

senstivity_analysis

January 31, 2021

0.1 Background about GR system simulation wrapper

Our GR system (`gr_ipc.jar`) is a goal recognition tool which can return a CSV file contains all the inference results of a certain domain with a specific parameter settings. The inference results are divided into 5 groups based on observation percentage (10%, 30%, 50%, 70% & 100%).

For example, in `blocks-world` 10% group, there are multiple problems (testing cases) to test how well our GR system can perform in `blocks-world` domain if we only observe 10% actions. Hence, our GR system will also return multiple results for this 10% group. Having the multiple results, we can calculate average precision for 10% group (`p_10`), average recall for 10% group (`r_10`) and average accuracy for 10% group (`a_10`).

Similarly, we also calculate `p_30`, `r_30`, `a_30`, `p_50`, `r_50`, `a_50`, `p_70`, `r_70`, `a_70`, `p_100`, `r_100`, `a_100` and `p_avg`, `r_avg`, `a_avg` (notice `_avg` means the average over all 10%, 30%, 50%, 70% and 100% groups). For a certain domain with a certain parameter settings, we can calculate all the statistics above.

Then we use the [EMA-workbench](#) to define a model to wrap up our GR system. The EMA-workbench provides simulation functions to randomly select parameters within pre-defined ranges and then run the GR system for many times (Simulation). It will collect performance statistics (`p_10`, `r_10`, `a_10`, `p_30`, `r_30`, `a_30`, `p_50`, `r_50`, `a_50`, `p_70`, `r_70`, `a_70`, `p_100`, `r_100`, `a_100`, `p_avg`, `r_avg`, `a_avg`) corresponding to each set of randomly selected parameters. The simulated performance statistics are stored in a `.tar.gz` files, it will be analysed by this notebook in following sections.

At this stage, the model (including uncertainties, levers, constants and outcomes) is defined in another python module `model.py`. This module is imported by another python program `experiment_simulator.py`.

Data: There are two directories `./topk/` and `./diverse/` to store plans generated by top-k and diverse planner correspondingly.

In either directory, the simulator will run 1000 scenarios on each domain using latin hypercube sampling, the experiment results are saved in `1000_<domain>.tar.gz`. And it will run 10500 scenarios (base number = 1050) on each domain using SOBOL sampling, the results are saved in `1050_<domain>.tar.gz`

In this notebook, we assume all experimental simulations are done and we have obtained all the results saved in `.tar.gz` files. So, we just load the stored data and do sensitivity analysis.

0.2 Requirements

Install the following requirements if they haven't been installed. Be careful with python version, we are using python3. Also be careful with pip3, some machine is just pip. If you found that some library can not be imported, just put ! in the front and use pip3 to install within the jupyter notebook environment.

```
! pip3 install <package_name>
```

```
[1]: # install packages within jupyter notebook
!pip3 install numpy
!pip3 install pandas
!pip3 install seaborn
!pip3 install matplotlib
!pip3 install ema_workbench
!pip3 install SALib
```

```
[2]: import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
from ema_workbench import load_results
from ema_workbench.analysis import feature_scoring
from ema_workbench.analysis import pairs_plotting
from ema_workbench.analysis import prim
```

0.3 Show feature scores and plots

```
[3]: # for feature score and plots
def show_feature_score(results):
    experiments, outcomes = results
    x = experiments
    y = outcomes

    fs = feature_scoring.get_feature_scores_all(x, y)
    plt.figure(figsize = (20,5))
    sns.heatmap(fs, cmap='viridis', annot=True)
    plt.show()

def show_points(results, label):
    experiments, outcomes = results

    # partial dict
    if label == "avg":
        partial_outcomes = dict((key,value) for key, value in outcomes.items() if key in ["p_avg", "r_avg", "a_avg"])
    if label == "100":
```

```

        partial_outcomes = dict((key,value) for key, value in outcomes.items())
→if key in ["p_100", "r_100", "a_100"])
    if label == "70":
        partial_outcomes = dict((key,value) for key, value in outcomes.items())
→if key in ["p_70", "r_70", "a_70"])
    if label == "50":
        partial_outcomes = dict((key,value) for key, value in outcomes.items())
→if key in ["p_50", "r_50", "a_50"])
    if label == "30":
        partial_outcomes = dict((key,value) for key, value in outcomes.items())
→if key in ["p_30", "r_30", "a_30"])
    if label == "10":
        partial_outcomes = dict((key,value) for key, value in outcomes.items())
→if key in ["p_10", "r_10", "a_10"])

    fig, axes = pairs_plotting.pairs_scatter(experiments, partial_outcomes,
→group_by='policy',
                                         legend=False)
    fig.set_size_inches(8,8)
    plt.show()

def display_scores_and_plots(results):
    show_feature_score(results)
    show_points(results, "avg")
    show_points(results, "100")
    show_points(results, "70")
    show_points(results, "50")
    show_points(results, "30")
    show_points(results, "10")

```

[4]: # specify a domain: (select one of below)

```

domain_name = "blocks-world"
#domain_name = "campus"
#domain_name = "depots"
#domain_name = "driverlog"
#domain_name = "dwr"
#domain_name = "easy-ipc-grid"
#domain_name = "ferry"
#domain_name = "intrusion-detection"
#domain_name = "kitchen"
#domain_name = "logistics"
#domain_name = "miconic"
#domain_name = "rovers"
#domain_name = "satellite"
#domain_name = "sokoban"

```

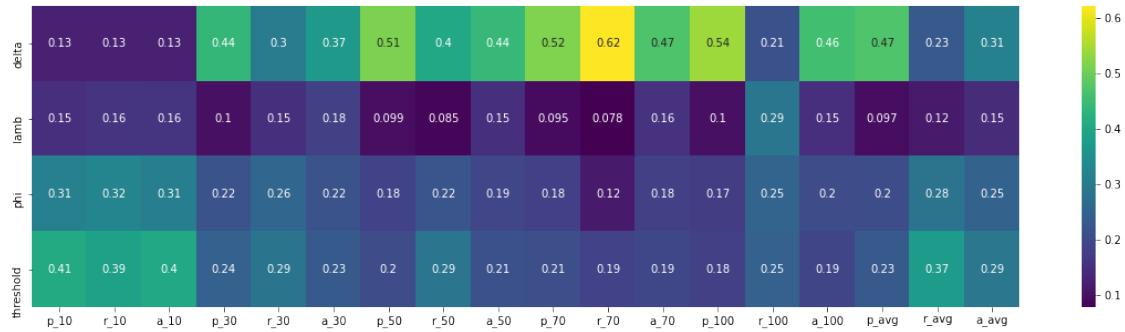
```

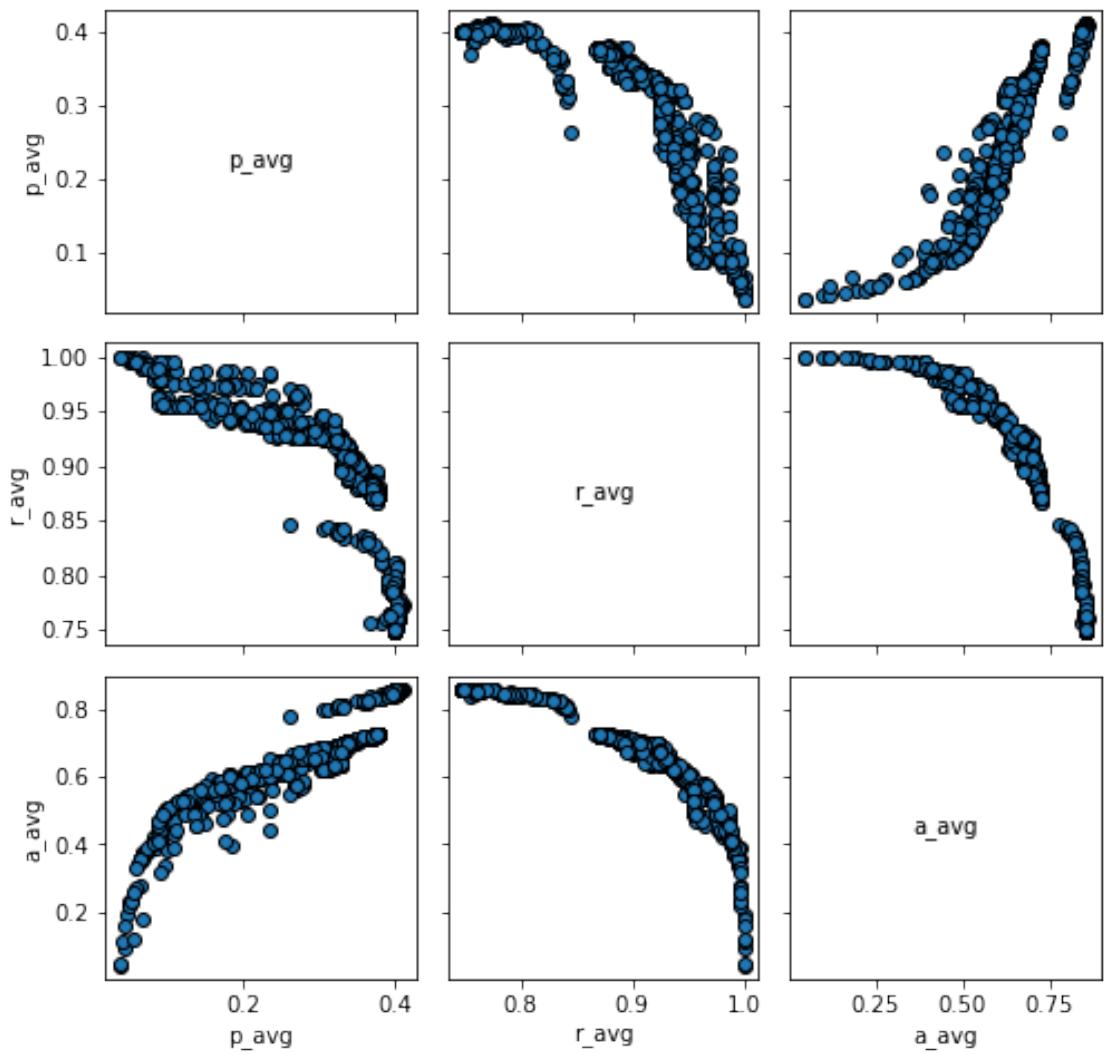
#domain_name = "zeno-travel"

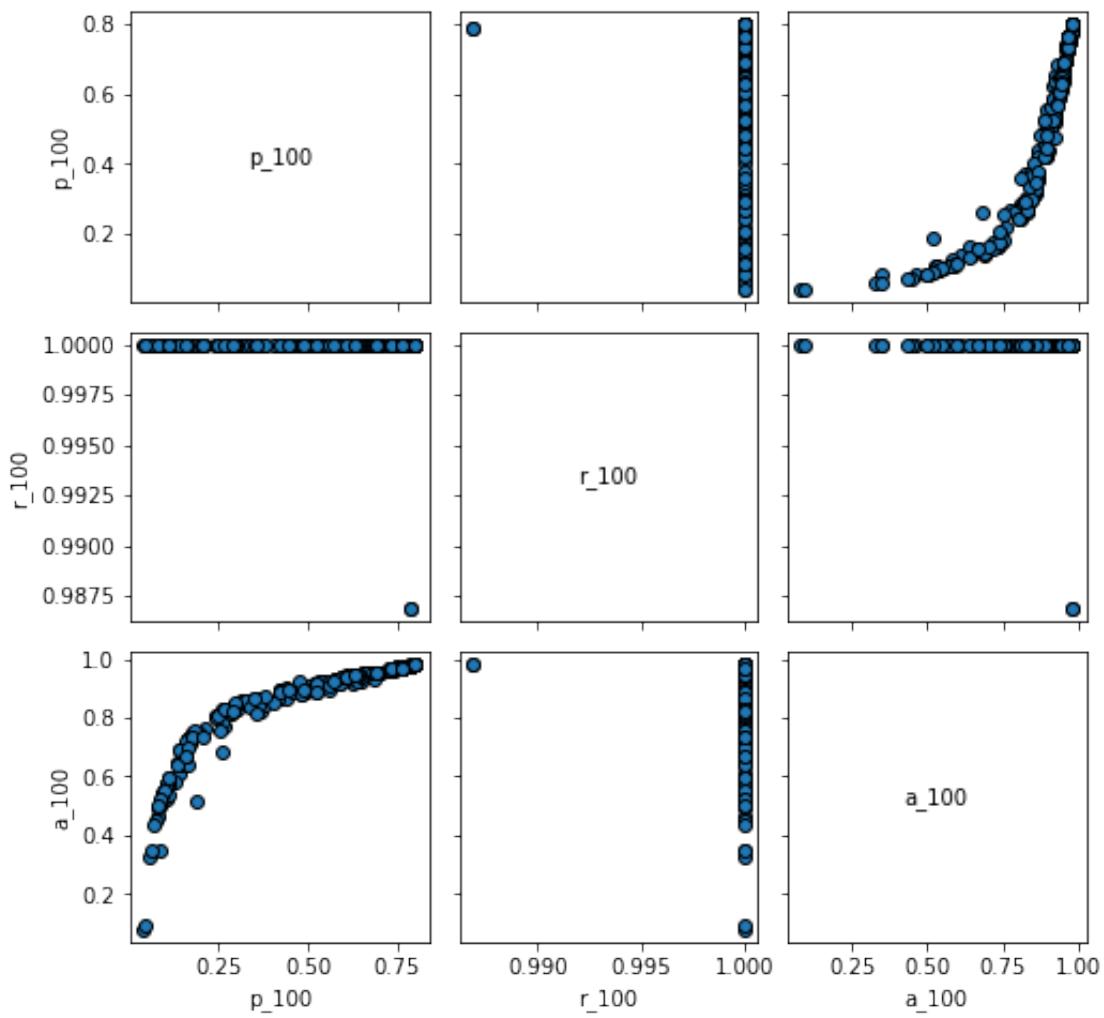
# load data
results = load_results('./topk/1000_' + domain_name + '.tar.gz')

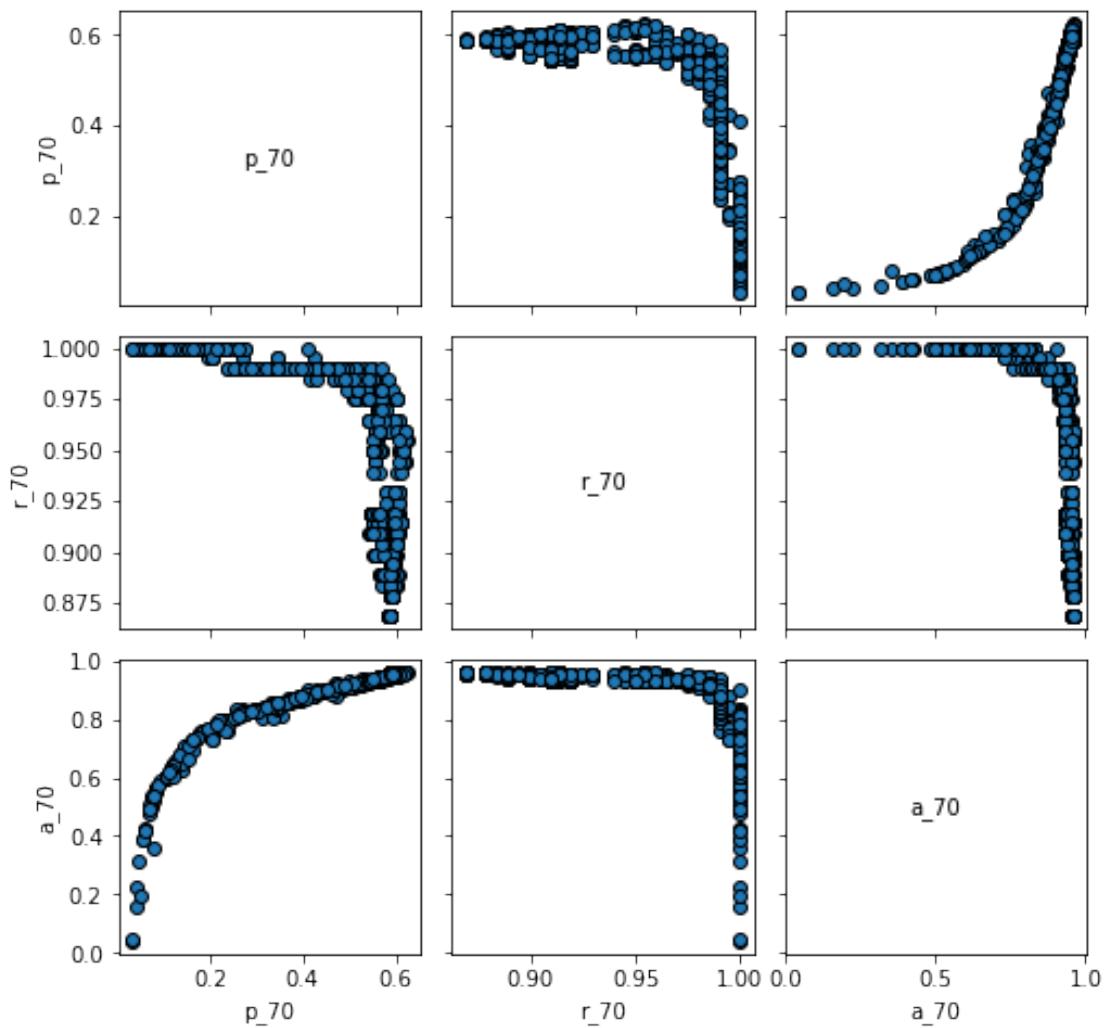
# show feature score and plots
display_scores_and_plots(results)

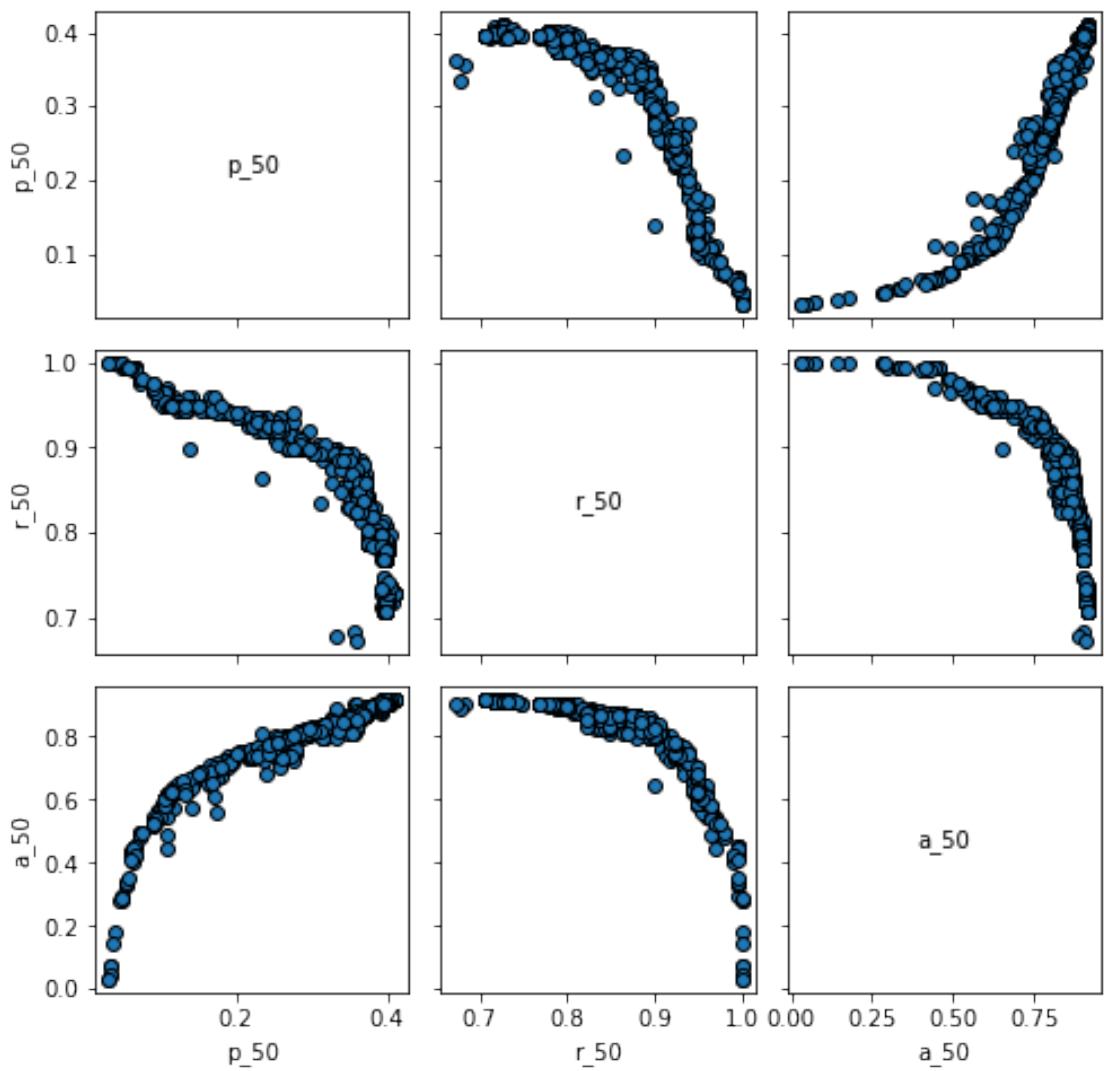
```

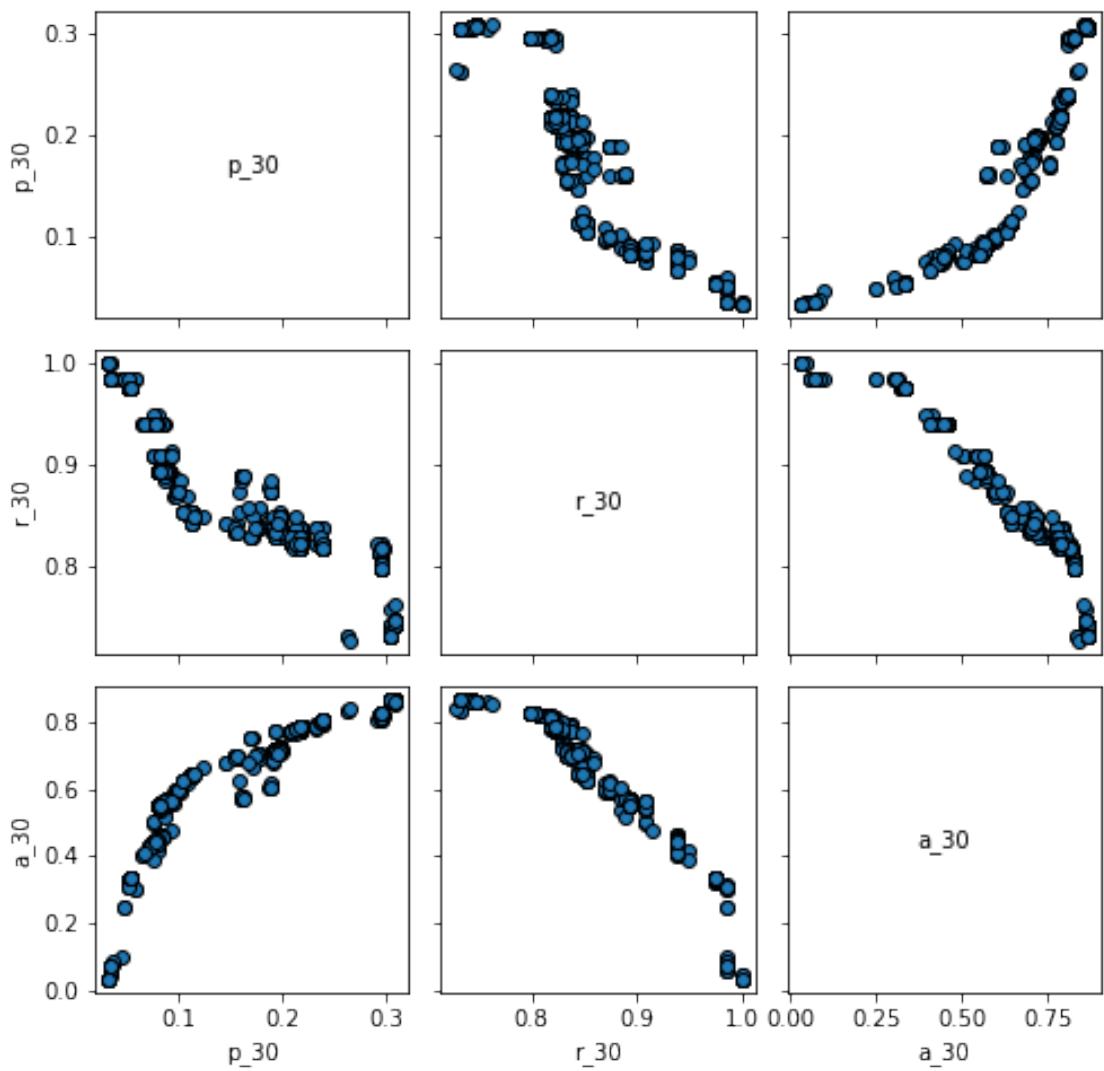


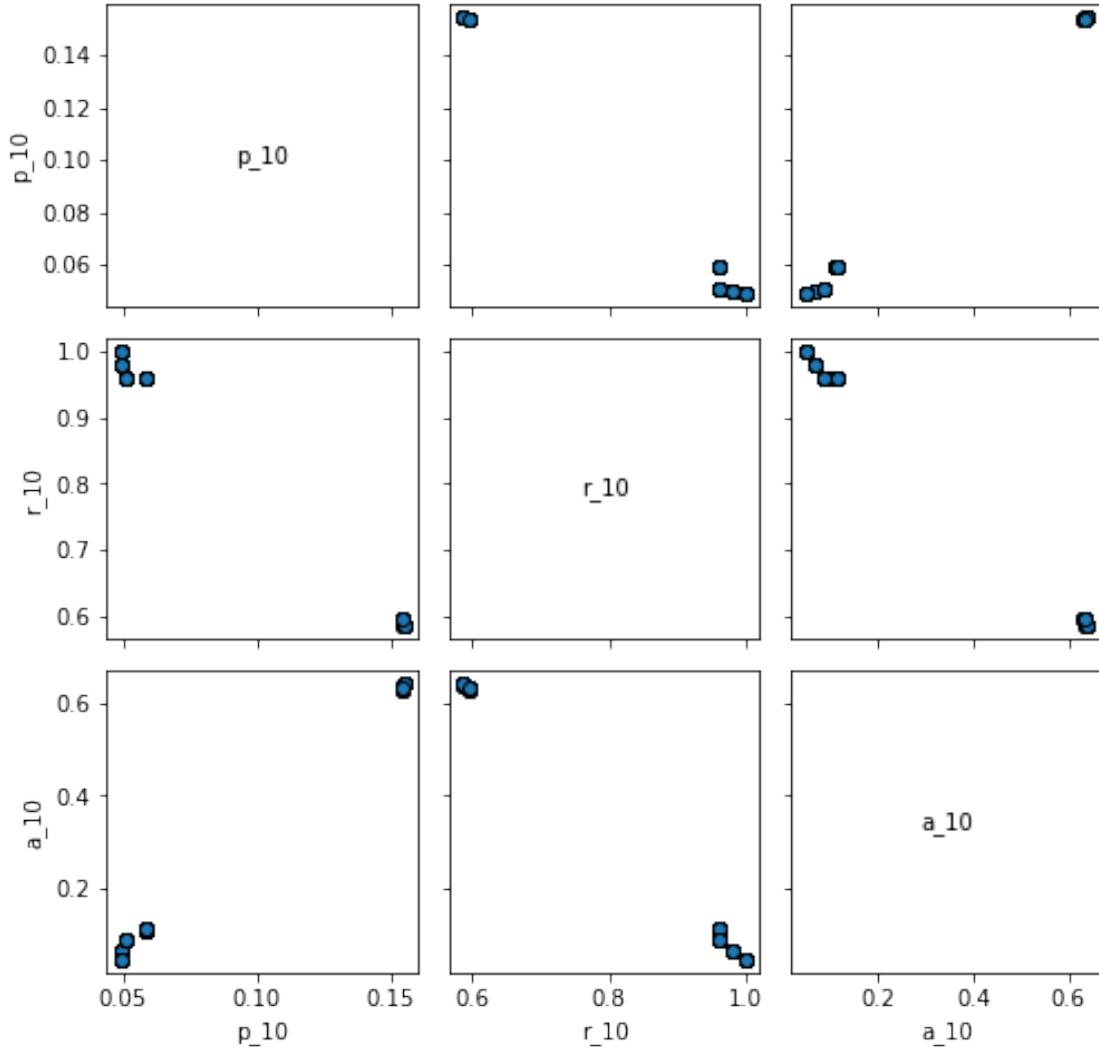












0.4 PRIM Algorithm

Once we get simulation results stored in `.tar.gz` file. We can apply PRIM algorithm to show what ranges of parameters lead to better performance. Here, we used `a_avg` as a metric to filter out the experiments with top 10% average accuracy (`a_avg`). There are **two steps** for finding the parameter ranges.

```
[5]: # load functions for PRIM algorithm
def get_top(results, percentage, metric):
    experiments, outcomes = results
    experiments[metric] = outcomes[metric]
    num = int(len(experiments.index) * percentage)
    df = experiments.sort_values(by=[metric], ascending=False).head(num)
```

```

    ...
# show the dataframe
print(df)
range_list = list(df["threshold"])
range_list.sort()
# print(range_list)
print("threshold range: ", range_list[0], range_list[-1])

range_list = list(df["lamb"])
range_list.sort()
print("lamb range: ", range_list[0], range_list[-1])

range_list = list(df["delta"])
range_list.sort()
print("delta range: ", range_list[0], range_list[-1])

range_list = list(df["phi"])
range_list.sort()
print("phi range: ", range_list[0], range_list[-1])
'''

return df.tail(1)[ "a_avg"]

def find_box(results, metric, lower_limit):
    experiments1, outcomes = results
    x = experiments1
    y = outcomes[metric] >= lower_limit

    prim_alg = prim.Prim(x, y, threshold=0.1)      ##### need to select a proper
    ↪threshold here
    box1 = prim_alg.find_box()

    box1.show_tradeoff()
    plt.show()

    return box1

def show_ranges(box_num, box1):
    box1.inspect(box_num)
    box1.inspect(box_num, style='graph')
    plt.show()

    box1.show_pairs_scatter(box_num)
    plt.show()

