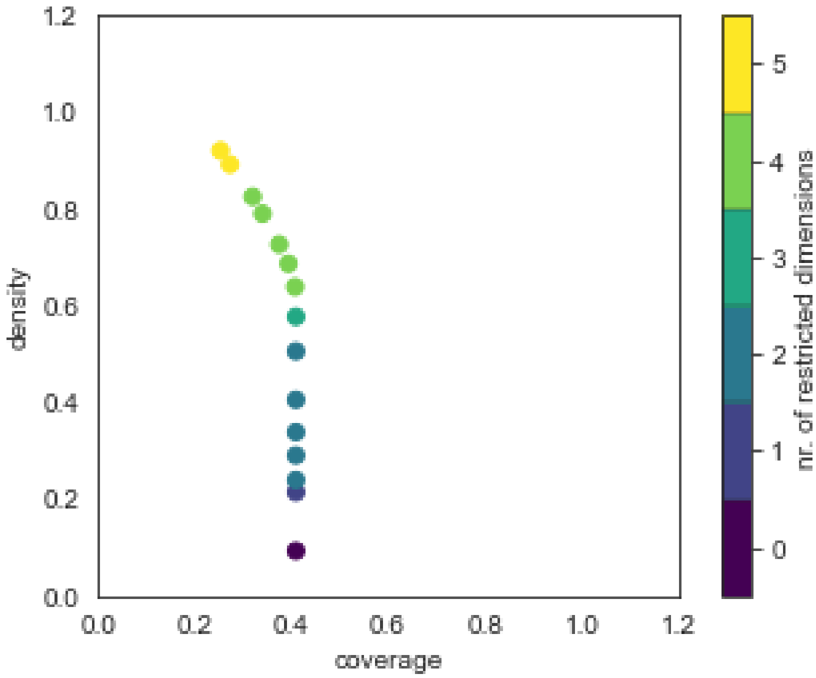
```
coverage      0.2536
density     0.921177
id                14
mass         0.05506
mean        0.921177
res_dim            5
Name: 14, dtype: object
```

```
                  box 14
                     min        max                            qp values
emdd           -0.099951   0.757789                          [-1.0, 0.0]
periodfullpart 10.000000  56.500000        [-1.0, 0.5127735603314563]
miu_period     37.500000  58.000000                          [0.0, -1.0]
vd_switch       0.500000   1.000000                          [0.0, -1.0]
sr              0.142786   0.497152  [1.0417481031993003e-59, -1.0]
```

[48]:
```python
box2.show_tradeoff()
```

[48]:





[49]:
```
# Disutility of Damage
# what causes the values  of V(D) higher than 5 (from the violin plot, U(C)␣
↪range never exceeds 4)
y_disutil_dam10 = end_outcome['Disutility of Damage'] > np.
↪percentile(end_outcome['Disutility of Damage'], 10)
# y_disutil_dam = end_outcome['Disutility of Damage'] < np.
↪percentile(end_outcome['Disutility of Damage'], 10)

###### by percentile
# #percentile < 80 = bottom 80
```