```

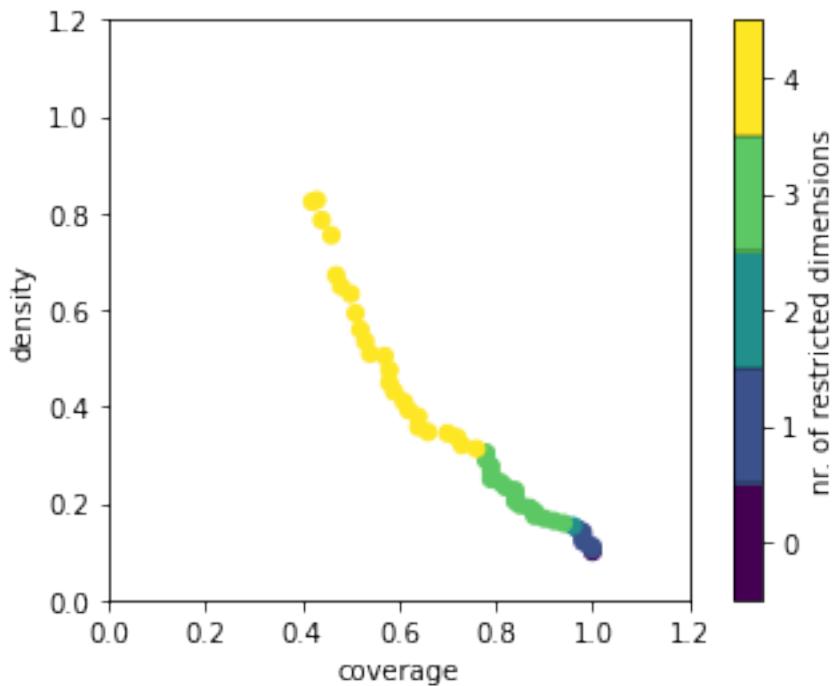
Step 1: show the trade-off graph The trade off graph as below. It contains many dots from the dark blue to yellow. We can inspect each dot by giving a `box_num` in **step two**. The right-hand side bar indicates number of parameters (phi, theta, lambda, threshold). The graph shows the

trade-off between coverage and density. So, when we set a `box_num`, we also need to consider the trade-off. The `box_num` can start from 1, which means the highest coverage but lowest density. The upper bound of `box_num` is different from domain to domain, usually around 50-60. If you set a `box_num` too large, it will give you errors, then you need to adjust it to some smaller number.

```
[6]: domain_name = "blocks-world"

# select the best 10% rows (experiments) with highest average accuracy
results = load_results('./topk/1000_' + domain_name + '.tar.gz')
a_avg = get_top(results, 0.1, "a_avg")

#results of PRIM algorithm (need to reload the data)
results = load_results('./topk/1000_' + domain_name + '.tar.gz')
box1 = find_box(results, 'a_avg', float(a_avg))
```



Step 2: set a proper `box_num` (need to consider the trade off between density and coverage)

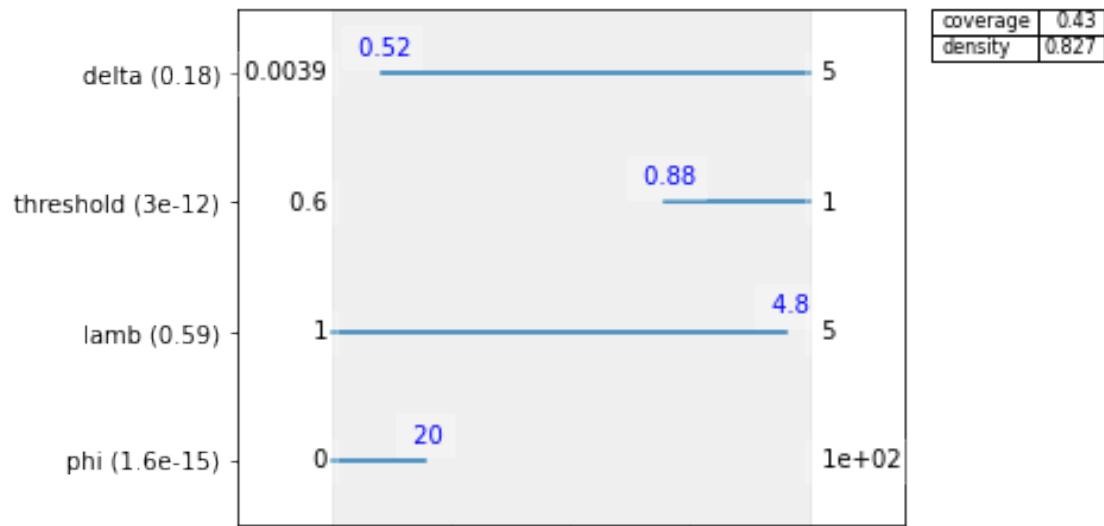
```
[7]: # 50, 25, 55, 55, 50, 50, 50, 50, 30, 50, 50, 50, 50, 50, 50, 50, 50, 50

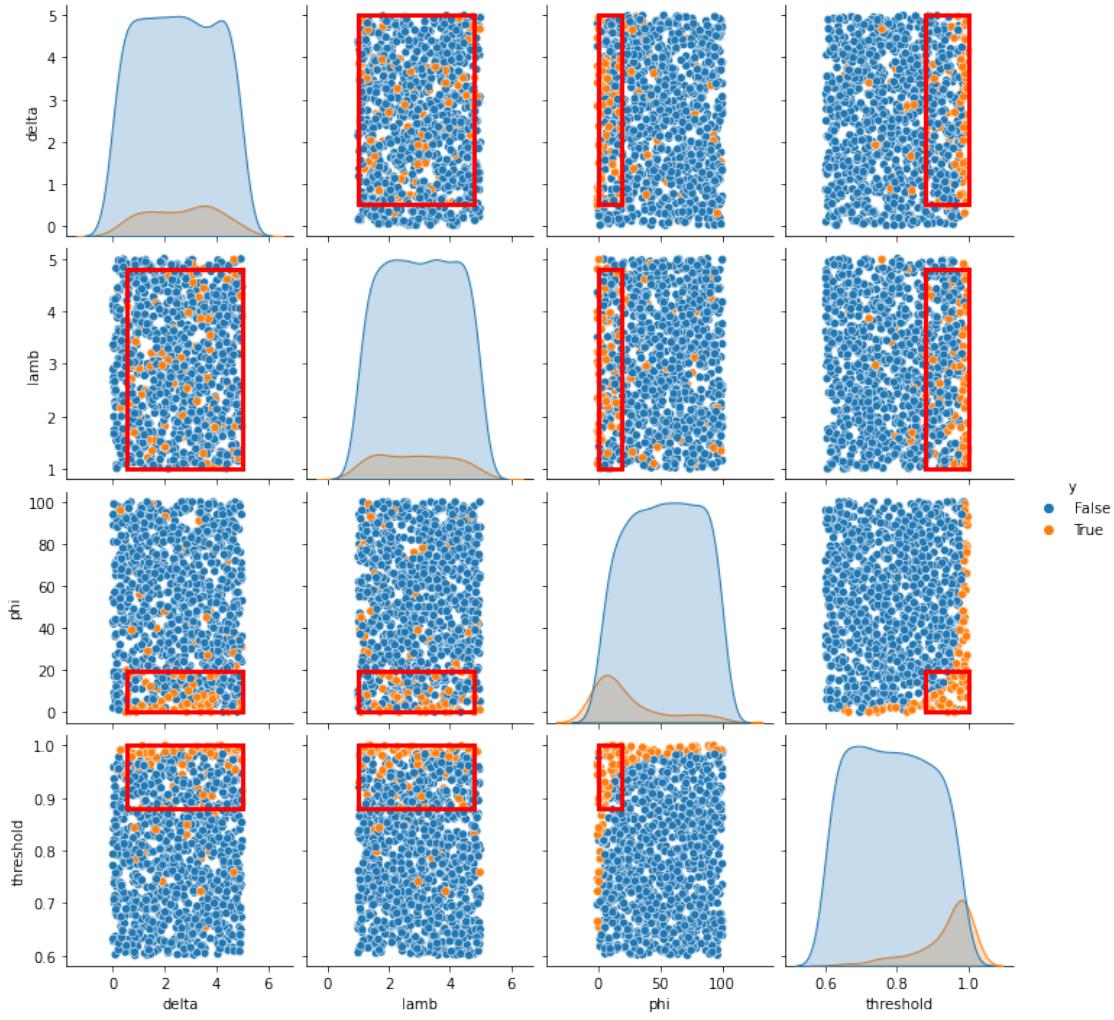
# need to set box_num according to the trade off graph
box_num = 50
show_ranges(box_num, box1)
```

coverage 0.43

```
density      0.826923
id           50
mass         0.052
mean         0.826923
res_dim      4
Name: 50, dtype: object
```

```
          box 50
          min       max      qp values
phi     0.000000 19.500000 [-1.0, 1.6188507007121986e-15]
lamb    1.003900 4.810672  [-1.0, 0.5878050850484972]
threshold 0.879567 0.999859 [3.0375970058123697e-12, -1.0]
delta   0.517886 4.997435  [0.17834844930969904, -1.0]
```





[]:

0.5 SOBOL Sampling

The SOBOL analysis indicates if a parameter has significant impact on performance or not, details see [here](#).

Firstly, we need to define a model as following code block. The four parameters (phi, delta, lambda, threshold) are defined as uncertainties, domain is defined as a constant, the outcomes are performance statistics ($p_{10}, r_{10}, a_{10}, p_{30}, r_{30}, a_{30}, p_{50}, r_{50}, a_{50}, p_{70}, r_{70}, a_{70}, p_{100}, r_{100}, a_{100}, p_{avg}, r_{avg}, a_{avg}$). The details of how to define a model can be found [here](#)

```
[8]: from model import gr_system
import os
import sys
```

```

import subprocess
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt

from ema_workbench import (RealParameter, IntegerParameter, □
    ↳CategoricalParameter,
    ScalarOutcome, Constant,
    Model, ema_logging, perform_experiments)

domain = "a_domain_name"
model = Model('grsystem', function=gr_system)

# set uncertainties
model.uncertainties = [IntegerParameter("phi", 0, 100),
    RealParameter("delta", 0, 5),
    RealParameter("lamb", 1, 5),
    RealParameter("threshold", 0.6, 1.0)]

# set domain to a constant
model.constants = [Constant("domain", domain)]

# specify outcomes
model.outcomes = [ScalarOutcome('p_10'),
    ScalarOutcome('r_10'),
    ScalarOutcome('a_10'),
    ScalarOutcome('p_30'),
    ScalarOutcome('r_30'),
    ScalarOutcome('a_30'),
    ScalarOutcome('p_50'),
    ScalarOutcome('r_50'),
    ScalarOutcome('a_50'),
    ScalarOutcome('p_70'),
    ScalarOutcome('r_70'),
    ScalarOutcome('a_70'),
    ScalarOutcome('p_100'),
    ScalarOutcome('r_100'),
    ScalarOutcome('a_100'),
    ScalarOutcome('p_avg'),
    ScalarOutcome('r_avg'),
    ScalarOutcome('a_avg')]

```

Load the SOBOL analysis helper functions Here we show the first order effect and total effect. And displayed SOBOL analysis results coresponding to all performance statistics (p_10, r_10, a_10, p_30, r_30, a_30, p_50, r_50, a_50, p_70, r_70, a_70, p_100, r_100, a_100, p_avg, r_avg, a_avg). Generally, we are more interested in the significance of impacts on a_avg

(avg: accuracy).

[9]: # the first order and total:

```
from SALib.analyze import sobol
from ema_workbench.em_framework.salib_samplers import get_SALib_problem

def show_effects(results, outcomes_field):
    experiments, outcomes = results
    problem = get_SALib_problem(model.uncertainties)
    Si = sobol.analyze(problem, outcomes[outcomes_field],
                       calc_second_order=True, print_to_console=False)

    scores_filtered = {k:Si[k] for k in ['ST','ST_conf','S1','S1_conf']}
    Si_df = pd.DataFrame(scores_filtered, index=problem['names'])

    sns.set_style('white')
    fig, ax = plt.subplots(1)

    indices = Si_df[['S1','ST']]
    err = Si_df[['S1_conf','ST_conf']]

    indices.plot.bar(yerr=err.values.T,ax=ax)
    fig.set_size_inches(8,6)
    fig.subplots_adjust(bottom=0.3)
    plt.show()

def display_sobol_analysis_results(results):
    print("avg: accuracy")
    show_effects(results, 'a_avg')
    print("avg: recall")
    show_effects(results, 'r_avg')
    print("avg: precision")
    show_effects(results, 'p_avg')
    print("100: accuracy")
    show_effects(results, 'a_100')
    print("100: recall")
    show_effects(results, 'r_100')
    print("100: precision")
    show_effects(results, 'p_100')
    print("70: accuracy")
    show_effects(results, 'a_70')
    print("70: recall")
    show_effects(results, 'r_70')
    print("70: precision")
    show_effects(results, 'p_70')
    print("50: accuracy")
```

```

show_effects(results, 'a_50')
print("50: recall")
show_effects(results, 'r_50')
print("50: precision")
show_effects(results, 'p_50')
print("30: accuracy")
show_effects(results, 'a_30')
print("30: recall")
show_effects(results, 'r_30')
print("30: precision")
show_effects(results, 'p_30')
print("10: accuracy")
show_effects(results, 'a_10')
print("10: recall")
show_effects(results, 'r_10')
print("10: precision")
show_effects(results, 'p_10')

# this function only show "a_avg"
def display_sobol_analysis_results_a_avg(results):
    print("avg: accuracy")
    show_effects(results, 'a_avg')

```

[10]:

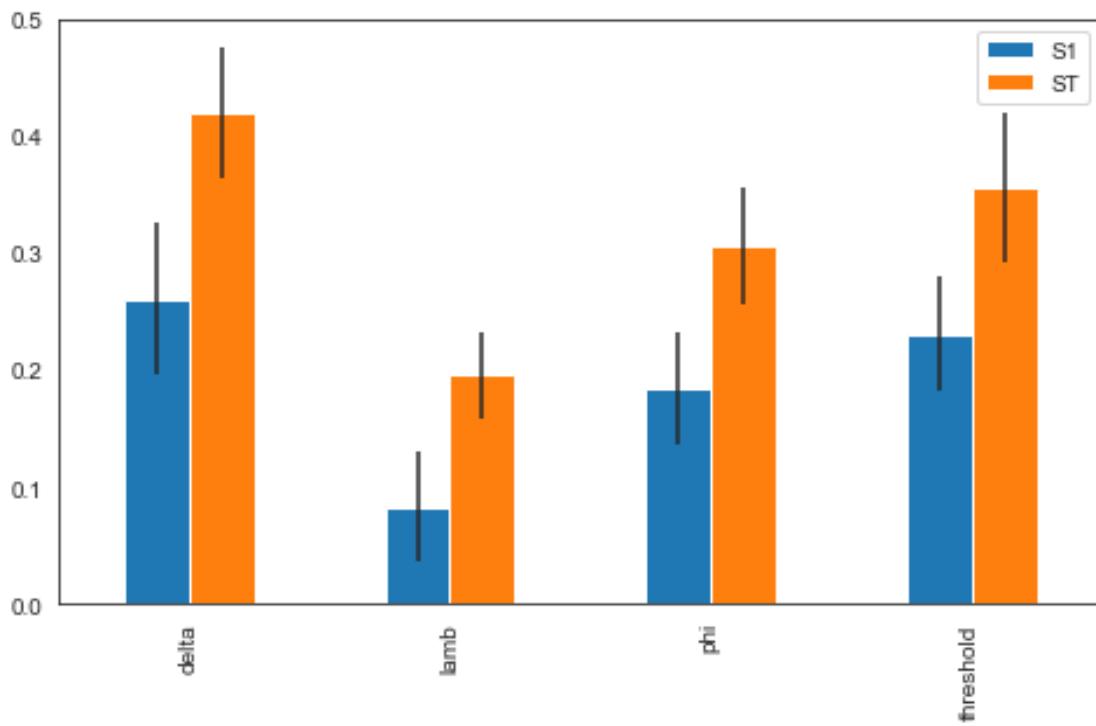
```

# load data
domain_name = "blocks-world"
sobel_results = load_results('./topk/1050_' + domain_name + '.tar.gz')

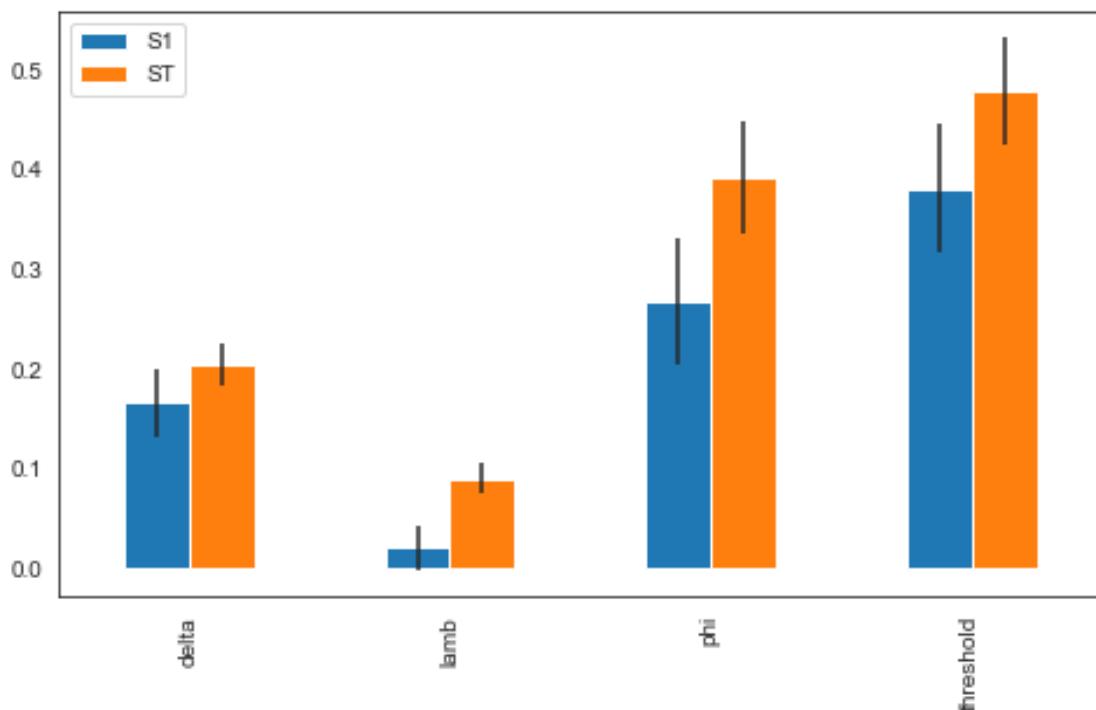
display_sobol_analysis_results(sobel_results)