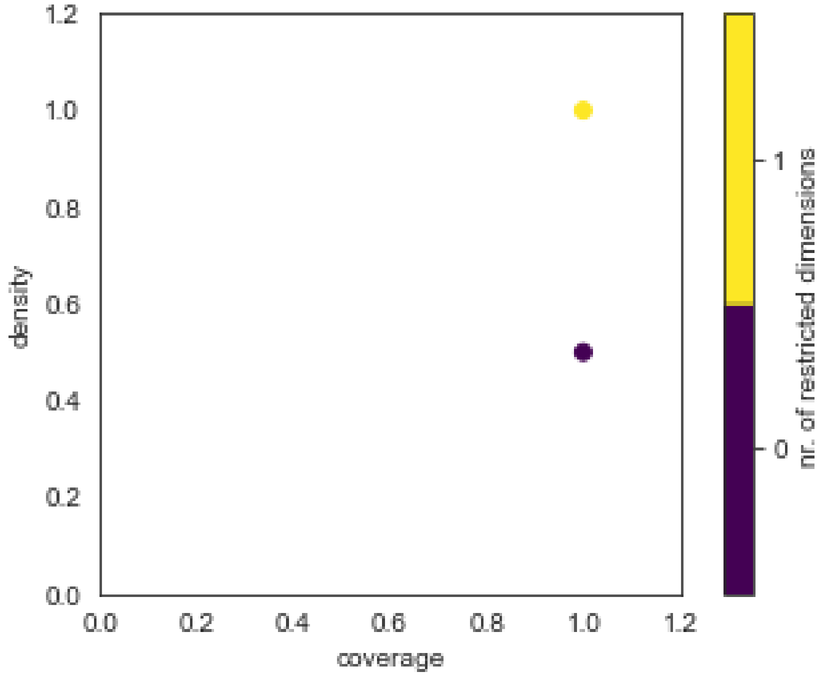
[50]:
```
# the meaning of peel_alpha is the percentile of the data that is to be removed
# The peeling alpha determines how much data is peeled off in each iteration of␣
↪the algorithm. The lower the value, the less data is removed in each␣
↪iteration. Controls the leniency of the algorithm, the higher the less␣
↪lenient.
# from ema_workbench.analysis import prim
x = cleaned_experiments
y = y_disutil_dam10

prim_alg = prim.Prim(x, y, threshold=0.5, peel_alpha=0.1) #0.1
```

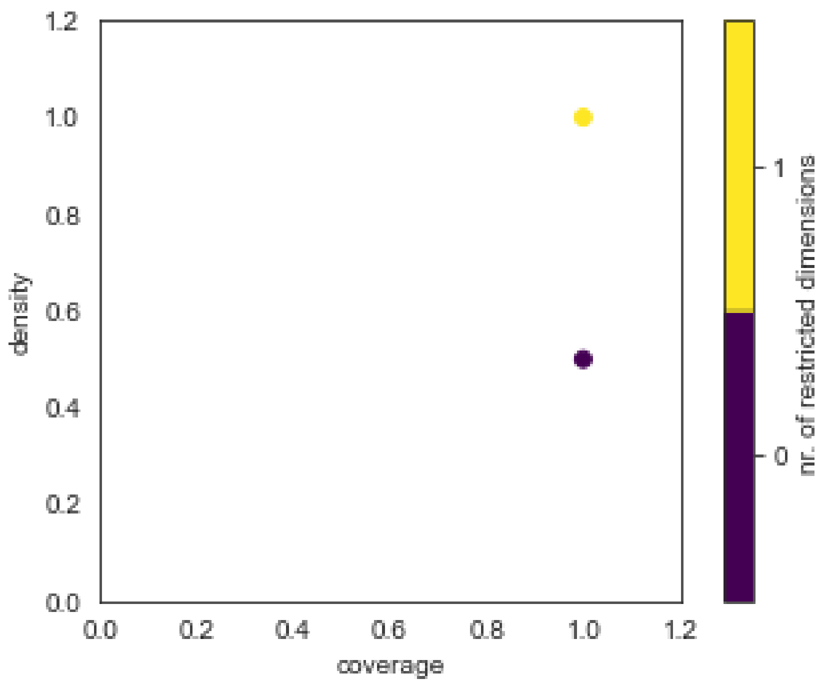
[51]:
```
box1 = prim_alg.find_box()
box1.peeling_trajectory
```

```
box1.show_tradeoff()
```

```
[MainProcess/INFO] 100000 points remaining, containing 50000 cases of interest
[MainProcess/INFO] mean: 1.0, mass: 0.5, coverage: 1.0, density: 1.0
restricted_dimensions: 1
```

[51]:





[52]:
```
box1.peeling_trajectory
```

[52]:

	coverage	density	id	mass	mean	res_dim
0	1.0	0.5	0	1.0	0.5	0
1	1.0	1.0	1	0.5	1.0	1

[54]:
```
box1.inspect(1)
```

```
coverage      1
density       1
id            1
mass        0.5
mean          1
res_dim       1
Name: 1, dtype: object

          box 1
            min  max    qp values
vd_switch   0.5  1.0  [0.0, -1.0]
```