```

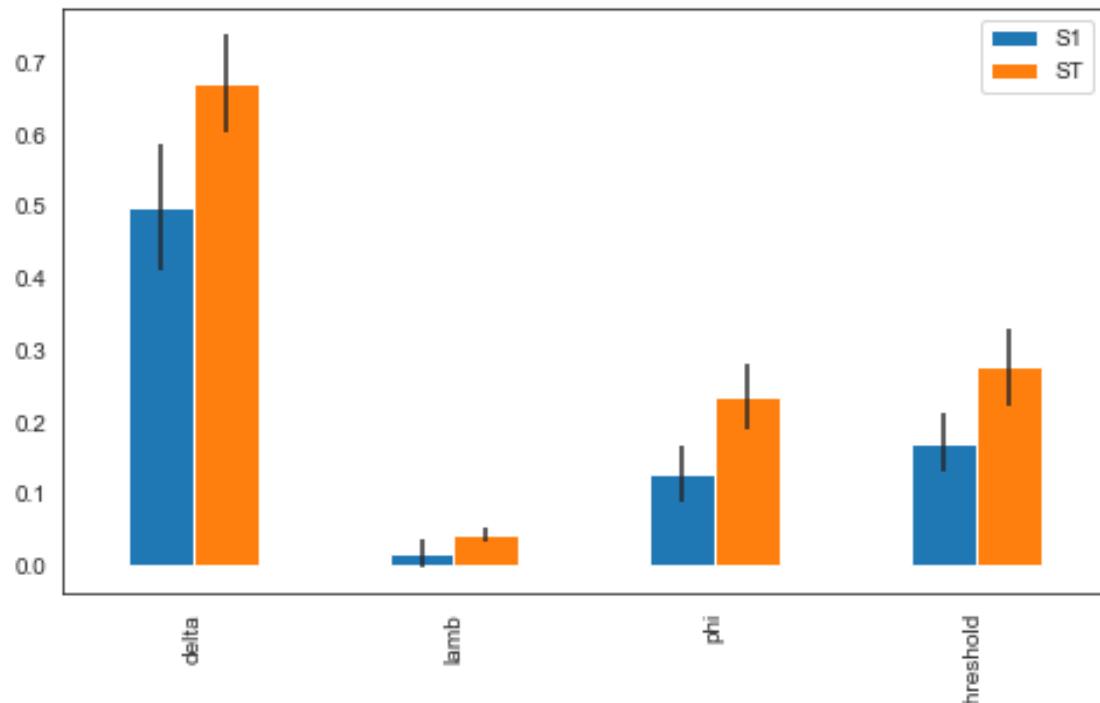
avg: accuracy



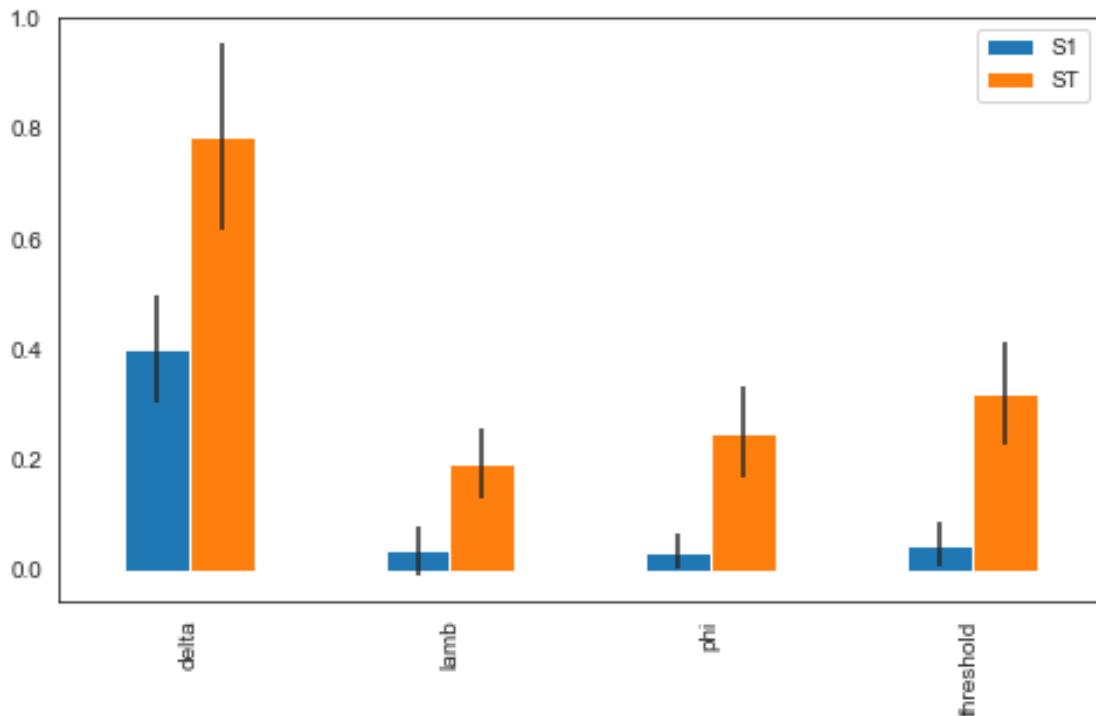
avg: recall



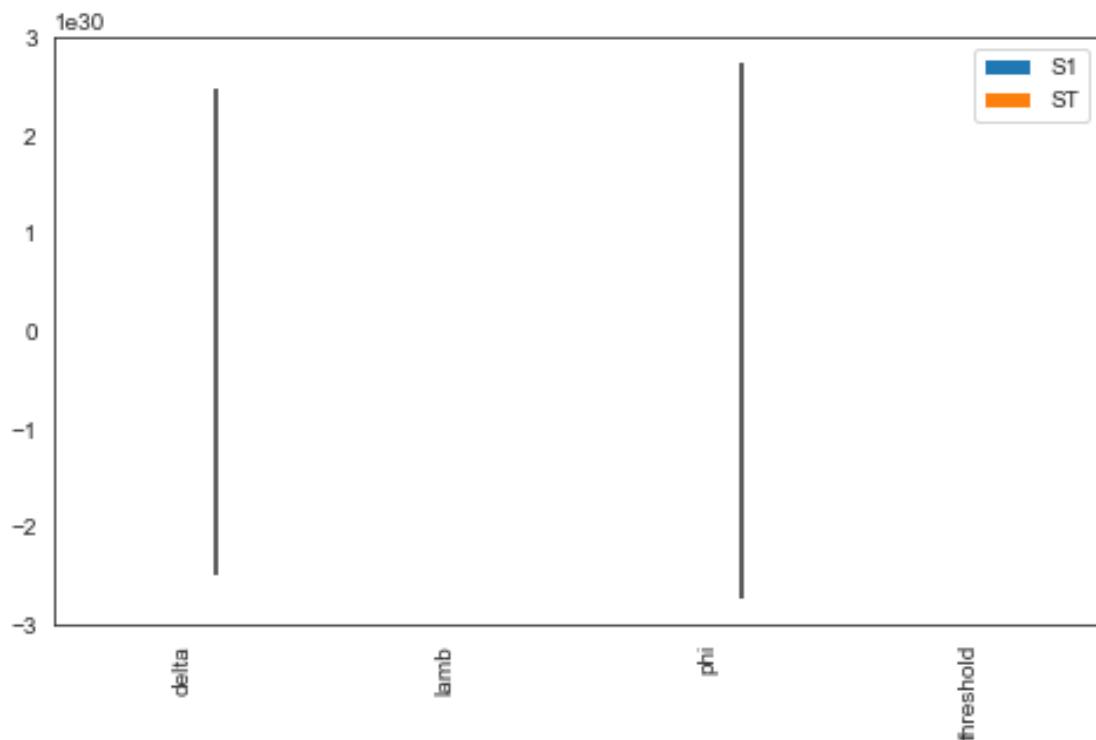
avg: precision



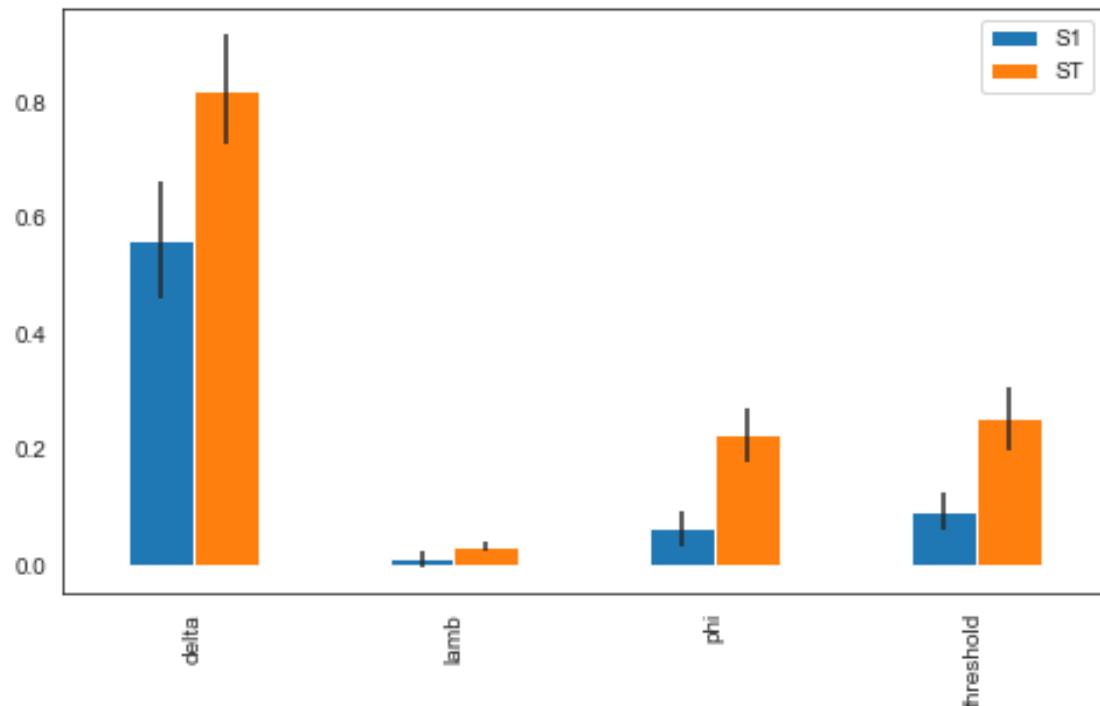
100: accuracy



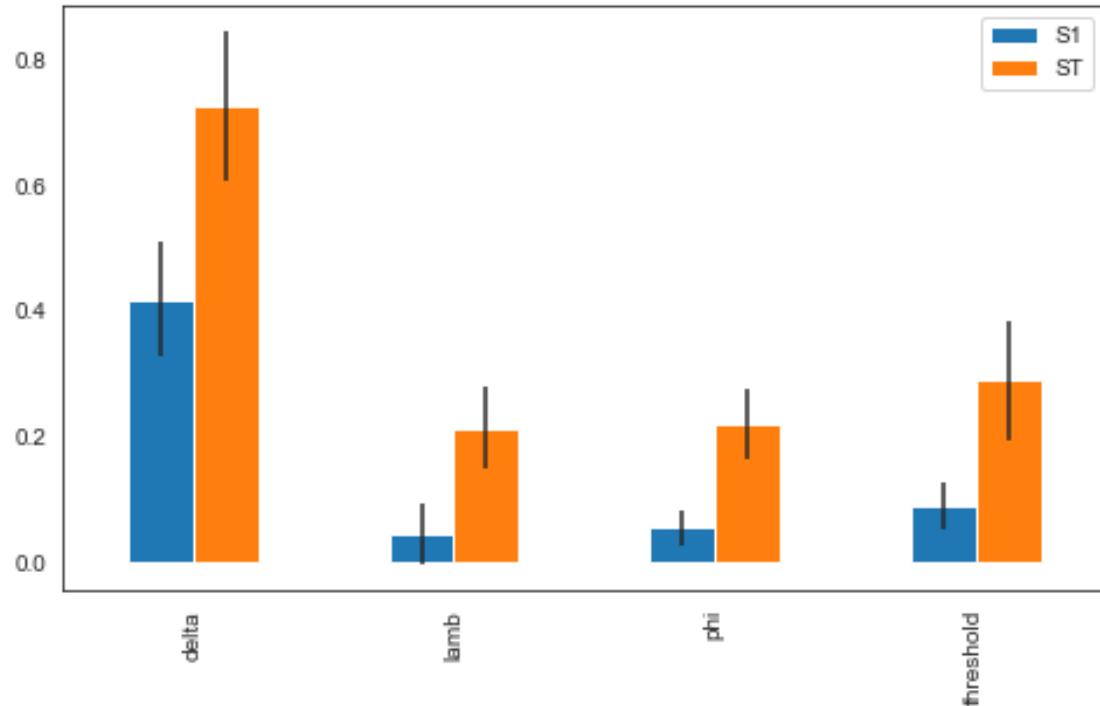
100: recall



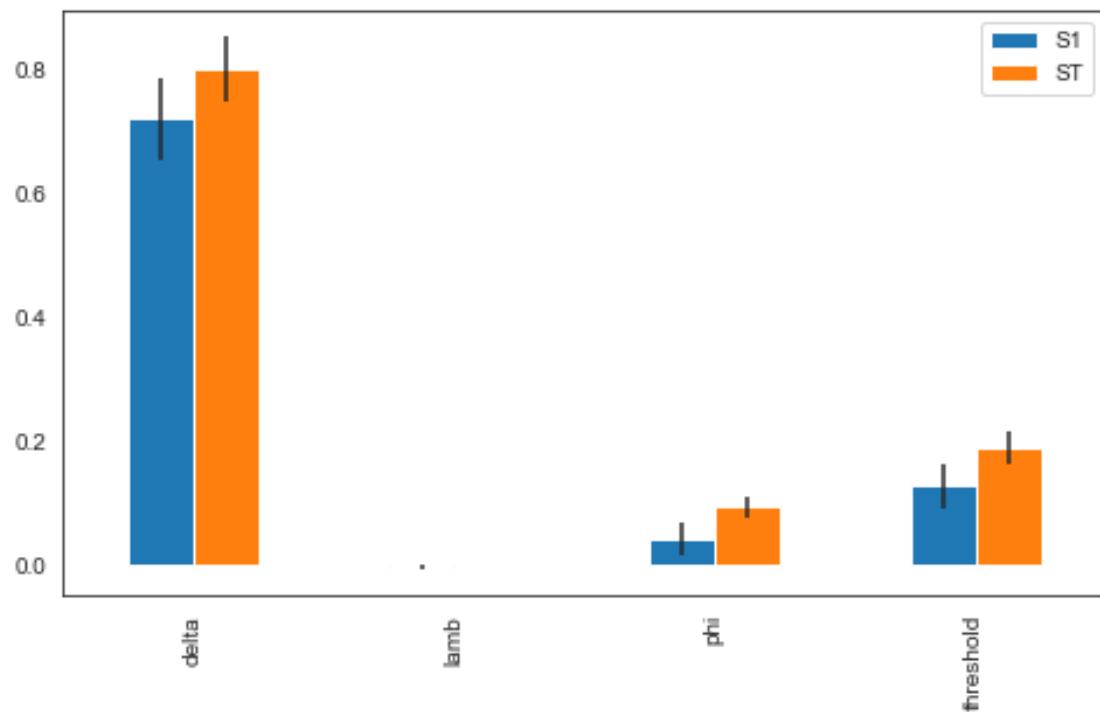
100: precision



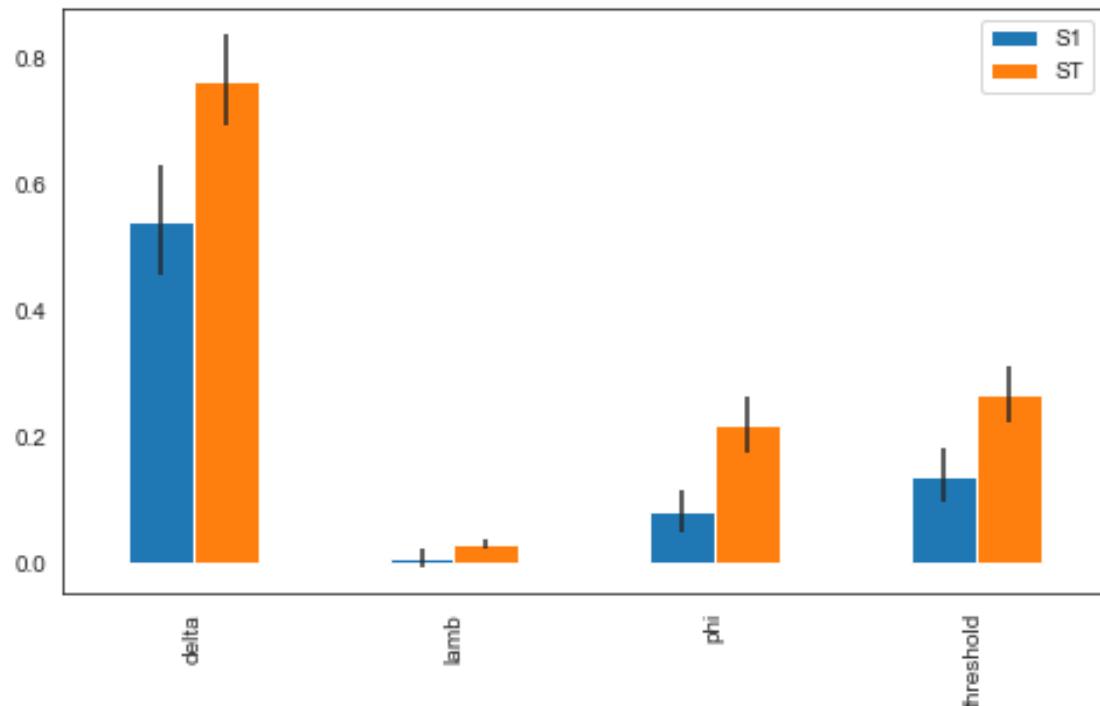
70: accuracy



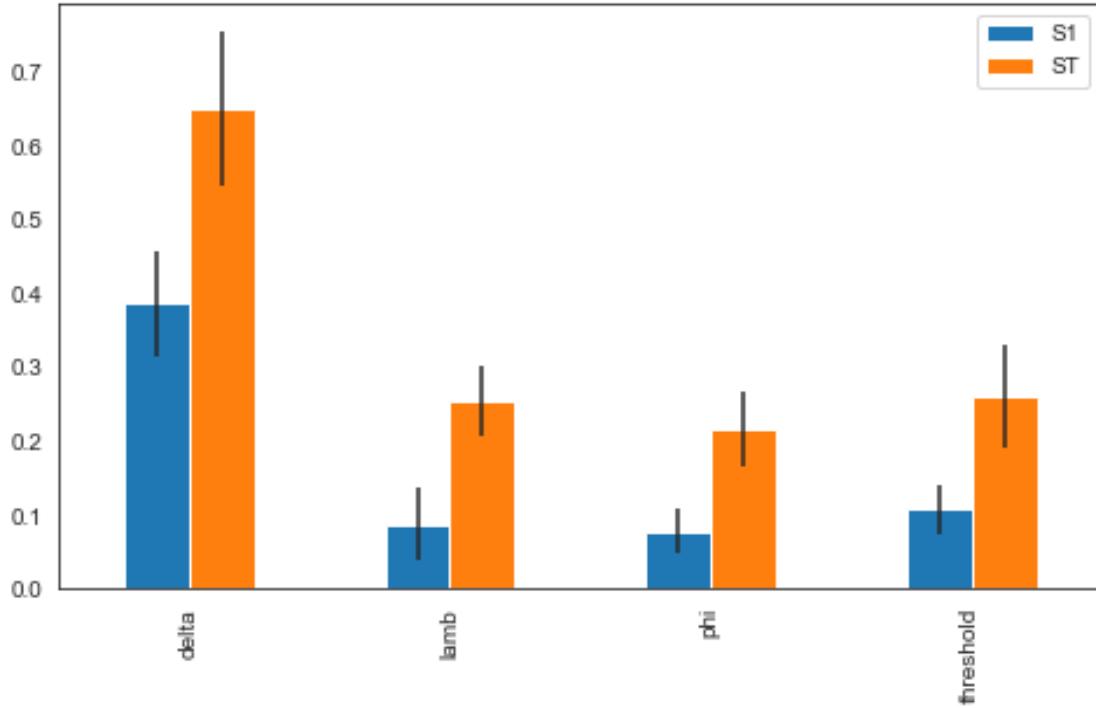
70: recall



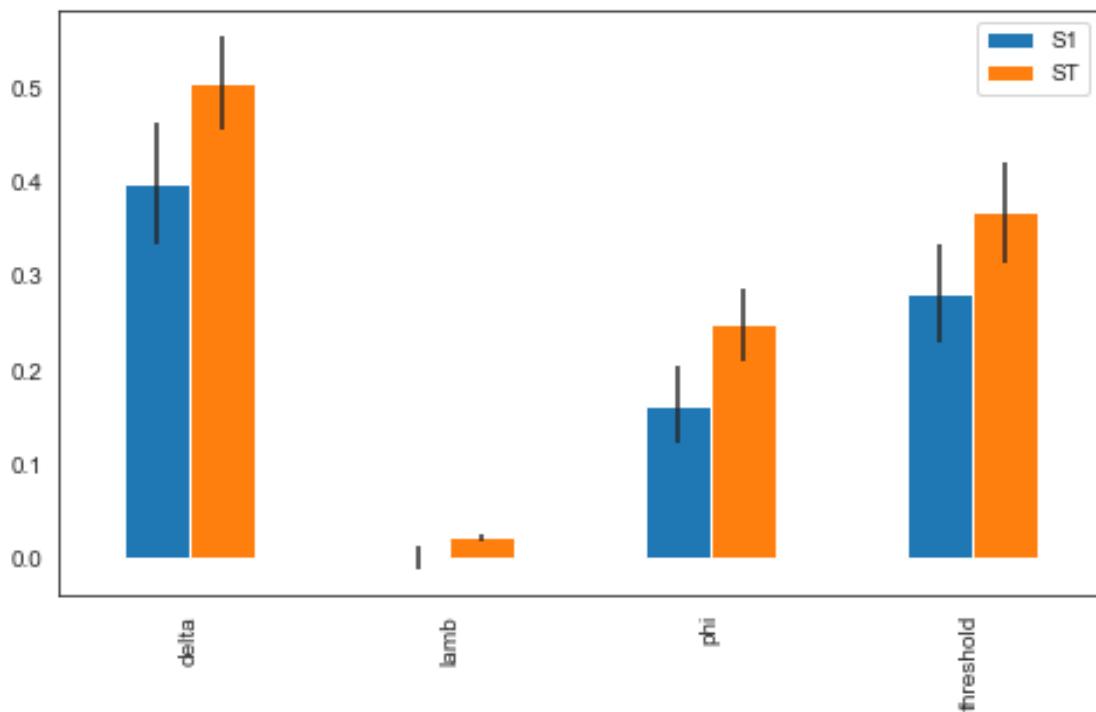
70: precision



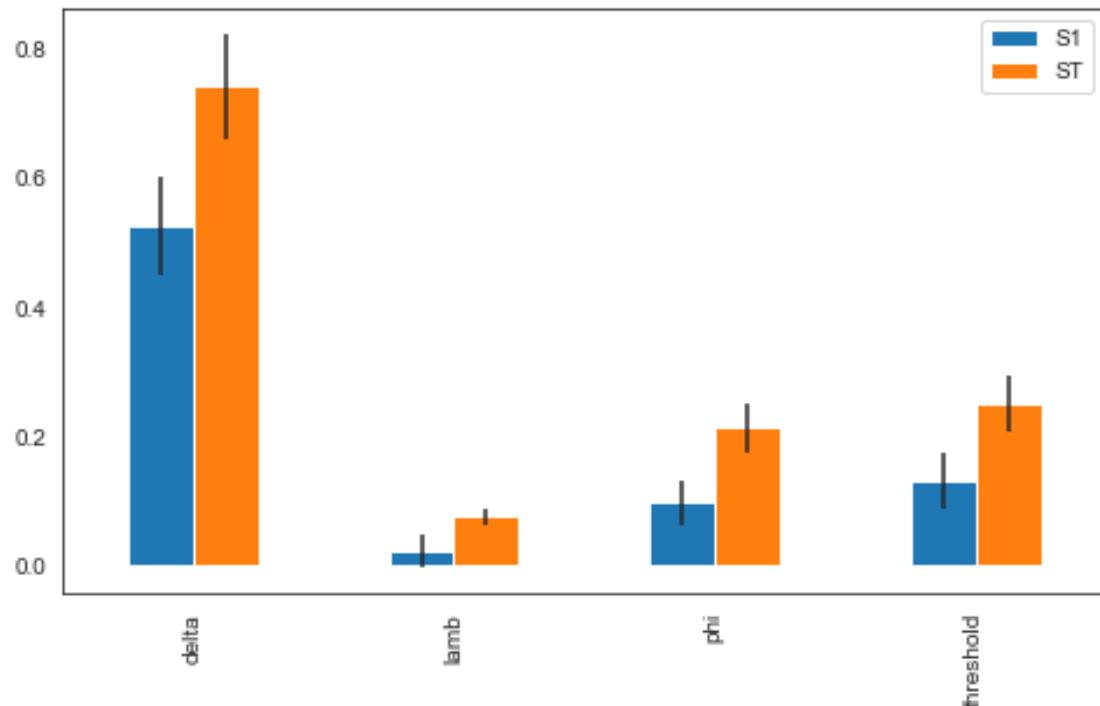
50: accuracy



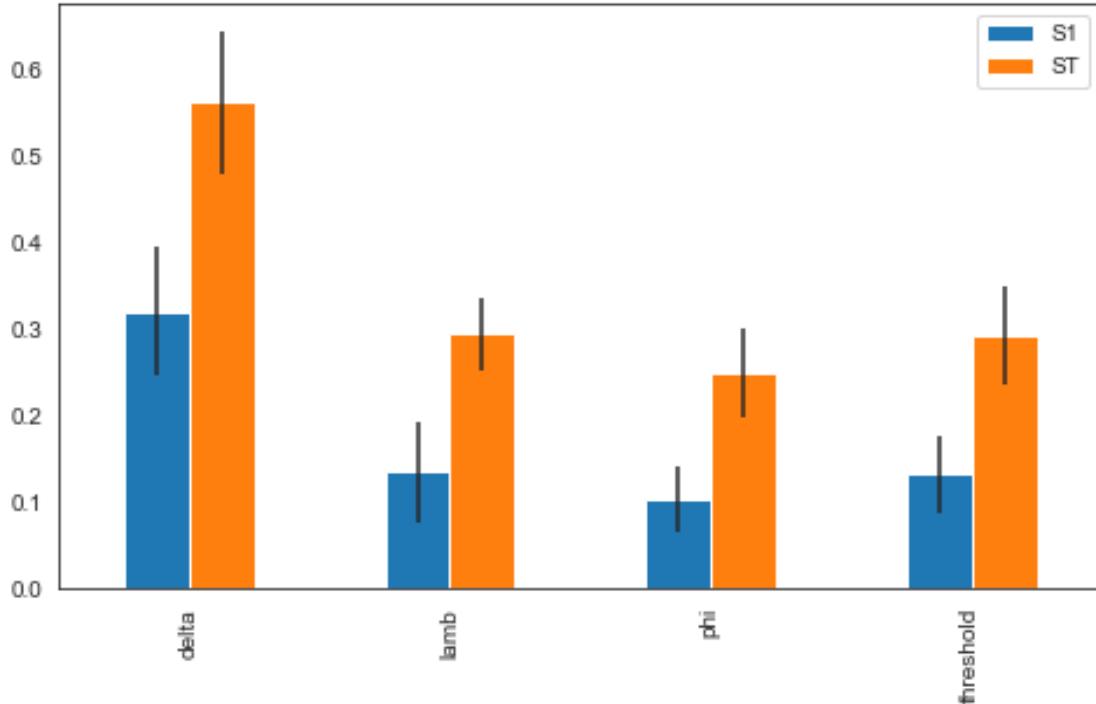
50: recall



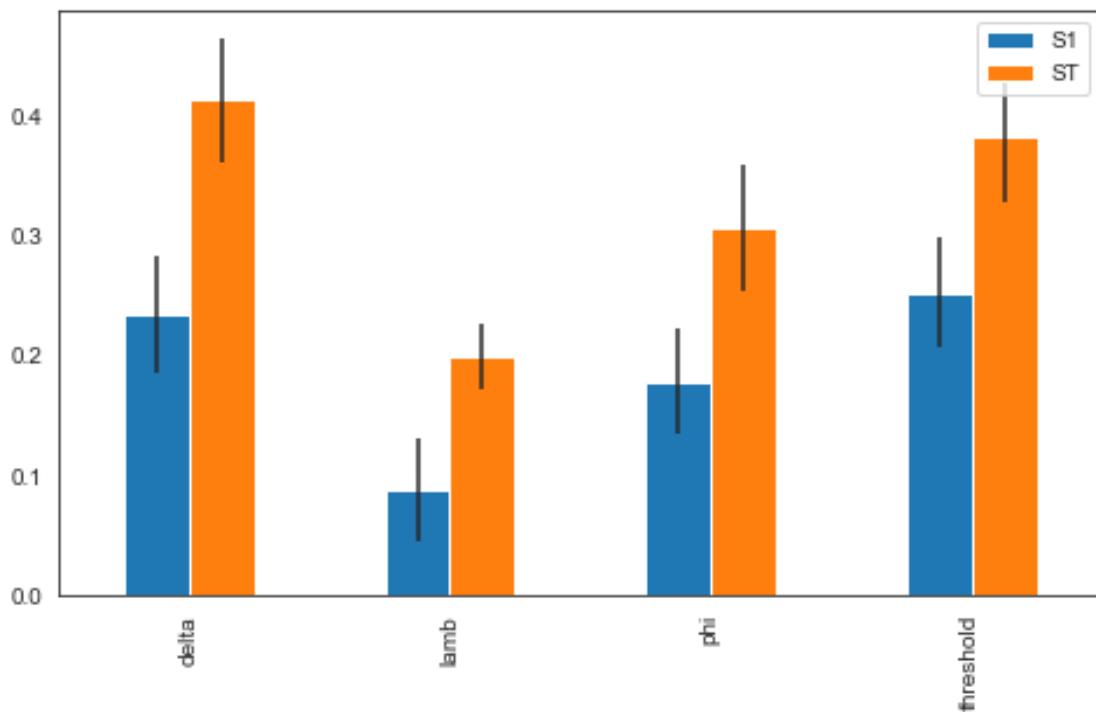
50: precision



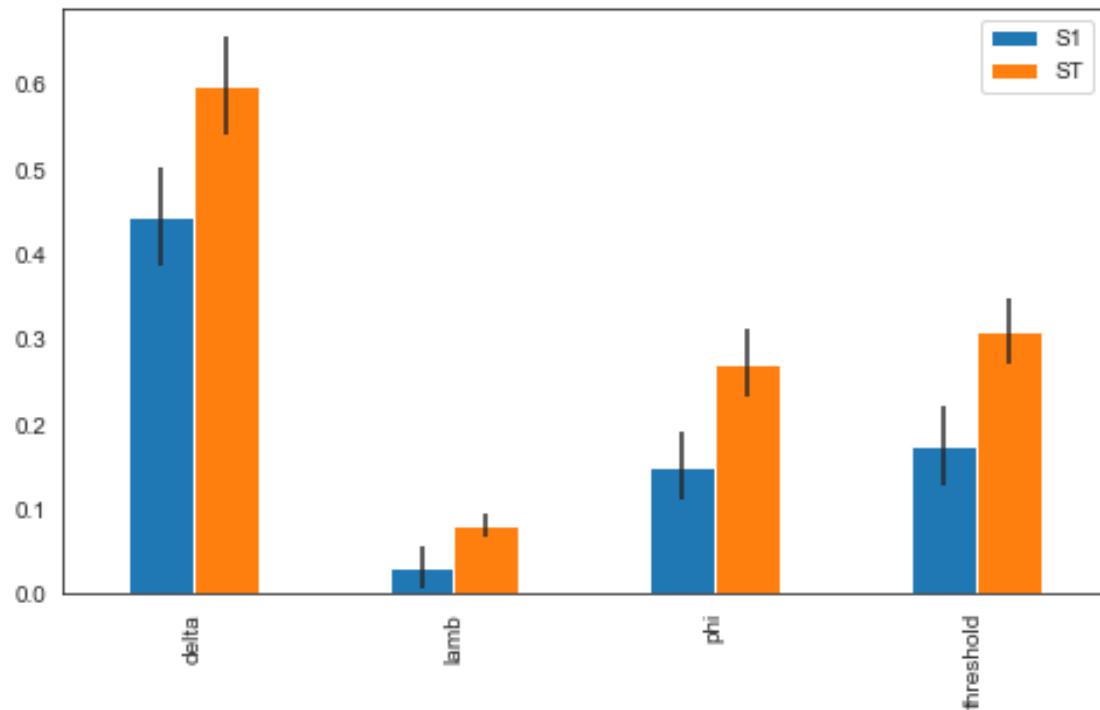
30: accuracy



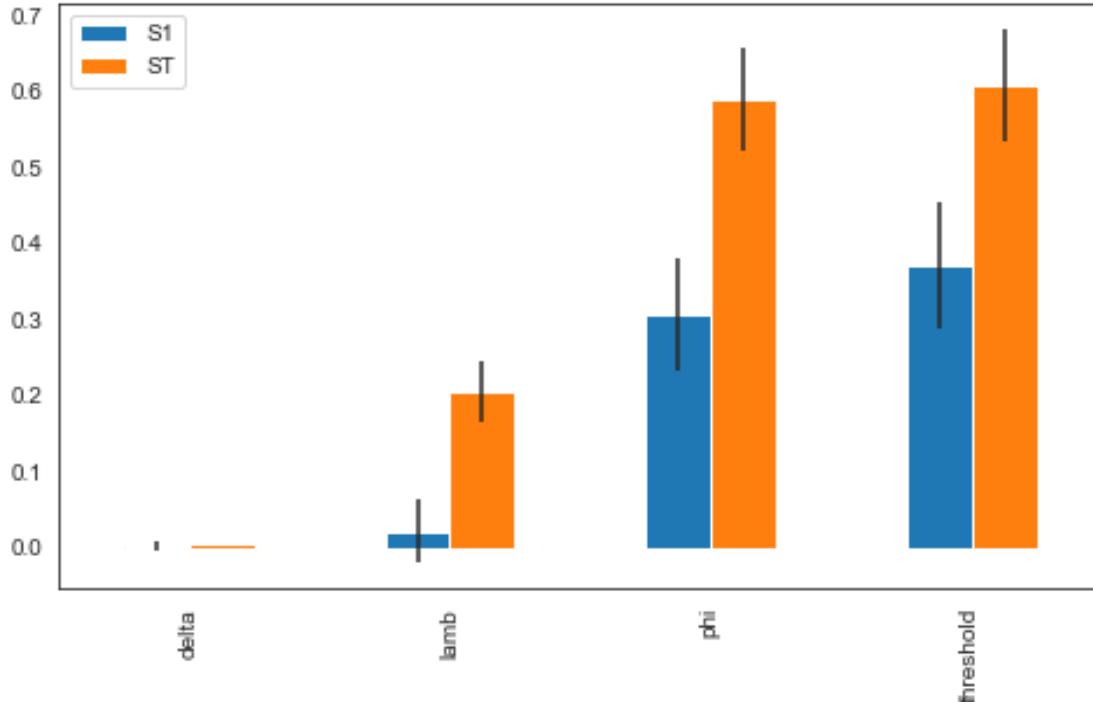
30: recall



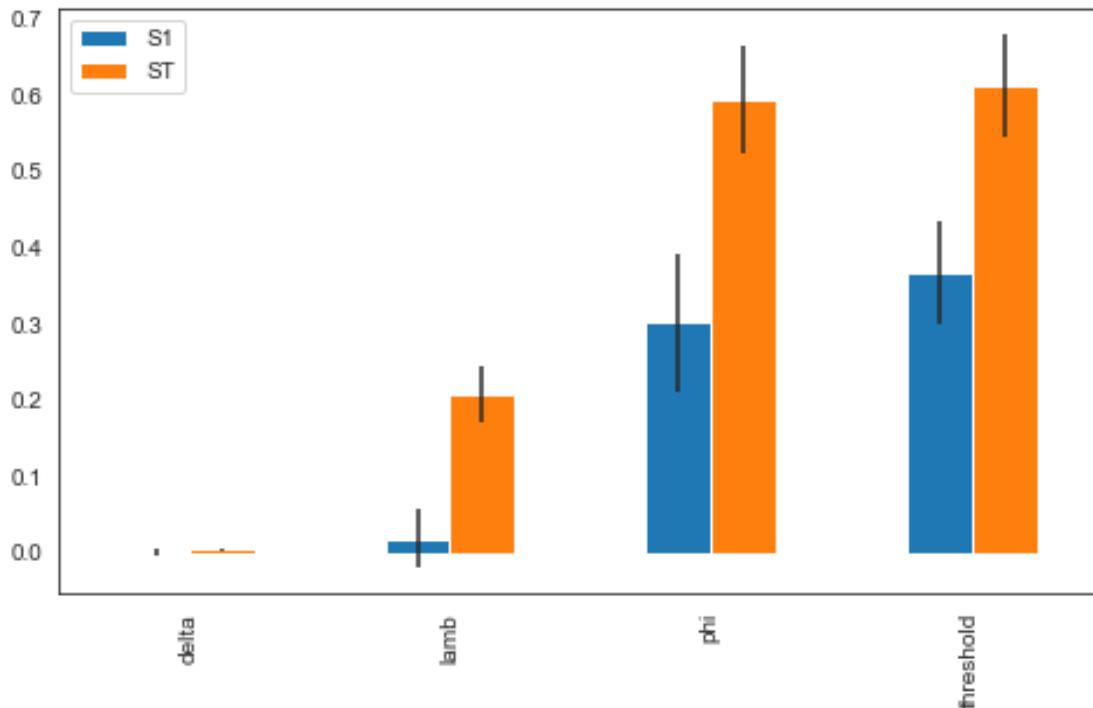
30: precision



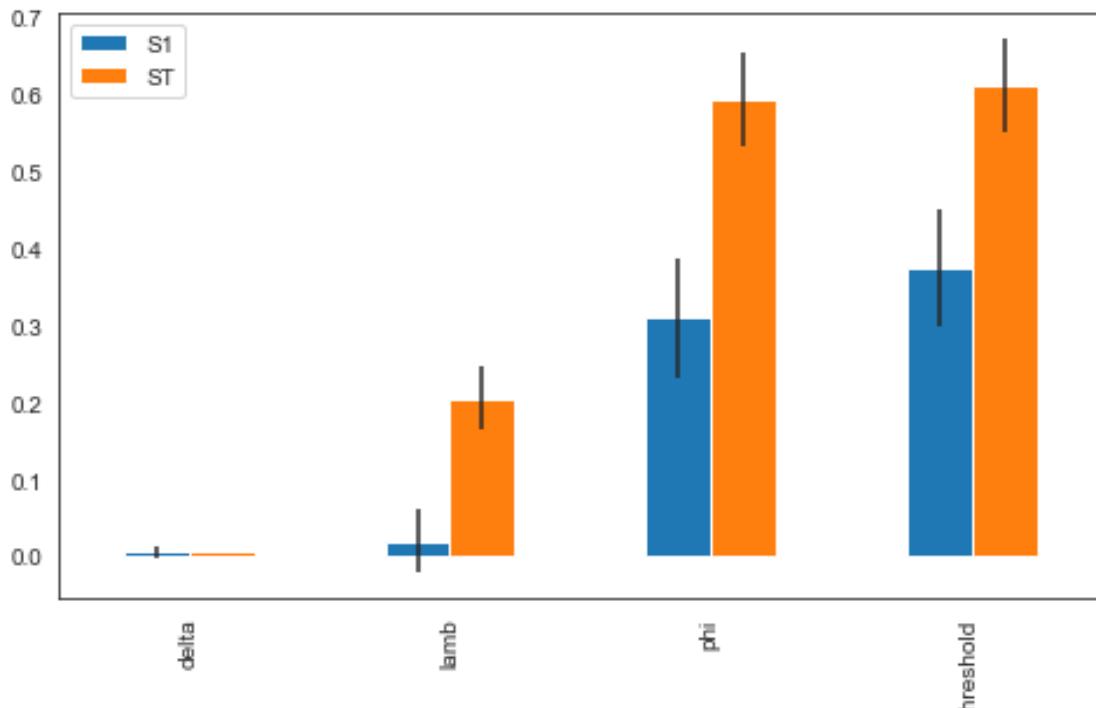
10: accuracy



10: recall



10: precision



0.6 Show results for all domains

The above code blocks explain and show the details of sensitivity analysis using blocks-world domain as an example. The following codes show a SOBOL analysis results on a_avg for 15 domains (including blocks-world). And also show the parameter ranges using PRIM algorithm.

```
[11]: # There are 15 domains

domain_list = ["blocks-world", "campus", "depots", "driverlog", "dwr",  
    ↴"easy-ipc-grid", "ferry",  
        "intrusion-detection", "kitchen", "logistics", "miconic",  
    ↴"rovers", "satellite",  
        "sokoban", "zeno-travel"]

# tweak and select a proper box_num for each domain
box_num_list = [50, 25, 55, 55, 50, 50, 50, 50, 30, 50, 50, 50, 50, 50, 50, 50]
```



```
for i in range(15):
    domain_name = domain_list[i]
    box_num = box_num_list[i]
```

```

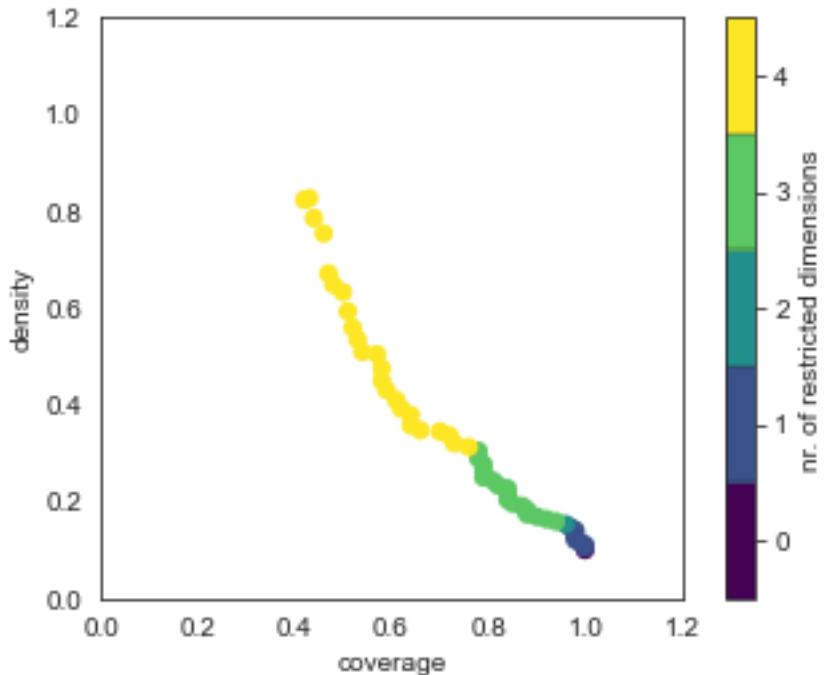
print(domain_name)
#PRIM
results = load_results('./topk/1000_' + domain_name + '.tar.gz')
a_avg = get_top(results, 0.1, "a_avg")

results = load_results('./topk/1000_' + domain_name + '.tar.gz')
box1 = find_box(results, 'a_avg', float(a_avg))
show_ranges(box_num, box1)

# SOBOL
sobol_results = load_results('./topk/1050_' + domain_name + '.tar.gz')
display_sobol_analysis_results_a_avg(sobol_results)

```

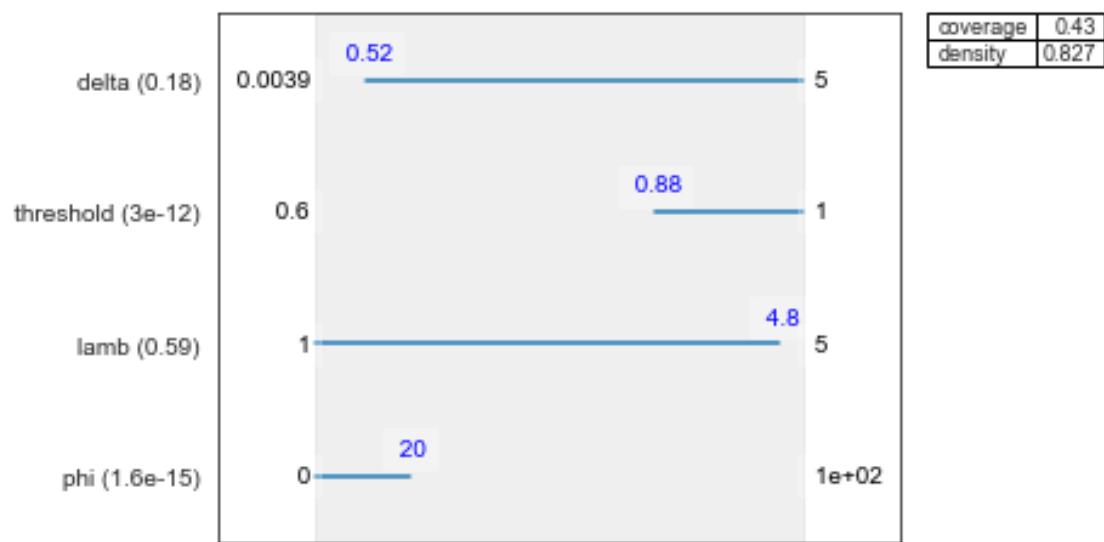
blocks-world

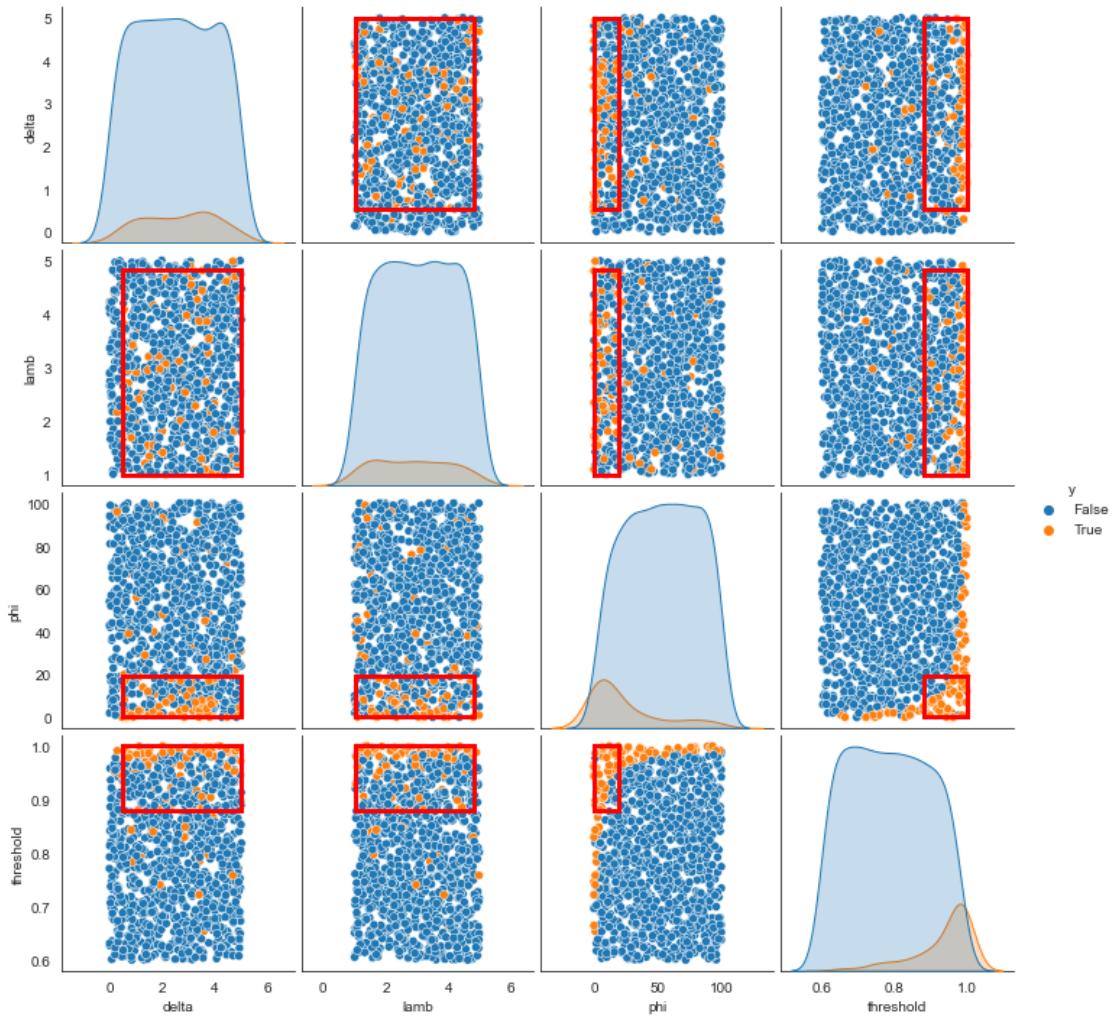


coverage	0.43
density	0.826923
id	50
mass	0.052
mean	0.826923
res_dim	4
Name:	50, dtype: object

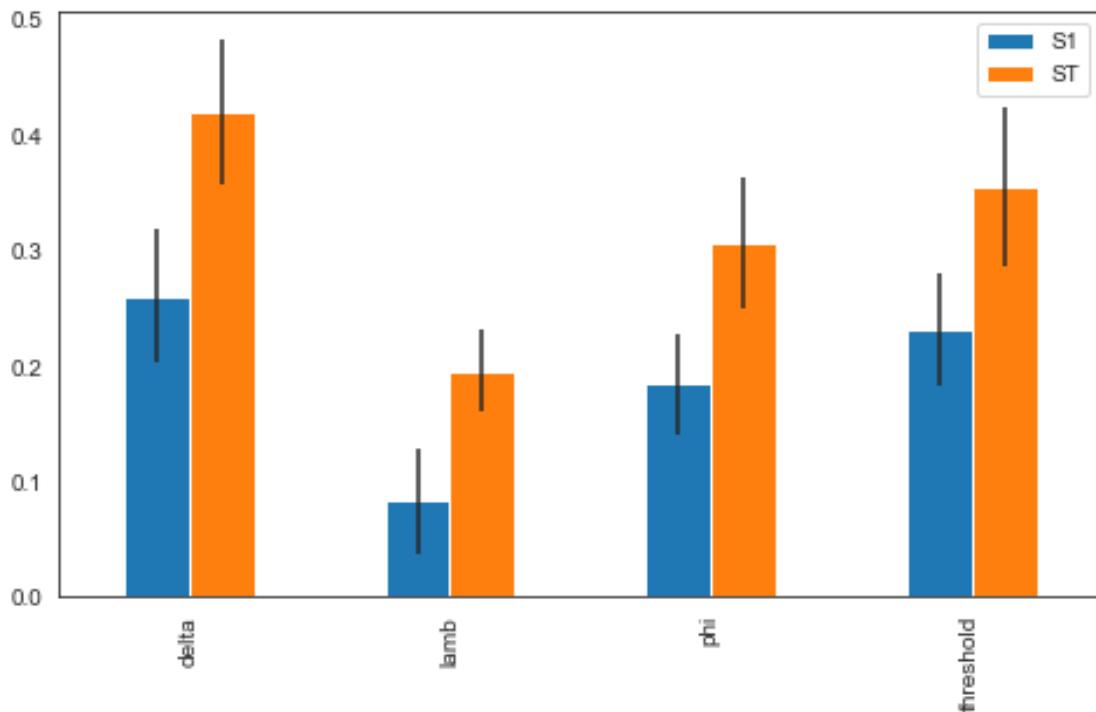
box 50

	min	max	qp values
phi	0.000000	19.500000	[-1.0, 1.6188507007121986e-15]
lamb	1.003900	4.810672	[-1.0, 0.5878050850484972]
threshold	0.879567	0.999859	[3.0375970058123697e-12, -1.0]
delta	0.517886	4.997435	[0.17834844930969904, -1.0]

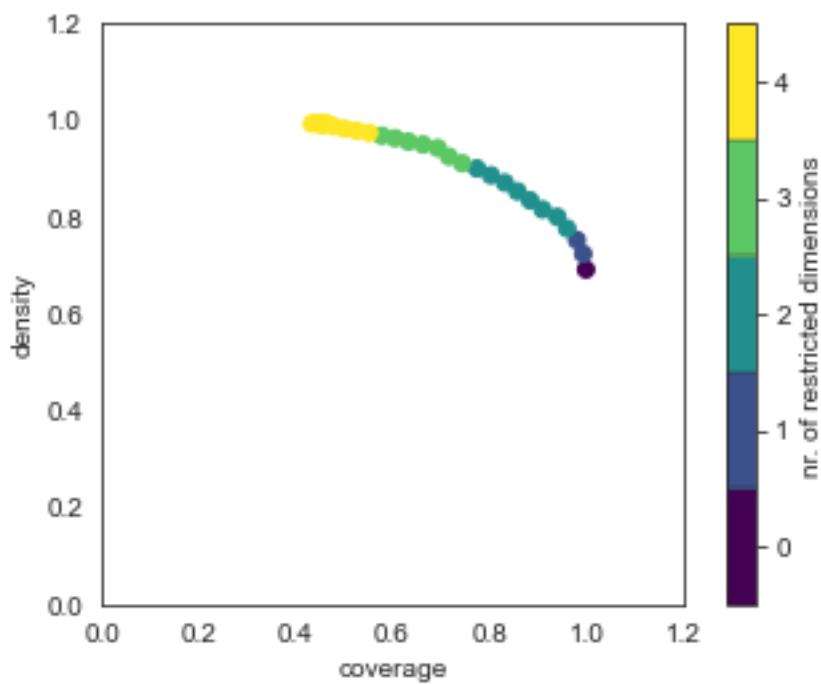




avg: accuracy



campus

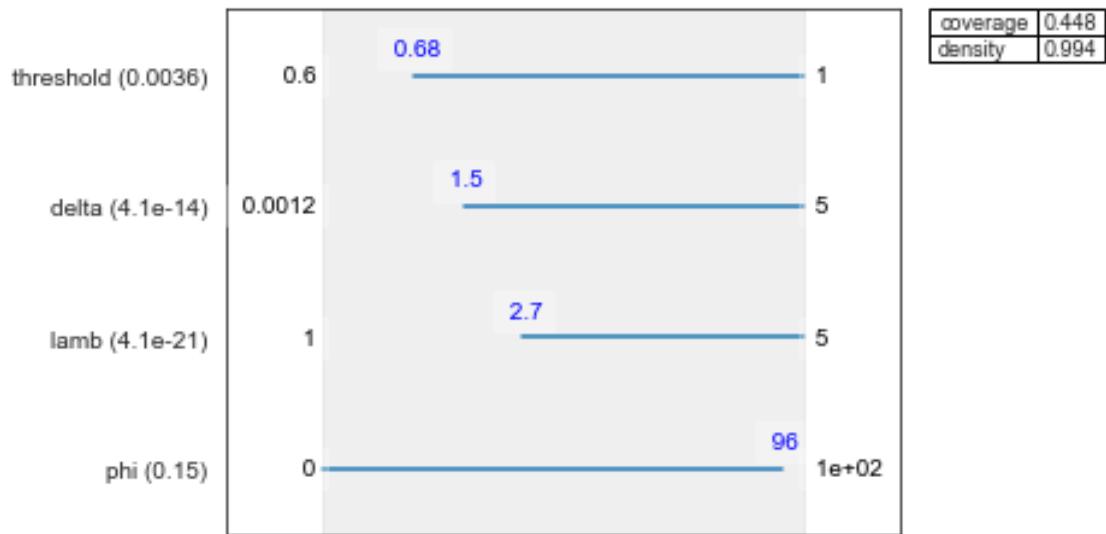


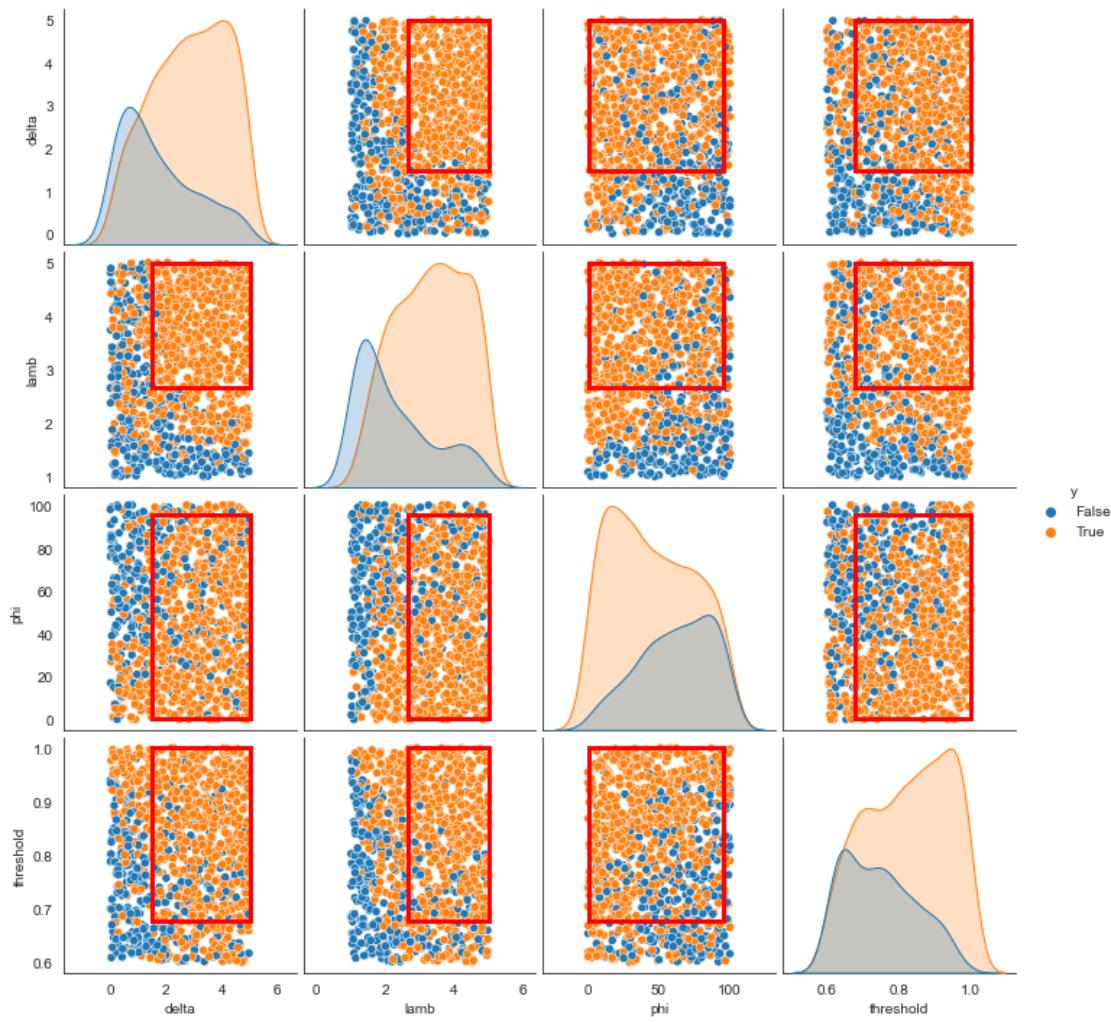
```

coverage      0.447977
density       0.99359
id            25
mass          0.312
mean          0.99359
res_dim       4
Name: 25, dtype: object

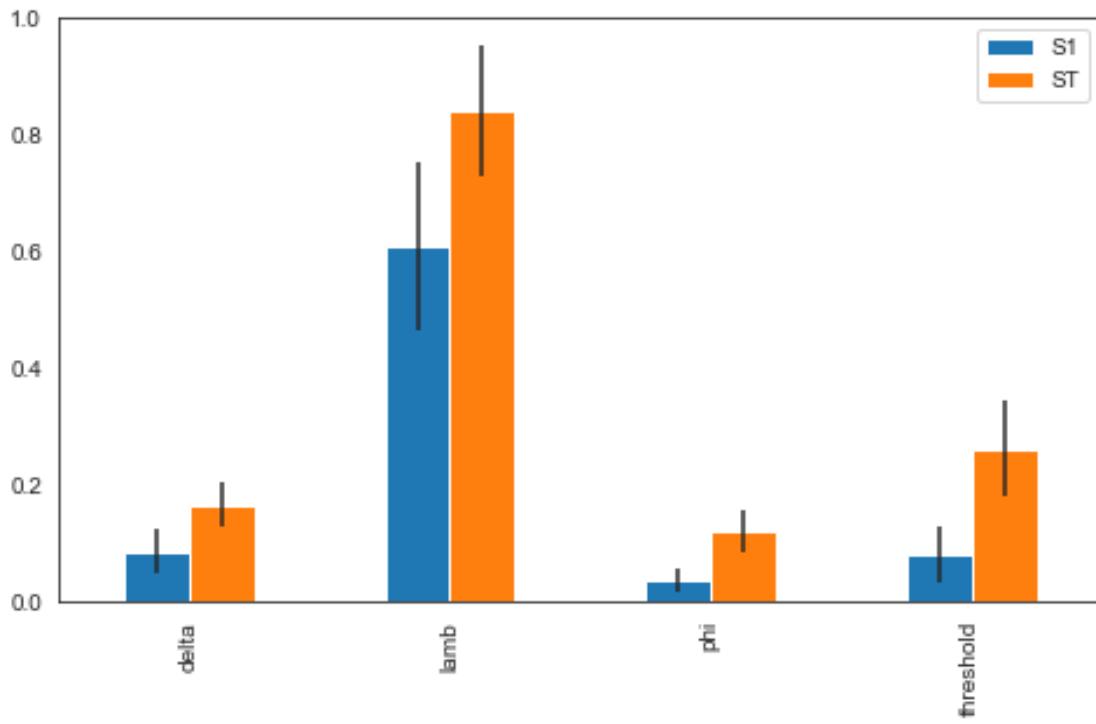
```

	box 25		qp values
	min	max	
phi	0.000000	95.500000	[-1.0, 0.15036965222897253]
lamb	2.667136	4.998111	[4.095205492809191e-21, -1.0]
delta	1.472077	4.999669	[4.126765009434943e-14, -1.0]
threshold	0.677180	0.999732	[0.003555642481970172, -1.0]

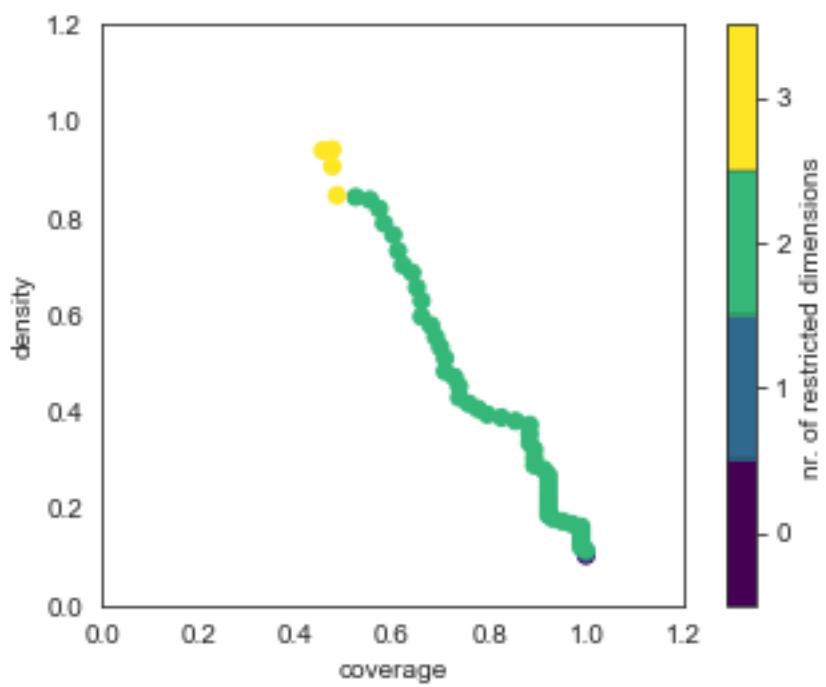




avg: accuracy

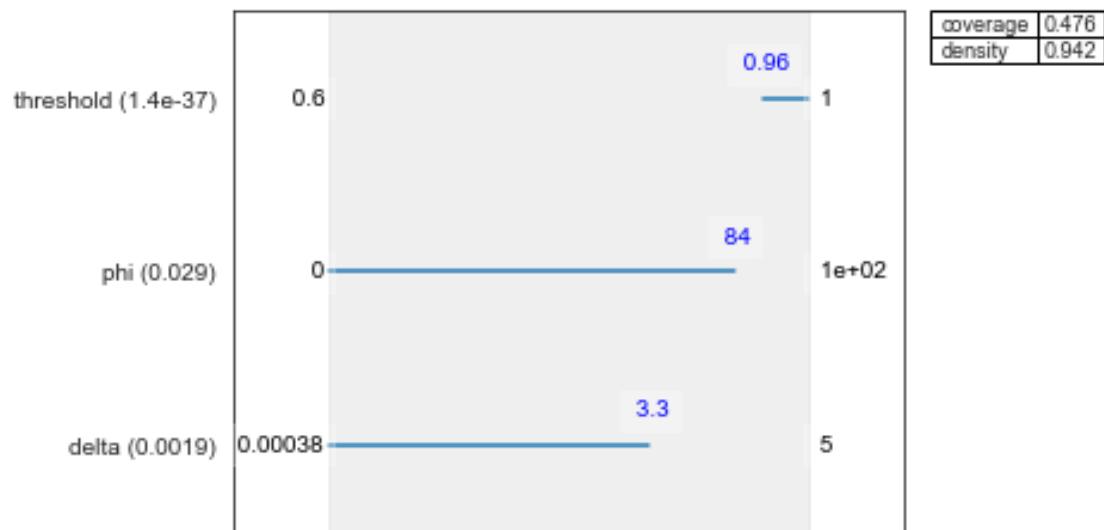


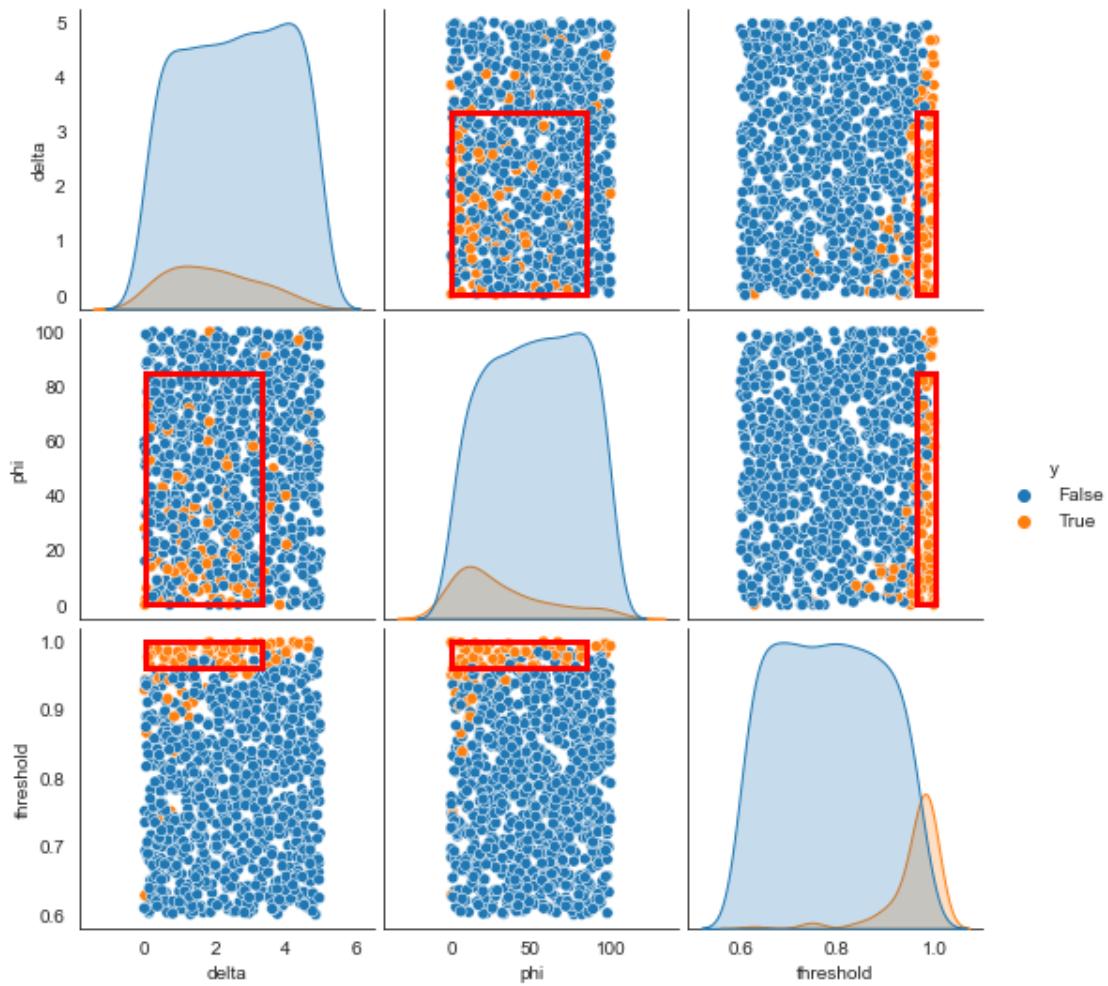
depots



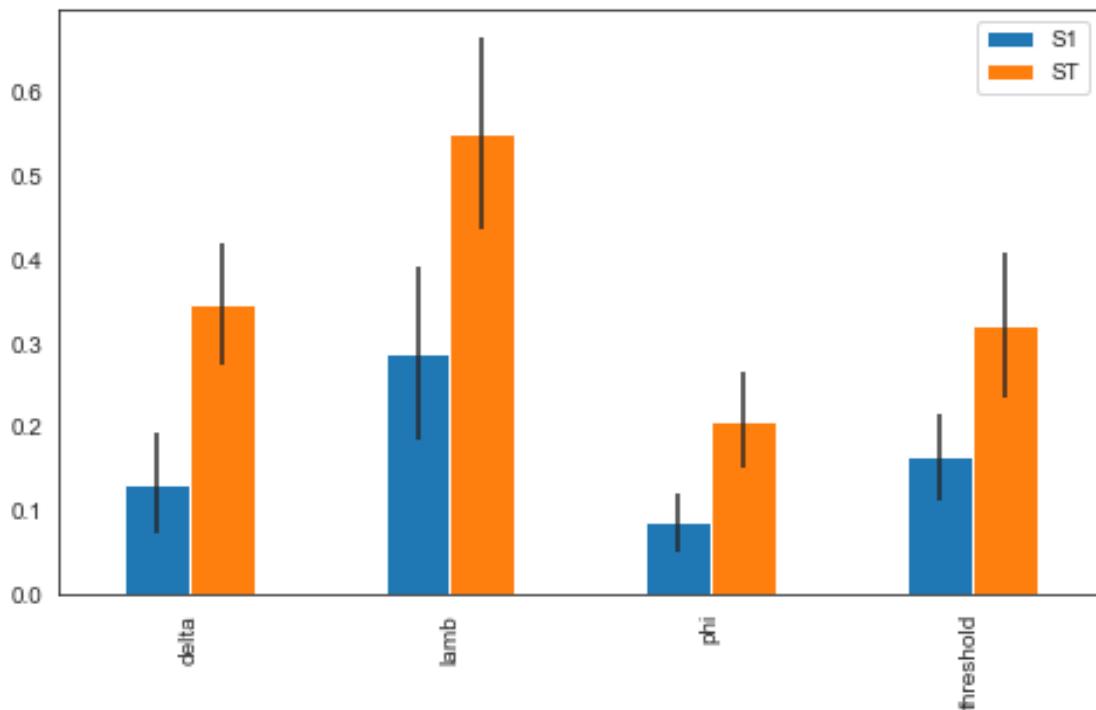
```
coverage      0.475728
density       0.942308
id            55
mass          0.052
mean          0.942308
res_dim       3
Name: 55, dtype: object
```

```
      box 55
      min      max      qp values
delta    0.000384  3.345904 [-1.0, 0.0019232542124863446]
phi      0.000000 84.500000 [-1.0, 0.028600541025970174]
threshold 0.962366 0.999900 [1.398681815586161e-37, -1.0]
```

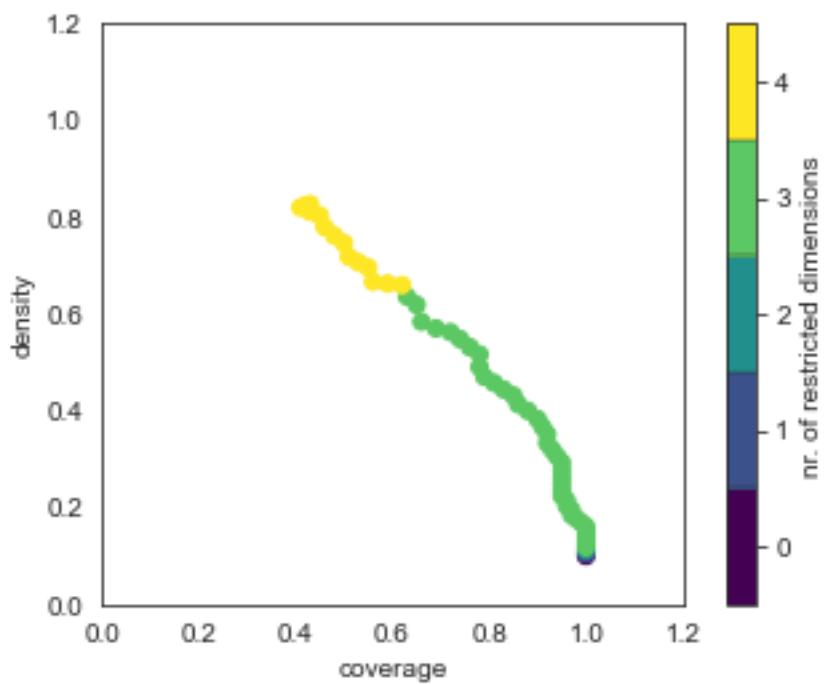




avg: accuracy



driverlog

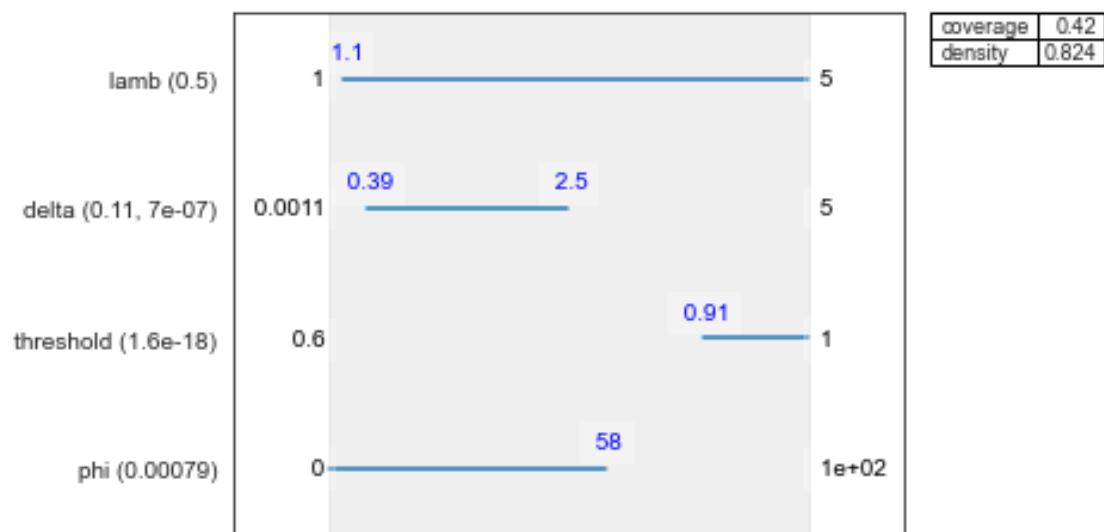


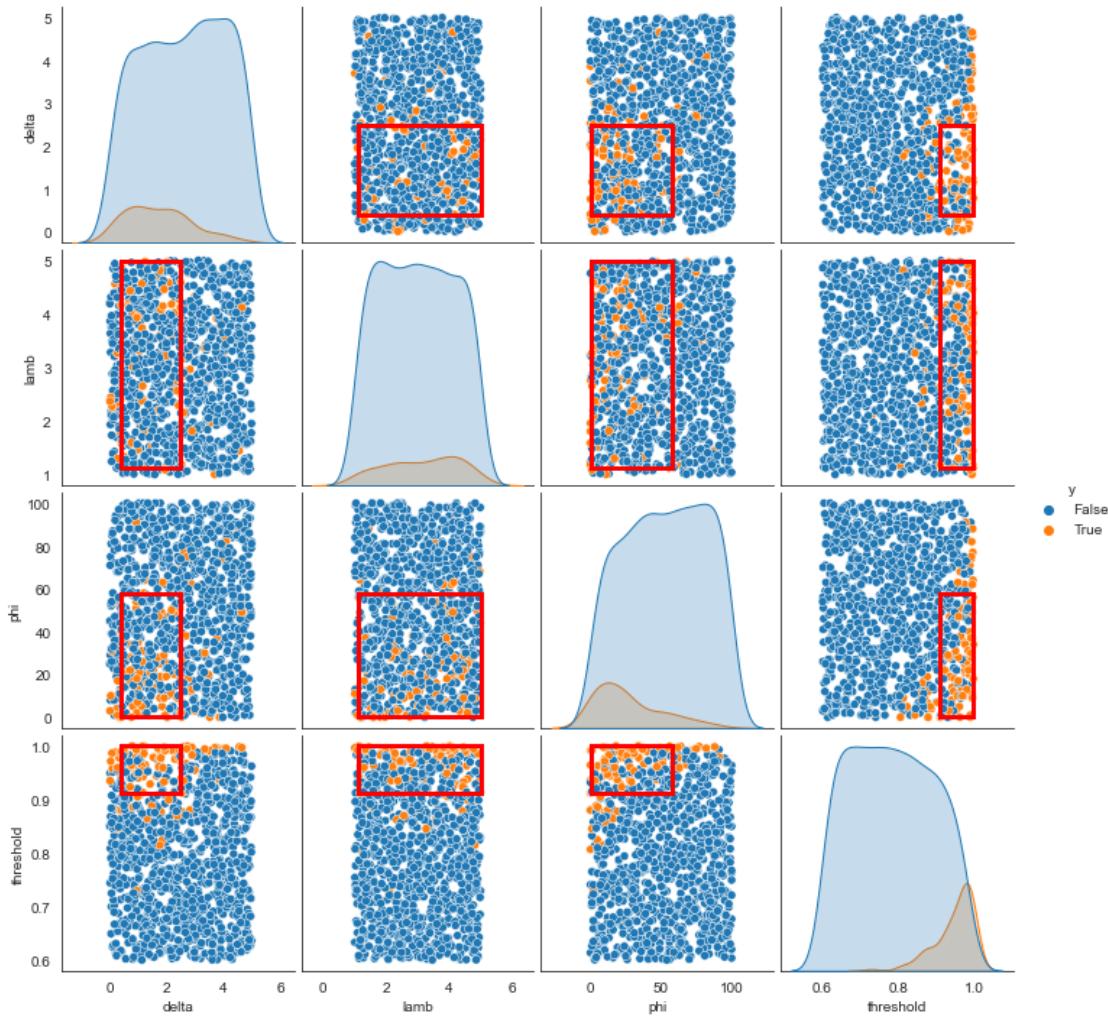
```

coverage          0.42
density          0.823529
id               55
mass             0.051
mean             0.823529
res_dim          4
Name: 55, dtype: object

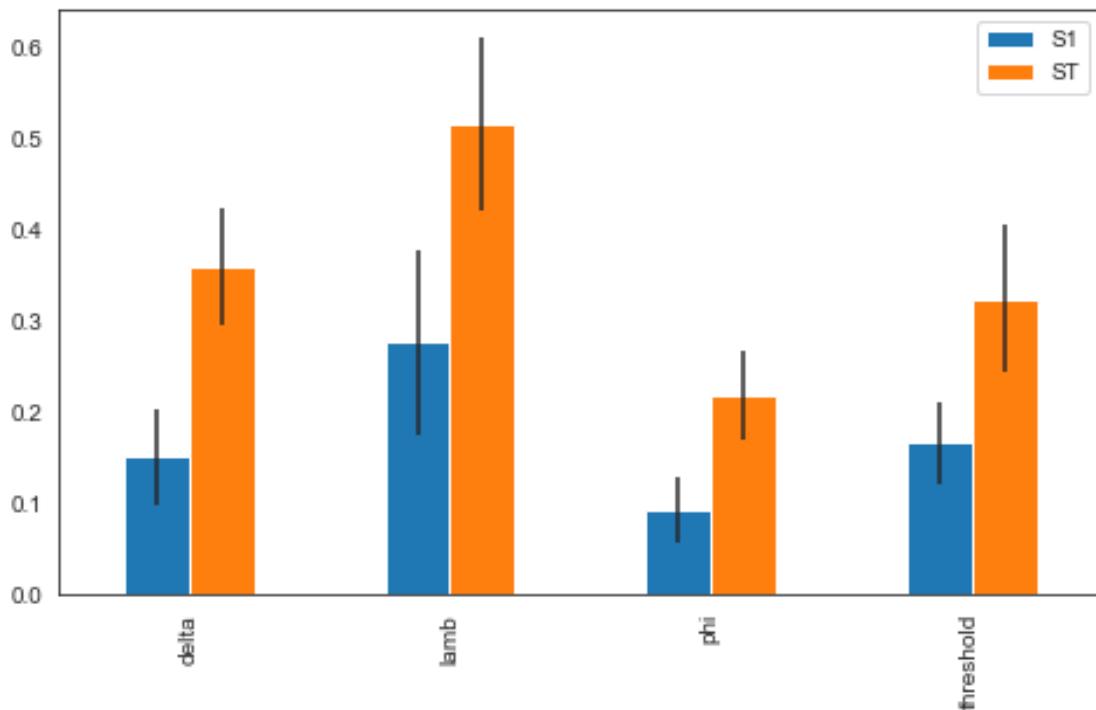
```

	box 55		qp values
	min	max	
phi	0.000000	57.500000	[-1.0, 0.0007902148082662998]
threshold	0.912177	0.999646	[1.6406392086458046e-18, -1.0]
delta	0.393675	2.479597	[0.10963883066482047, 6.952570541033969e-07]
lamb	1.118845	4.998966	[0.49754775586406597, -1.0]

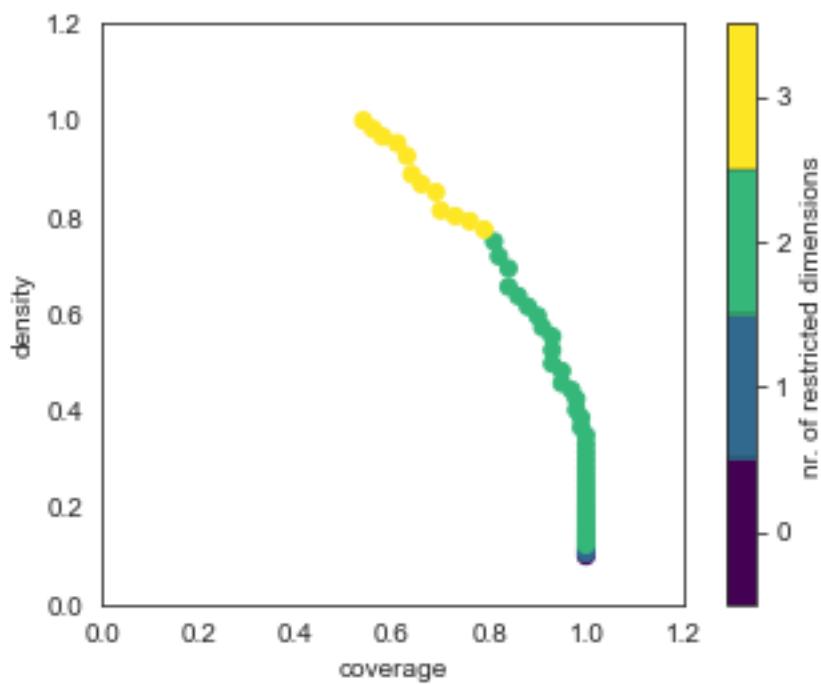




avg: accuracy

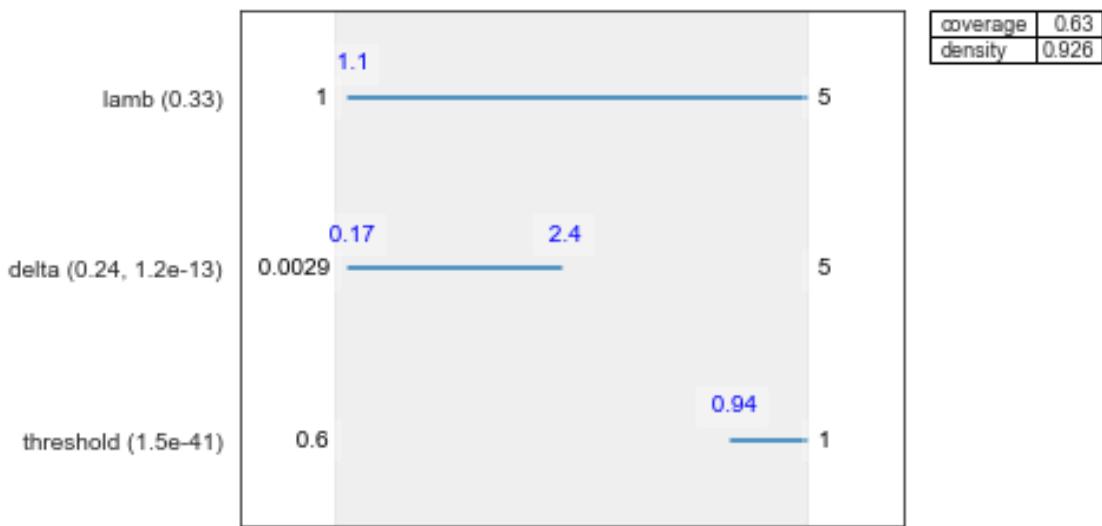


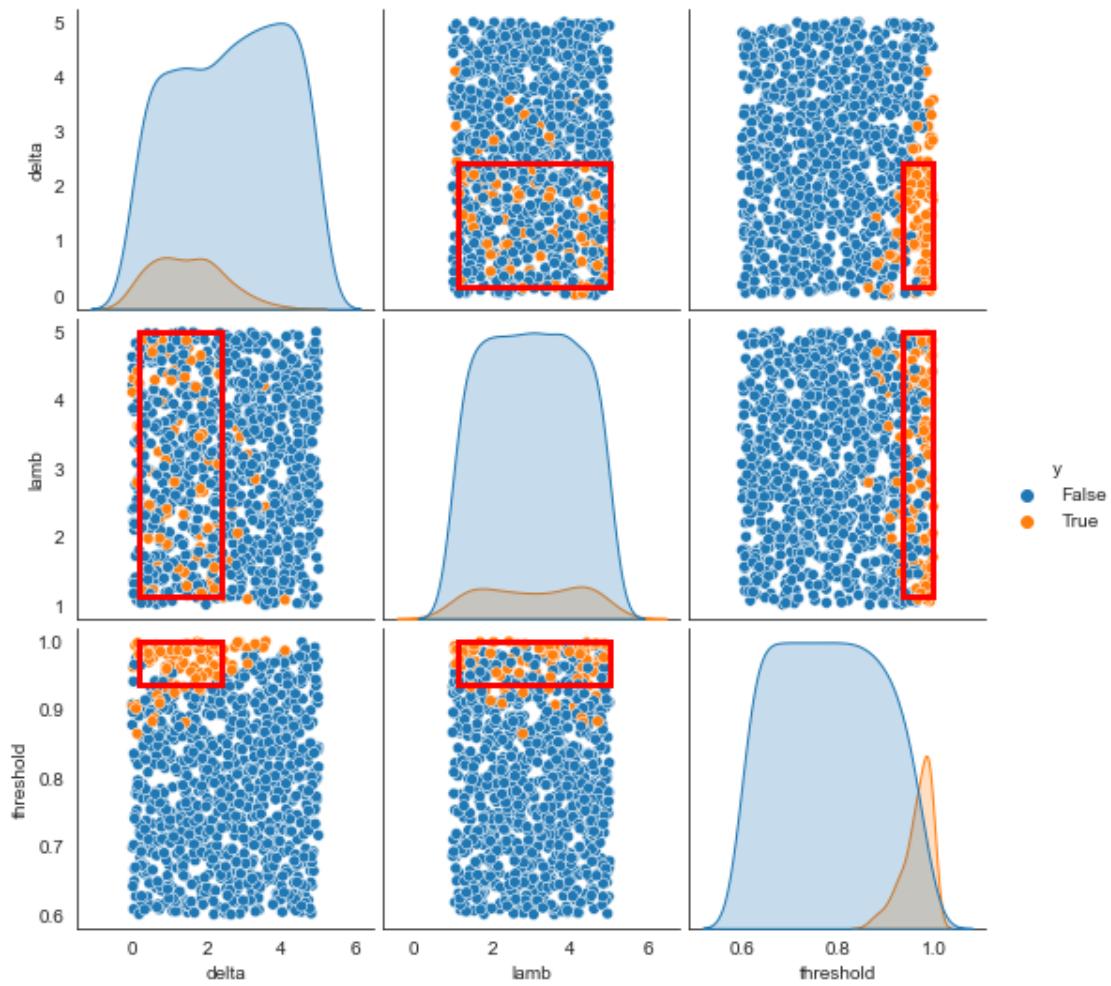
dwr



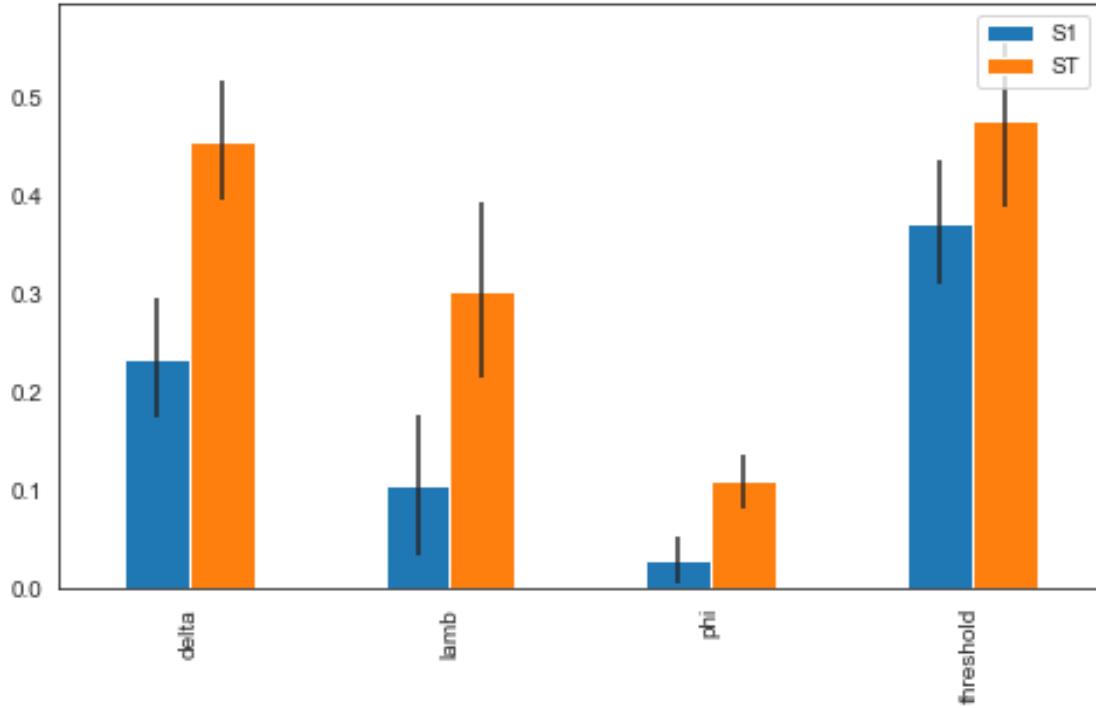
```
coverage          0.63
density          0.926471
id               50
mass             0.068
mean             0.926471
res_dim          3
Name: 50, dtype: object
```

	box 50		qp values
	min	max	
threshold	0.935421	0.999857	[1.4610288370512375e-41, -1.0]
delta	0.165411	2.406049	[0.24268535678601247, 1.2363838764110285e-13]
lamb	1.124228	4.996235	[0.32776936949069213, -1.0]

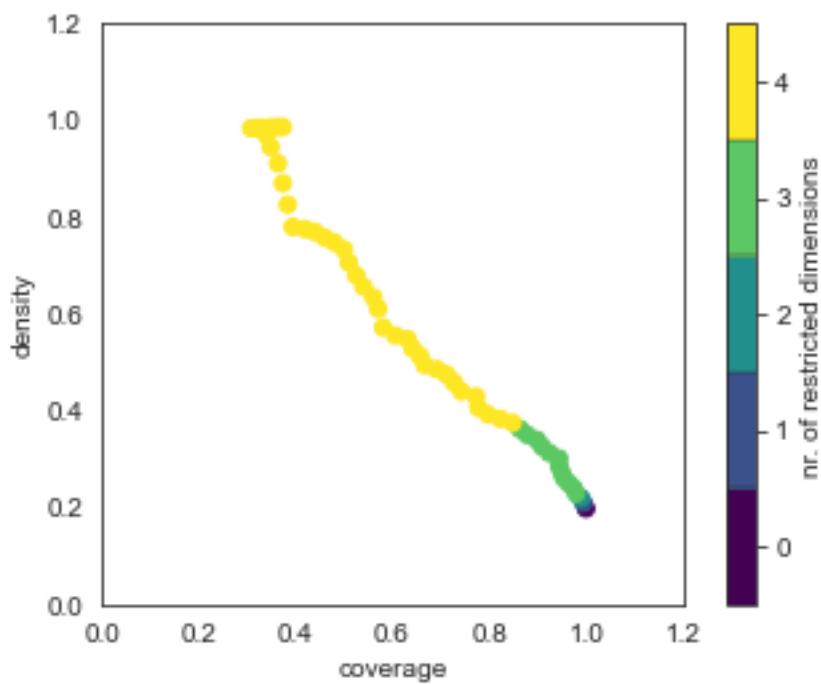




avg: accuracy

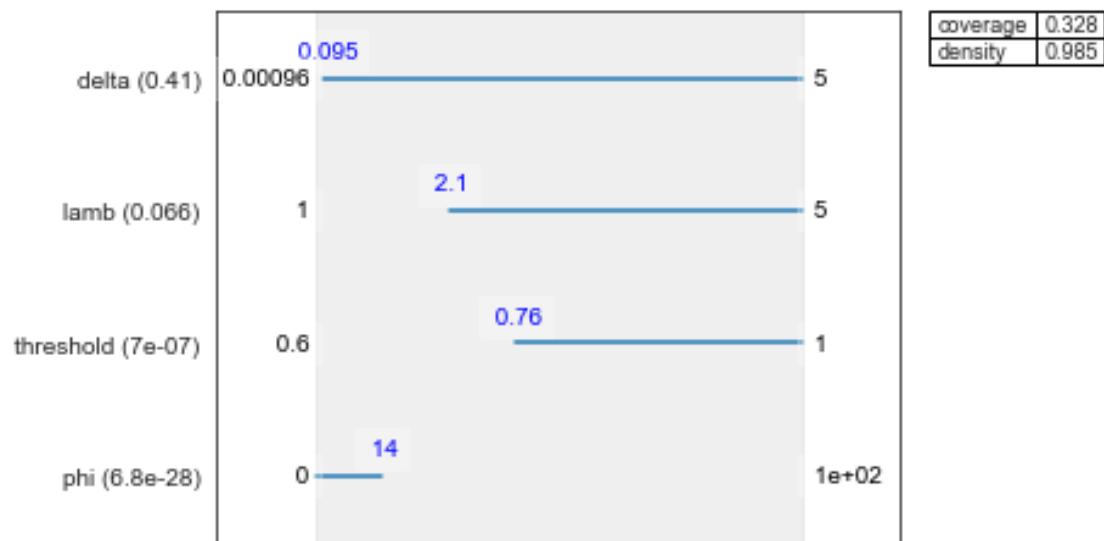


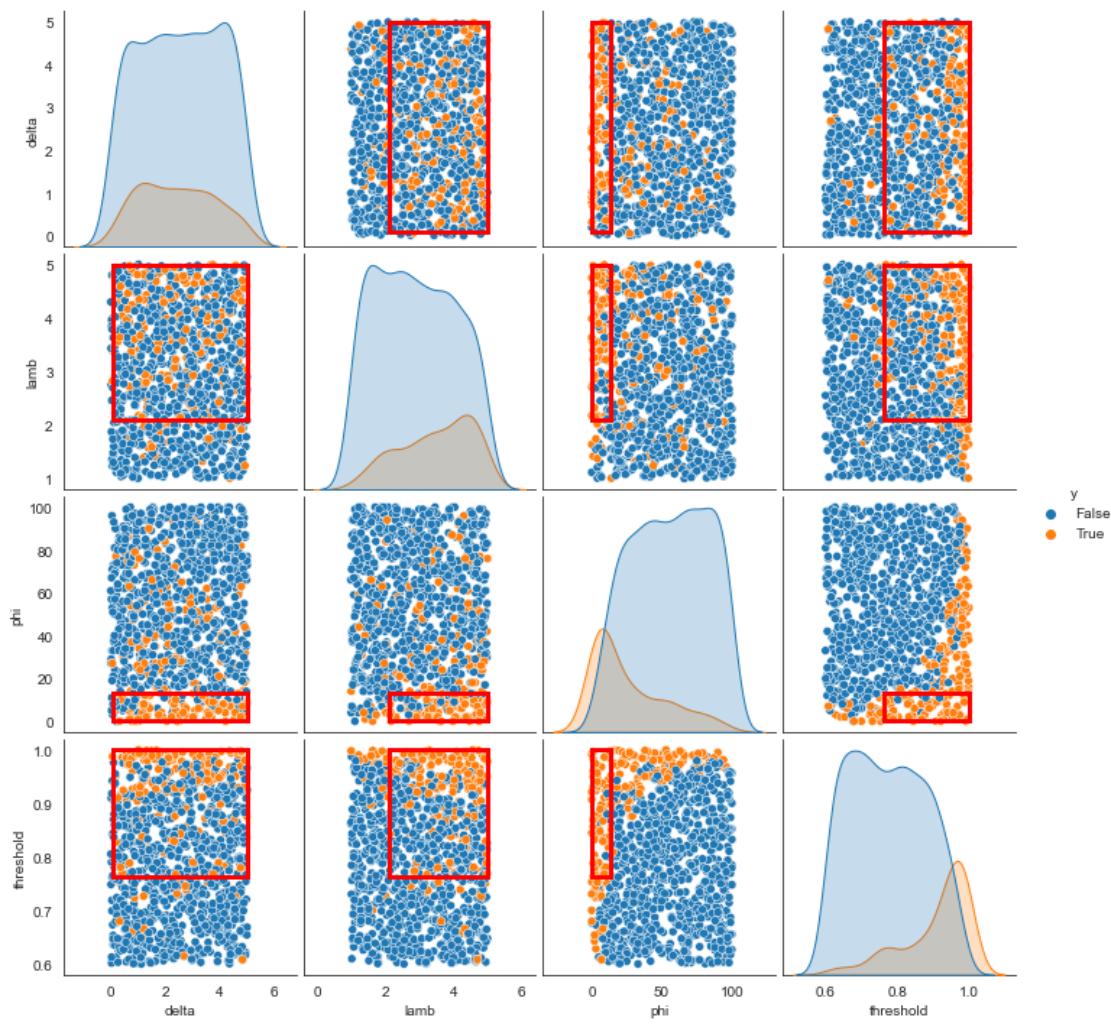
easy-ipc-grid



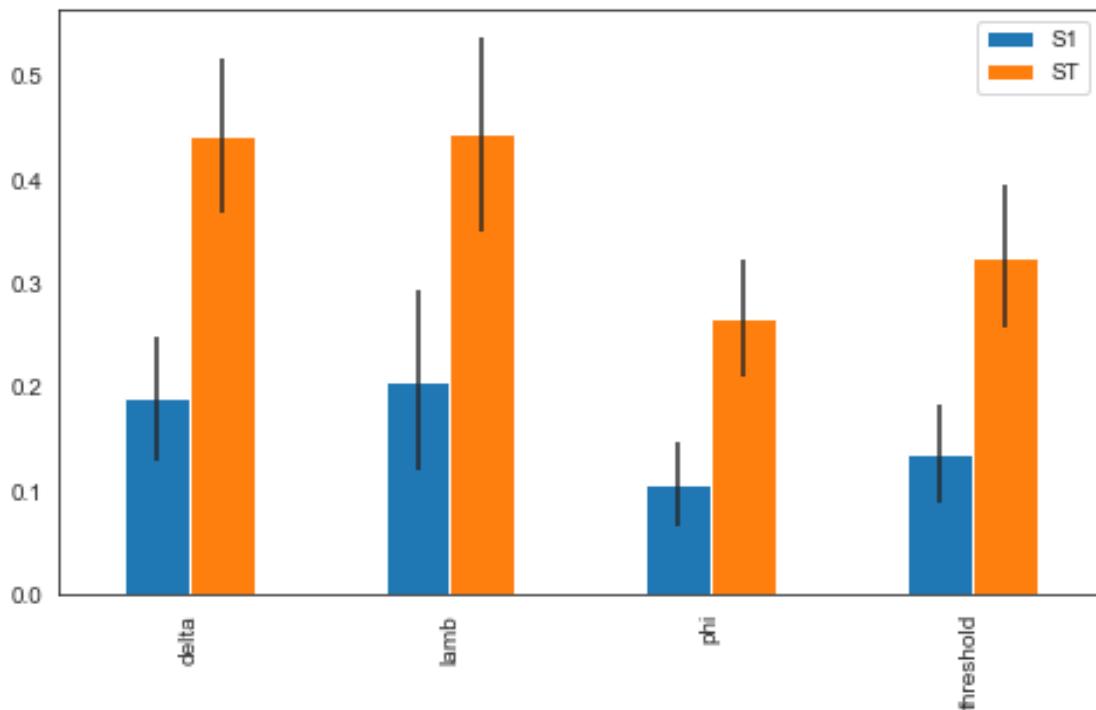
```
coverage      0.328283
density       0.984848
id            50
mass          0.066
mean          0.984848
res_dim       4
Name: 50, dtype: object
```

	box	50		
		min	max	qp values
phi	0.000000	13.500000	[-1.0, 6.821697812702756e-28]	
threshold	0.763970	0.999991	[7.031594586001354e-07, -1.0]	
lamb	2.100676	4.997264	[0.0664431876388809, -1.0]	
delta	0.094708	4.996166	[0.4101072337089218, -1.0]	

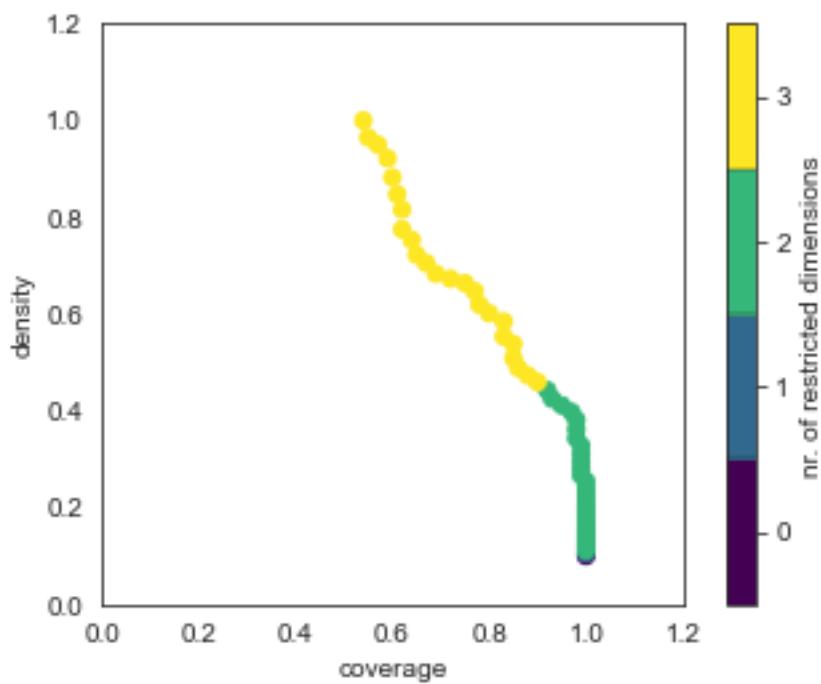




avg: accuracy



ferry

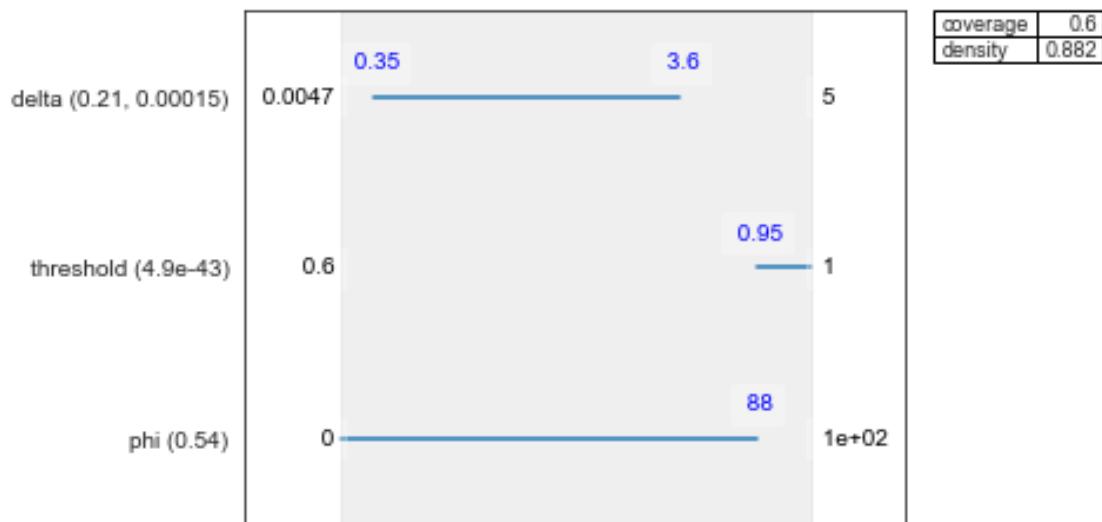


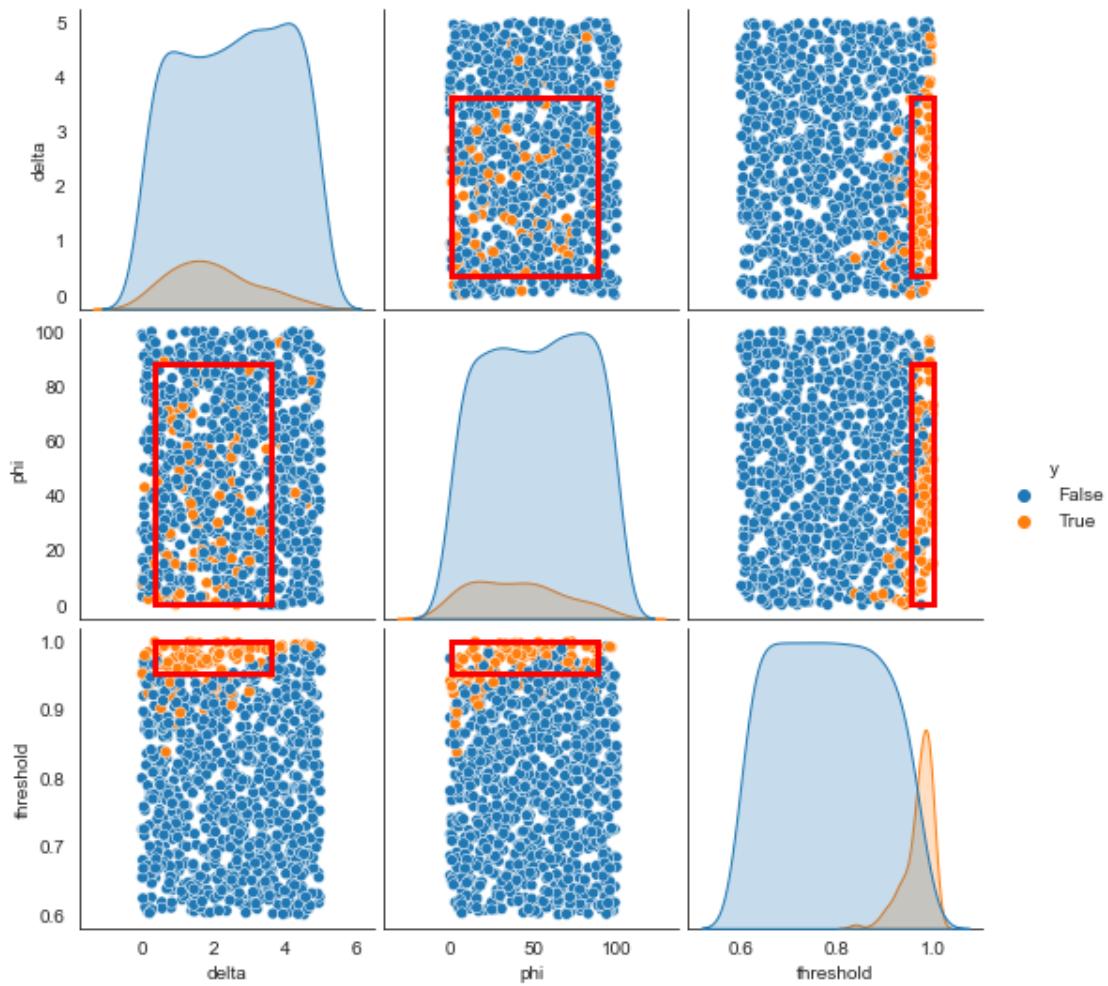
```

coverage      0.6
density      0.882353
id           50
mass         0.068
mean         0.882353
res_dim      3
Name: 50, dtype: object

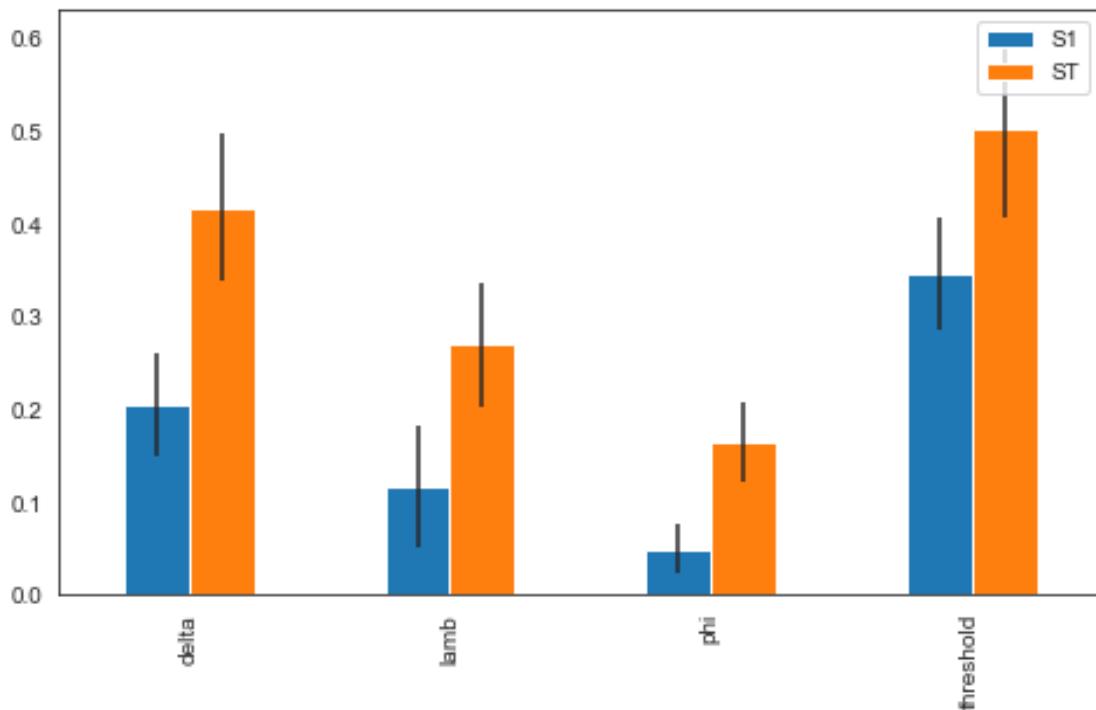
```

	box 50		qp values
	min	max	
phi	0.000000	88.500000	[-1.0, 0.535752582852719]
threshold	0.952656	0.999630	[4.857133270393899e-43, -1.0]
delta	0.353303	3.610603	[0.20611344542981067, 0.00014772758880682464]

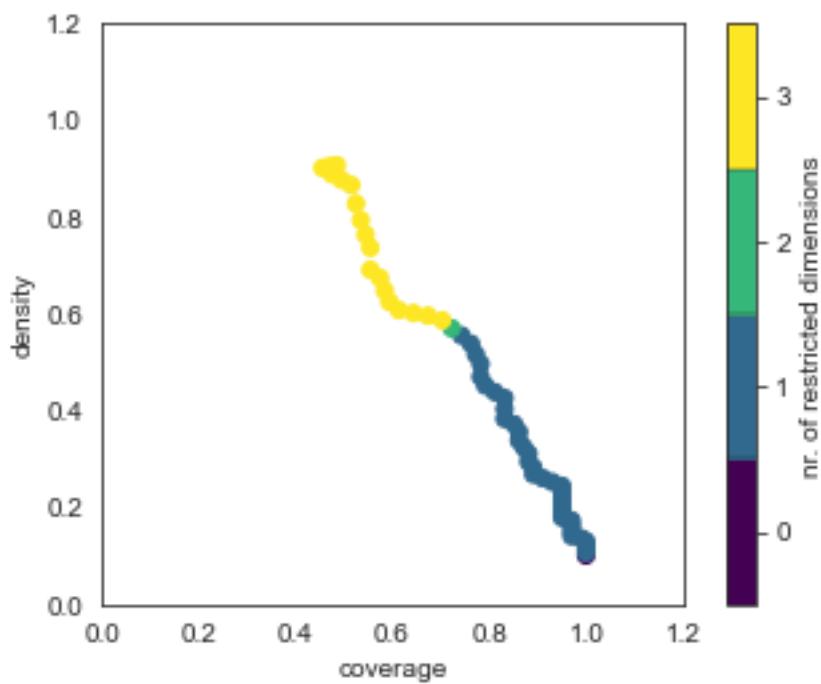




avg: accuracy

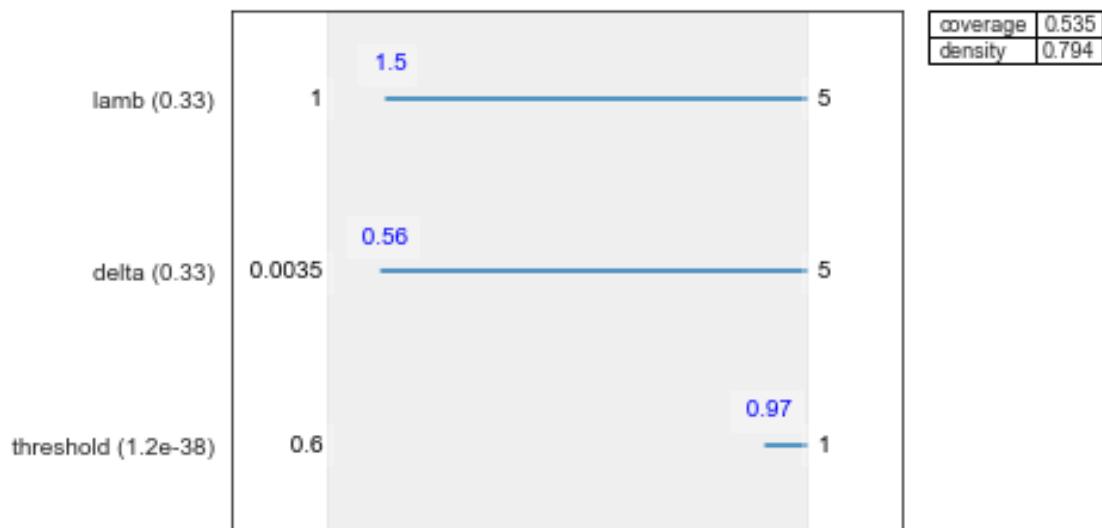


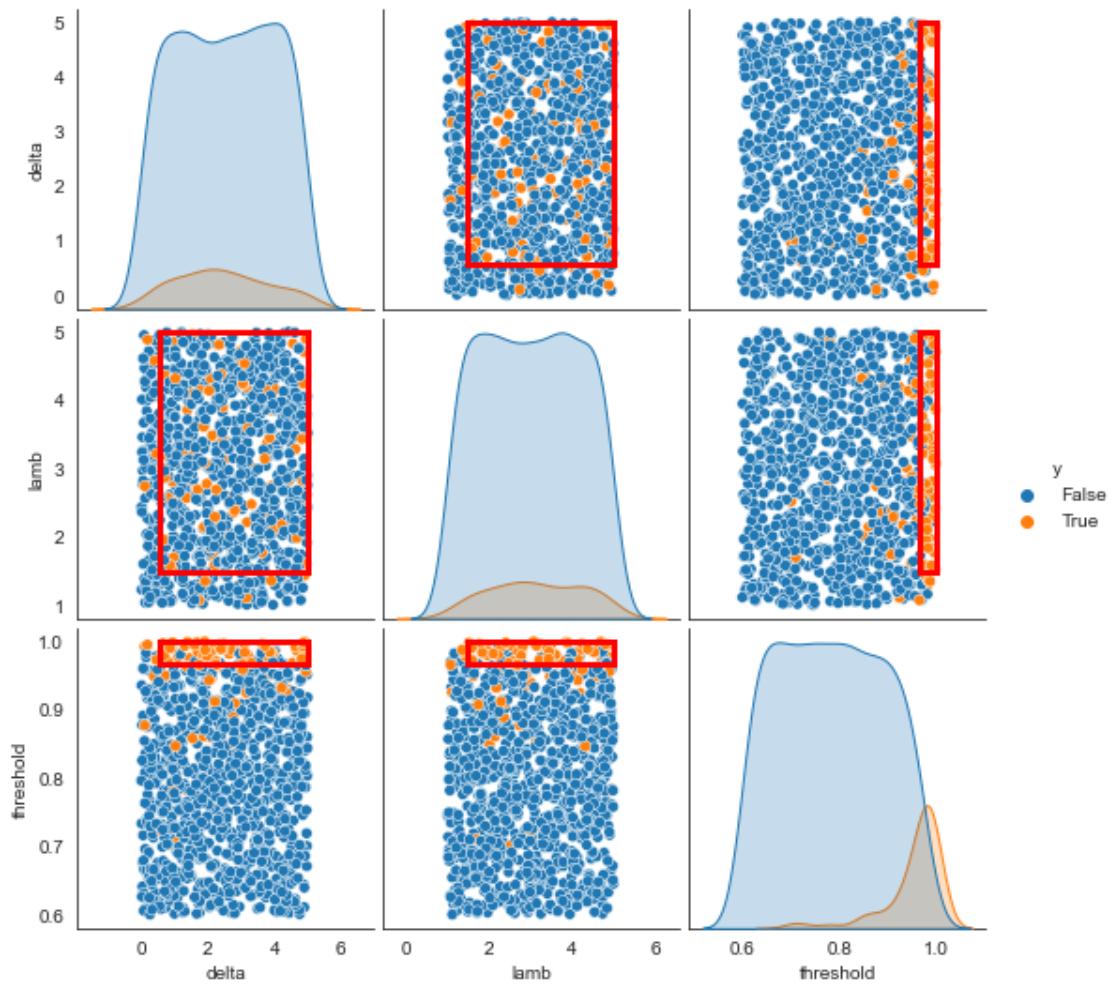
intrusion-detection



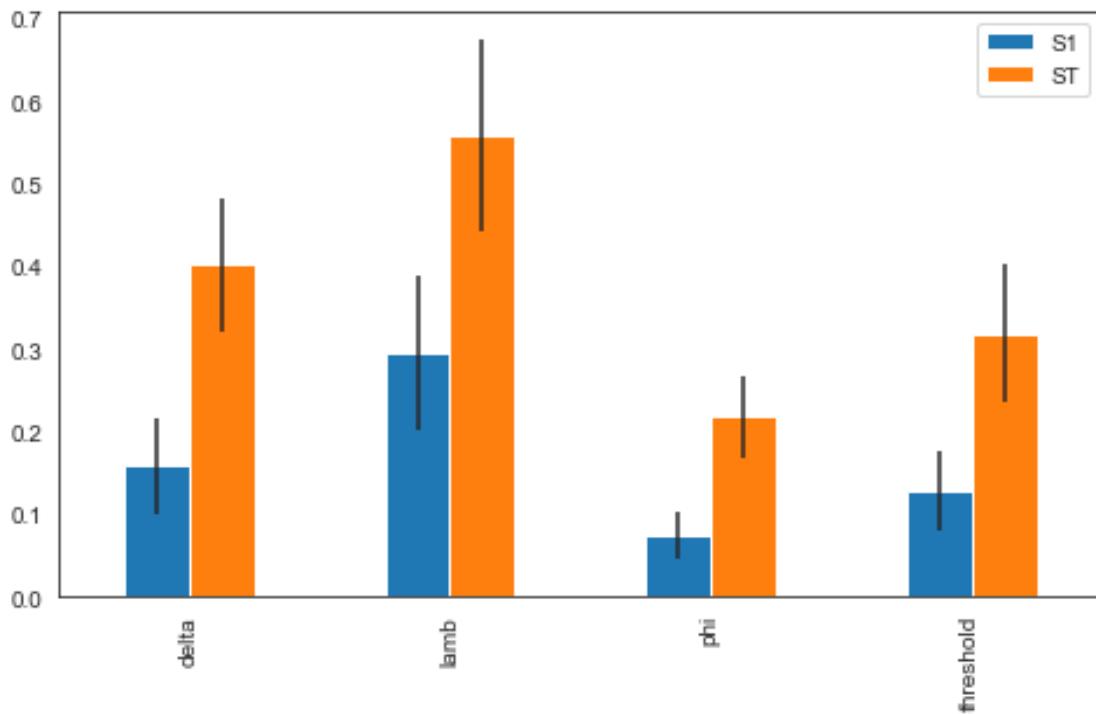
```
coverage      0.534653
density       0.794118
id            50
mass          0.068
mean          0.794118
res_dim       3
Name: 50, dtype: object
```

```
      box 50
           min      max      qp values
threshold 0.966153 0.999695 [1.23026342186239e-38, -1.0]
delta     0.558982 4.997110 [0.3309678068897105, -1.0]
lamb      1.490211 4.996453 [0.3309678068897105, -1.0]
```

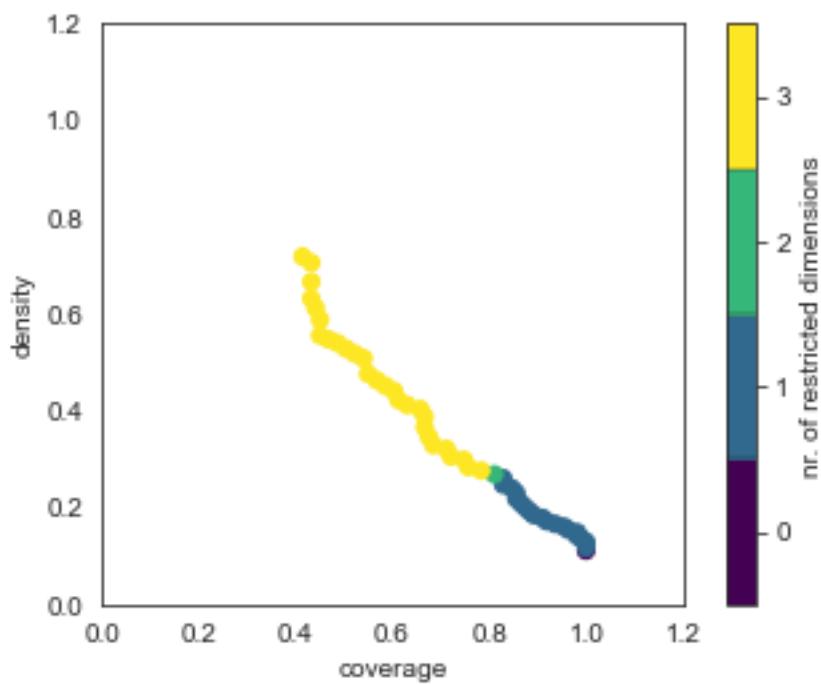




avg: accuracy

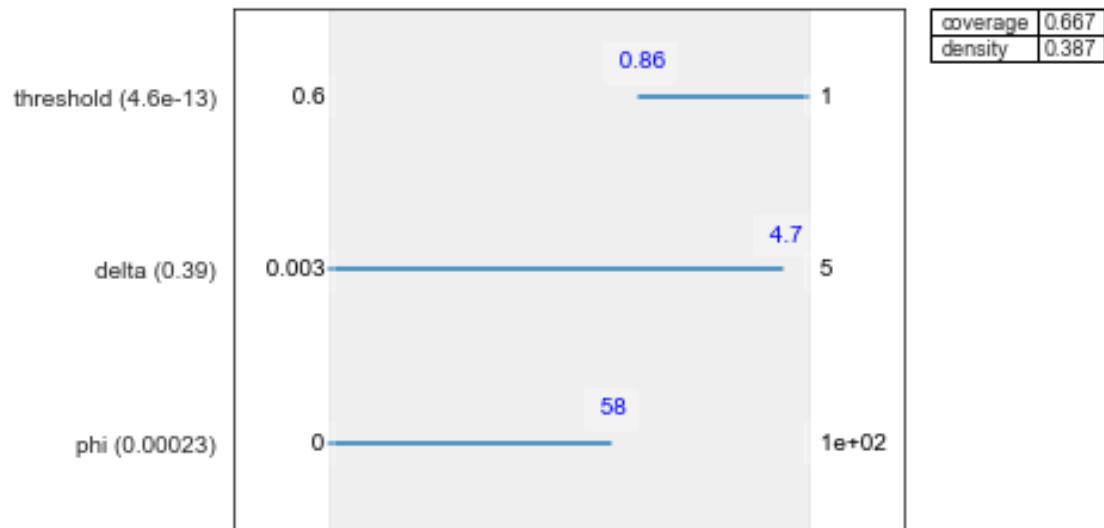


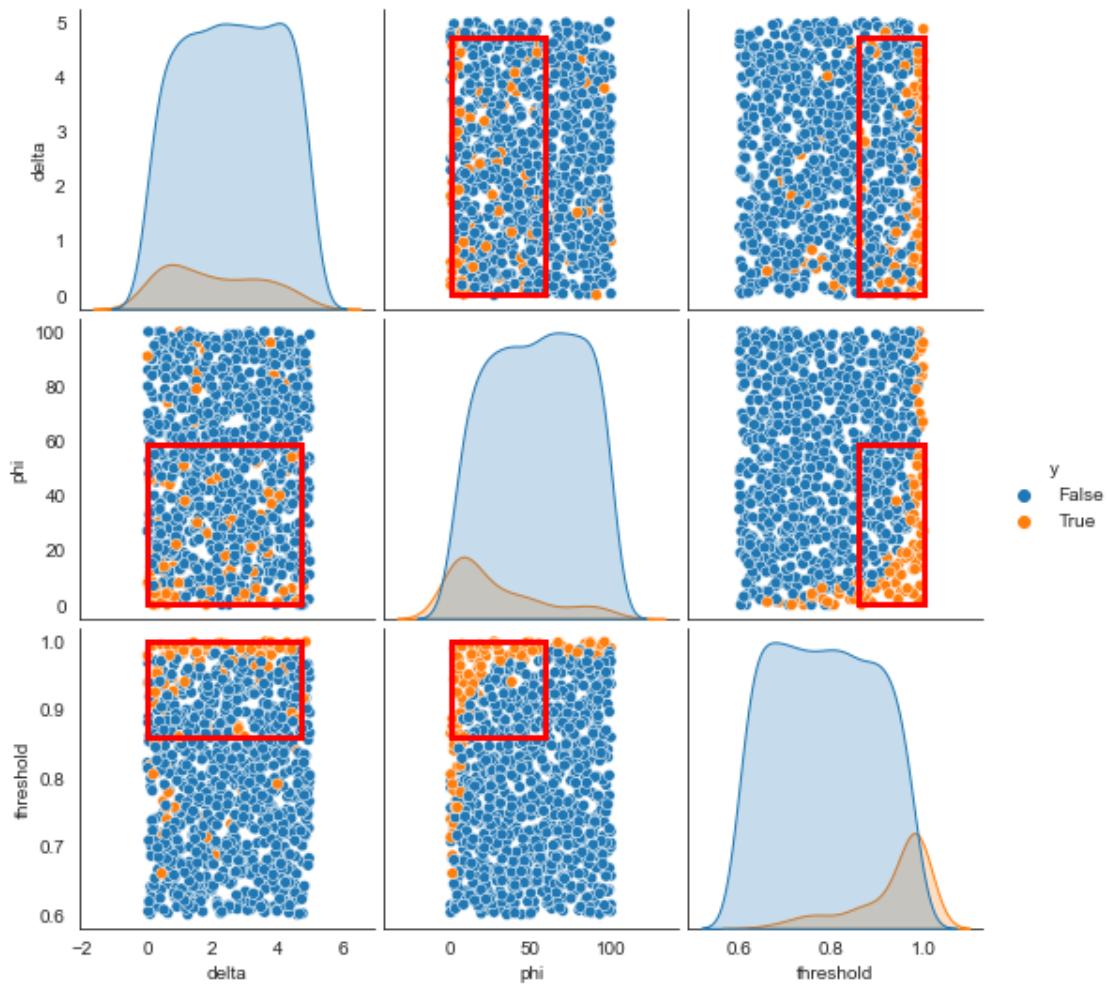
kitchen



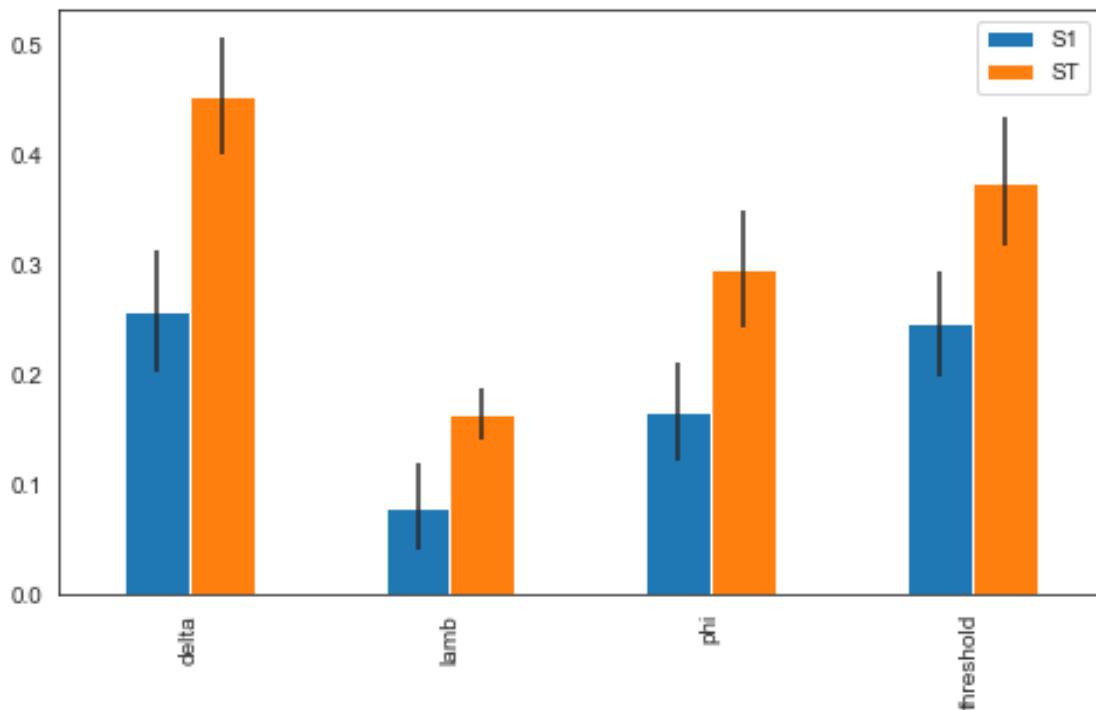
```
coverage      0.666667
density       0.387435
id            30
mass          0.191
mean          0.387435
res_dim       3
Name: 30, dtype: object
```

```
      box 30
           min      max      qp values
phi     0.000000  58.500000 [-1.0, 0.0002325832966247555]
delta   0.003013  4.732179  [-1.0, 0.3874883149043474]
threshold 0.858698 0.999771 [4.58290142601594e-13, -1.0]
```

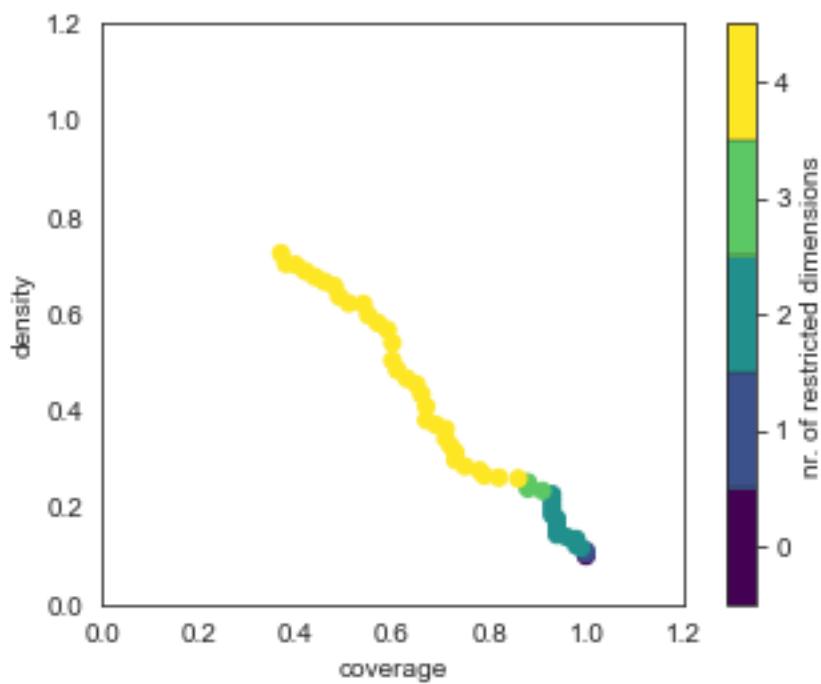




avg: accuracy



logistics

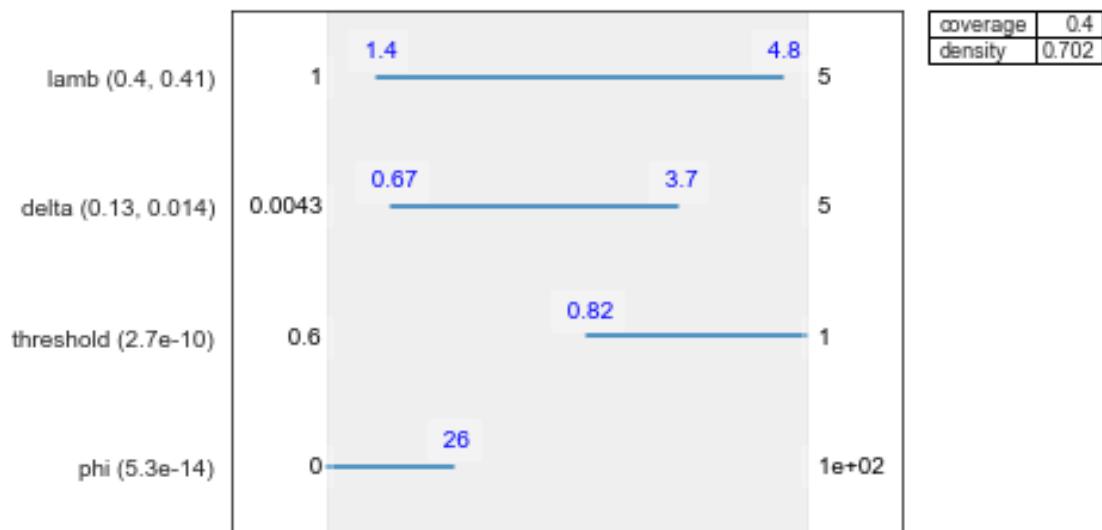


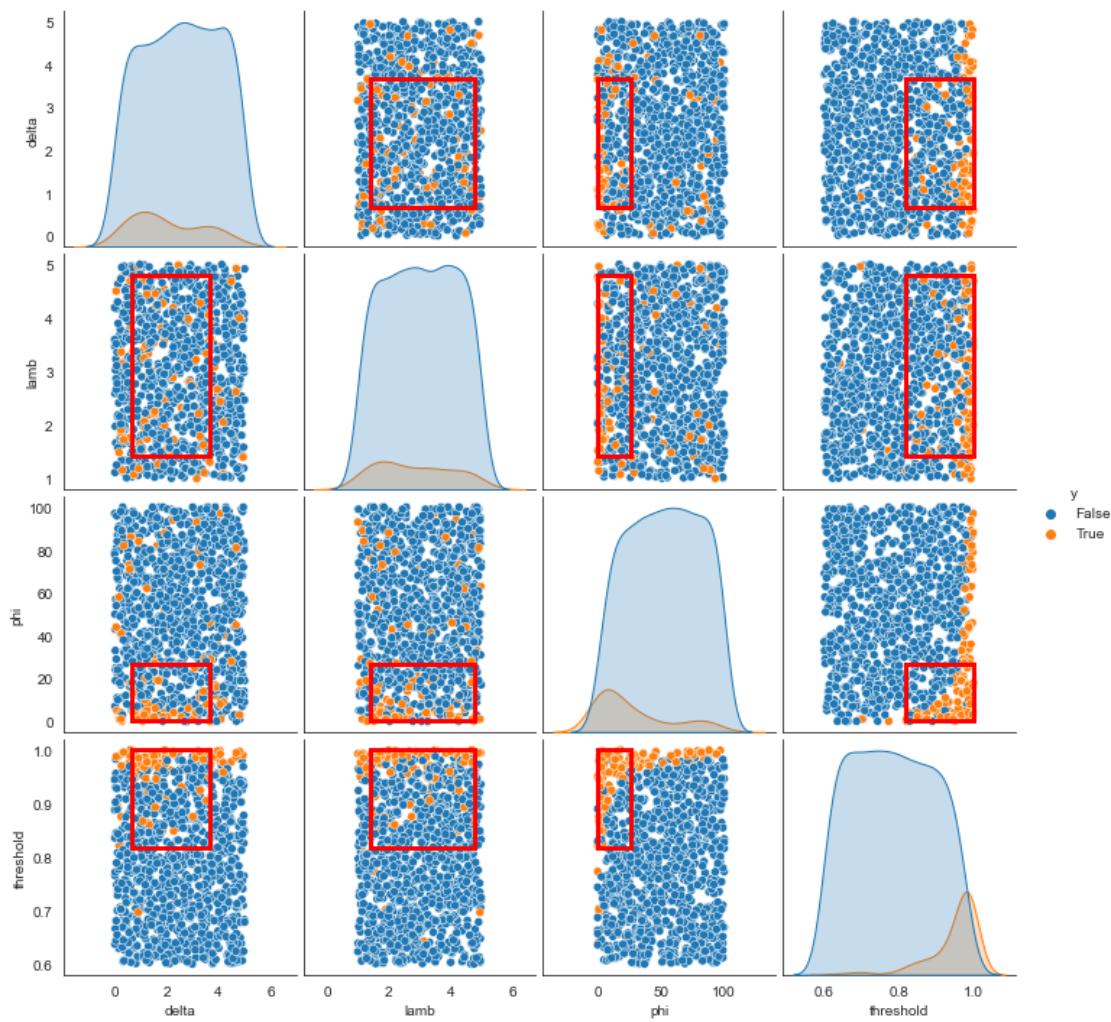
```

coverage      0.4
density      0.701754
id           50
mass         0.057
mean         0.701754
res_dim      4
Name: 50, dtype: object

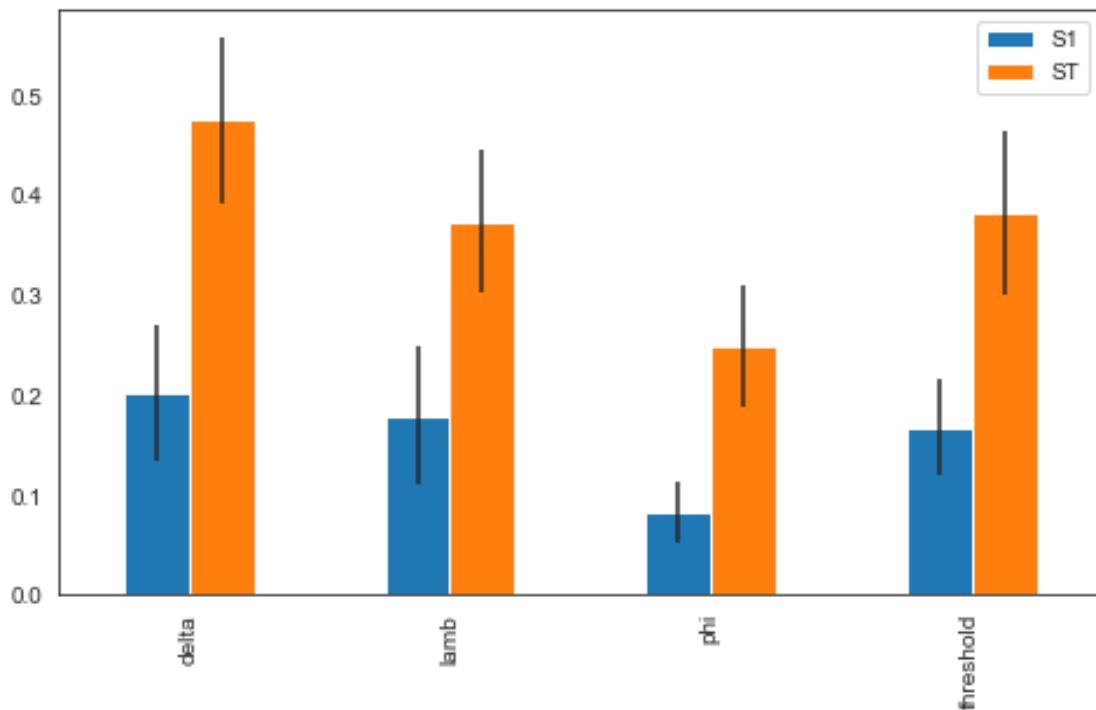
```

	box 50		qp values
	min	max	
phi	0.000000	26.500000	[-1.0, 5.3347693634223285e-14]
threshold	0.817235	0.999944	[2.7330357641051353e-10, -1.0]
delta	0.668168	3.660067	[0.12642876896295208, 0.014215248405283735]
lamb	1.416186	4.802064	[0.4039644610013883, 0.4105067721298188]

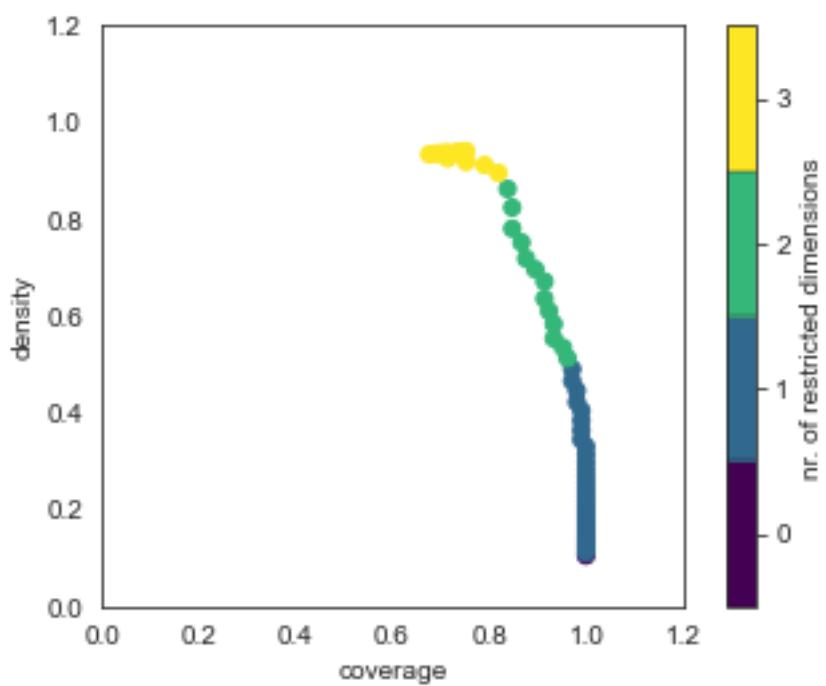




avg: accuracy

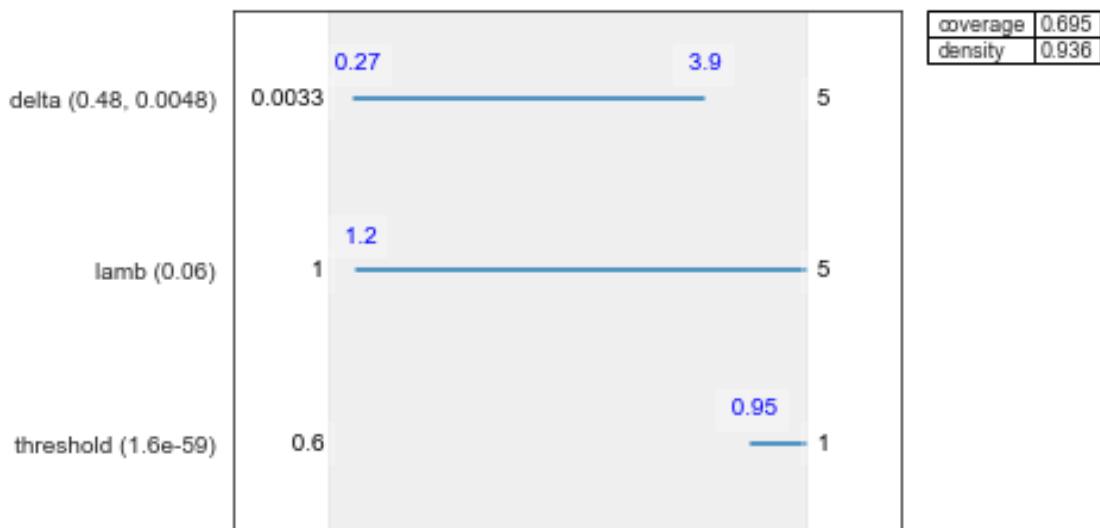


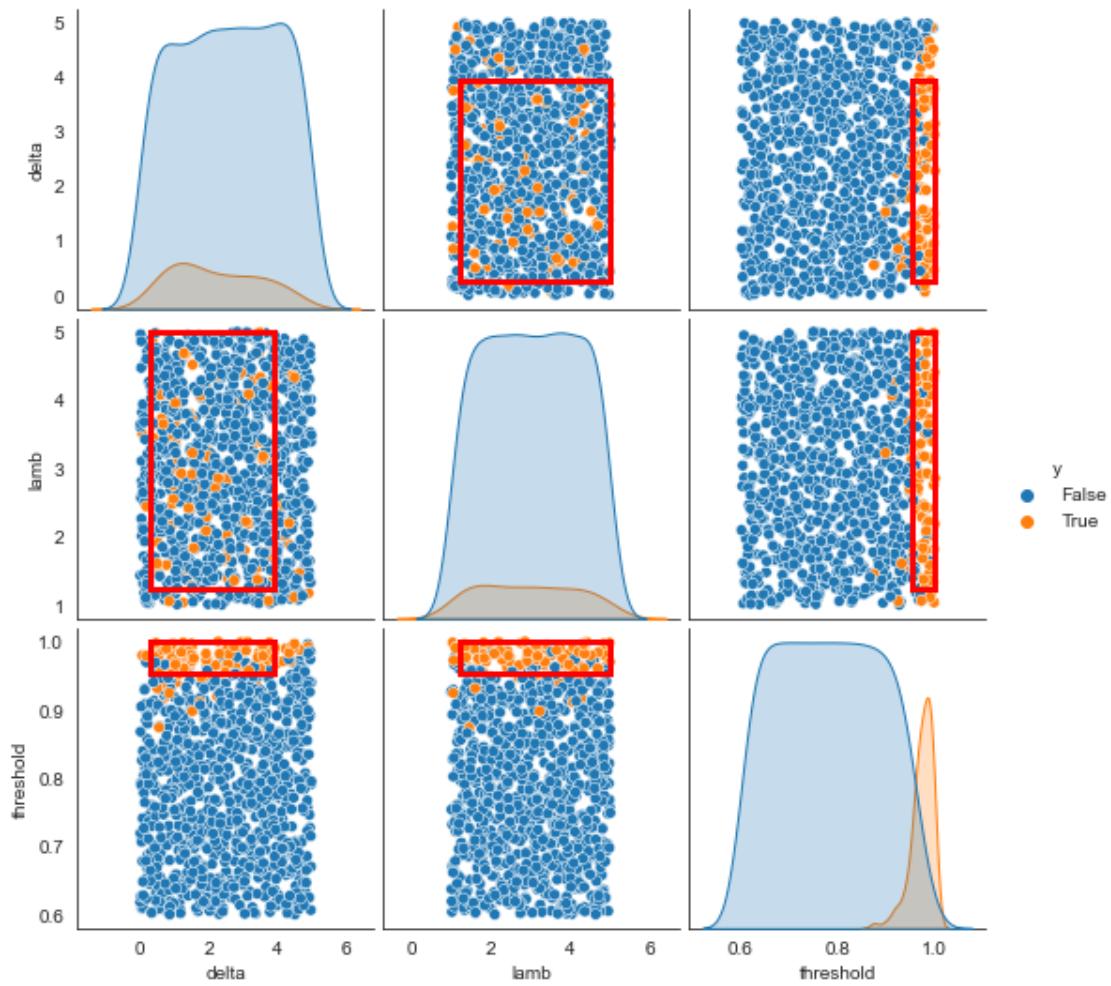
miconic



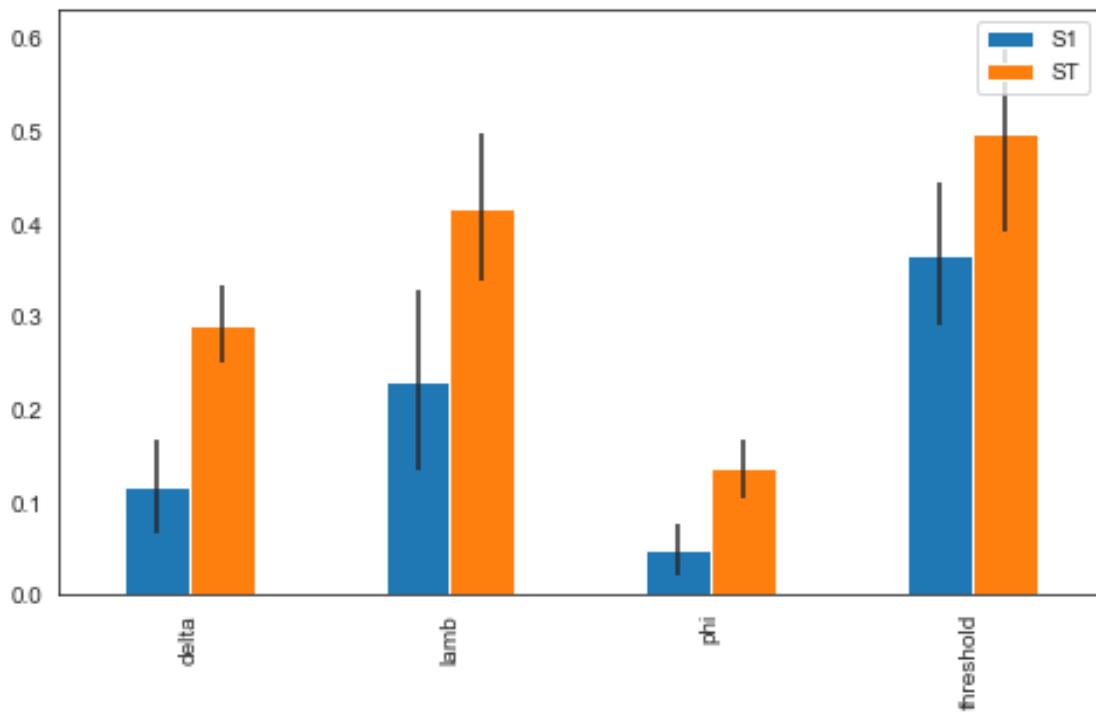
```
coverage      0.695238
density       0.935897
id            50
mass          0.078
mean          0.935897
res_dim       3
Name: 50, dtype: object
```

```
      box 50
      min      max           qp values
threshold 0.954132 0.999936 [1.5978591310829218e-59, -1.0]
lamb      1.233999 4.999281 [0.05991234816245654, -1.0]
delta     0.273098 3.922304 [0.4770174949785684, 0.004789633930689048]
```

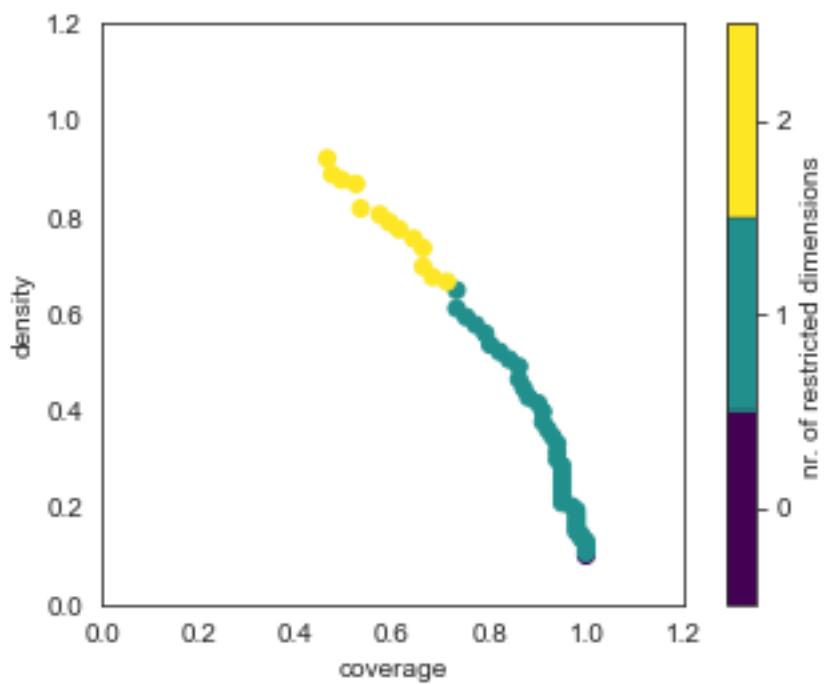




avg: accuracy

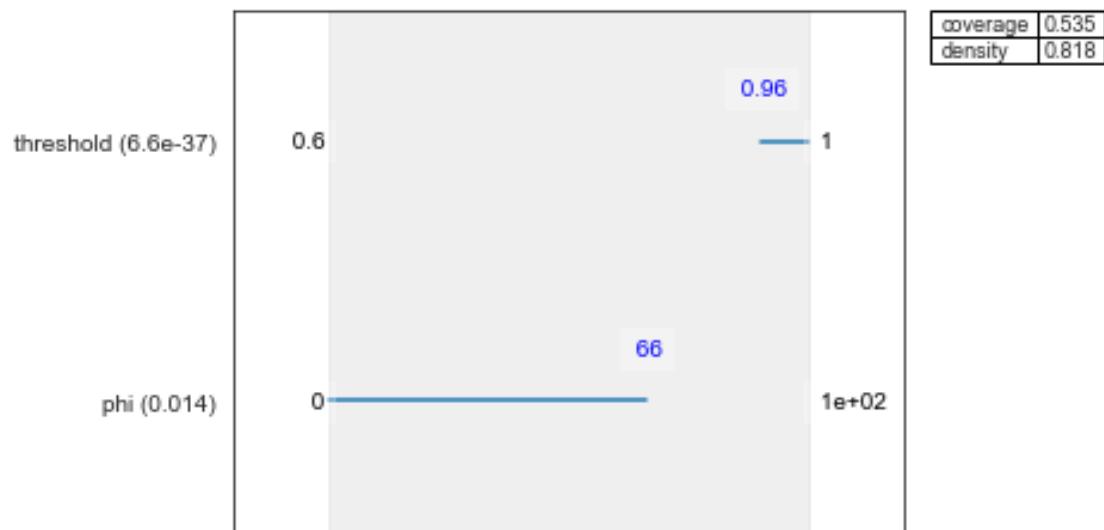


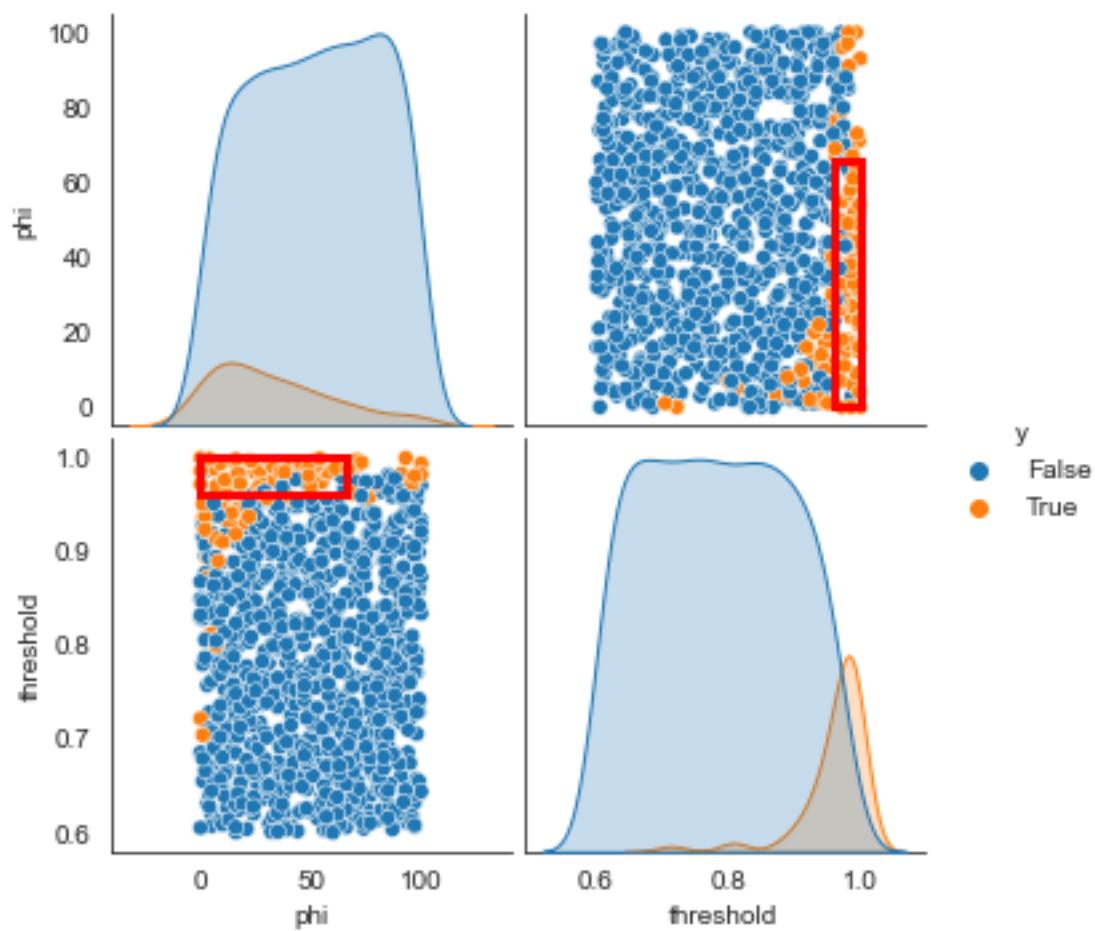
rovers



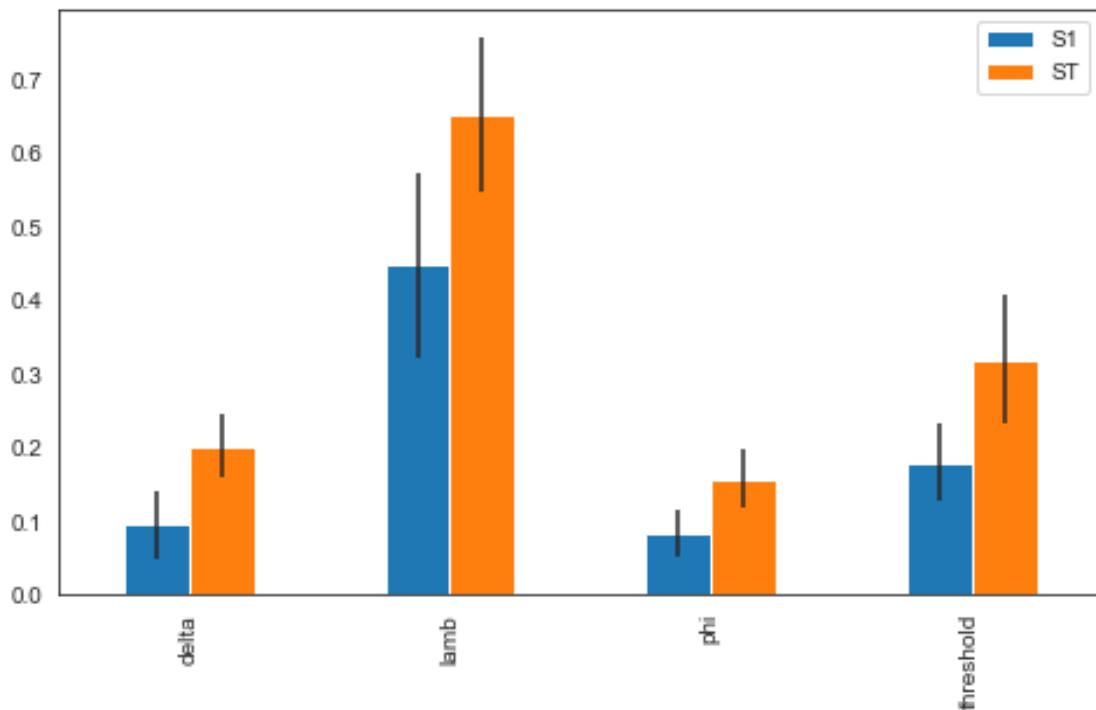
```
coverage      0.534653
density       0.818182
id            50
mass          0.066
mean          0.818182
res_dim       2
Name: 50, dtype: object
```

```
      box 50
      min      max      qp values
phi     0.000000 66.000000 [-1.0, 0.014018959882765126]
threshold 0.960073 0.999779 [6.579580452179475e-37, -1.0]
```

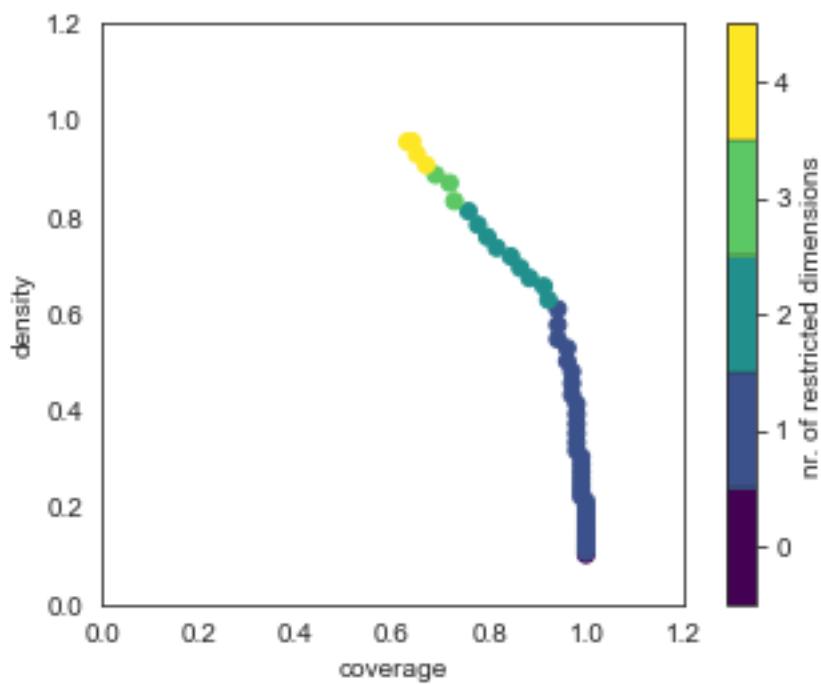




avg: accuracy



satellite

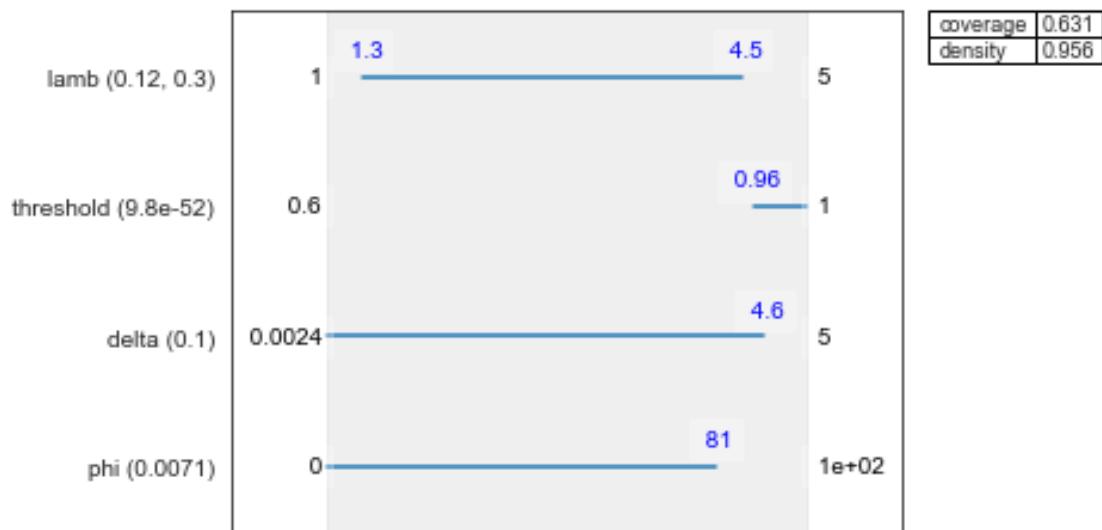


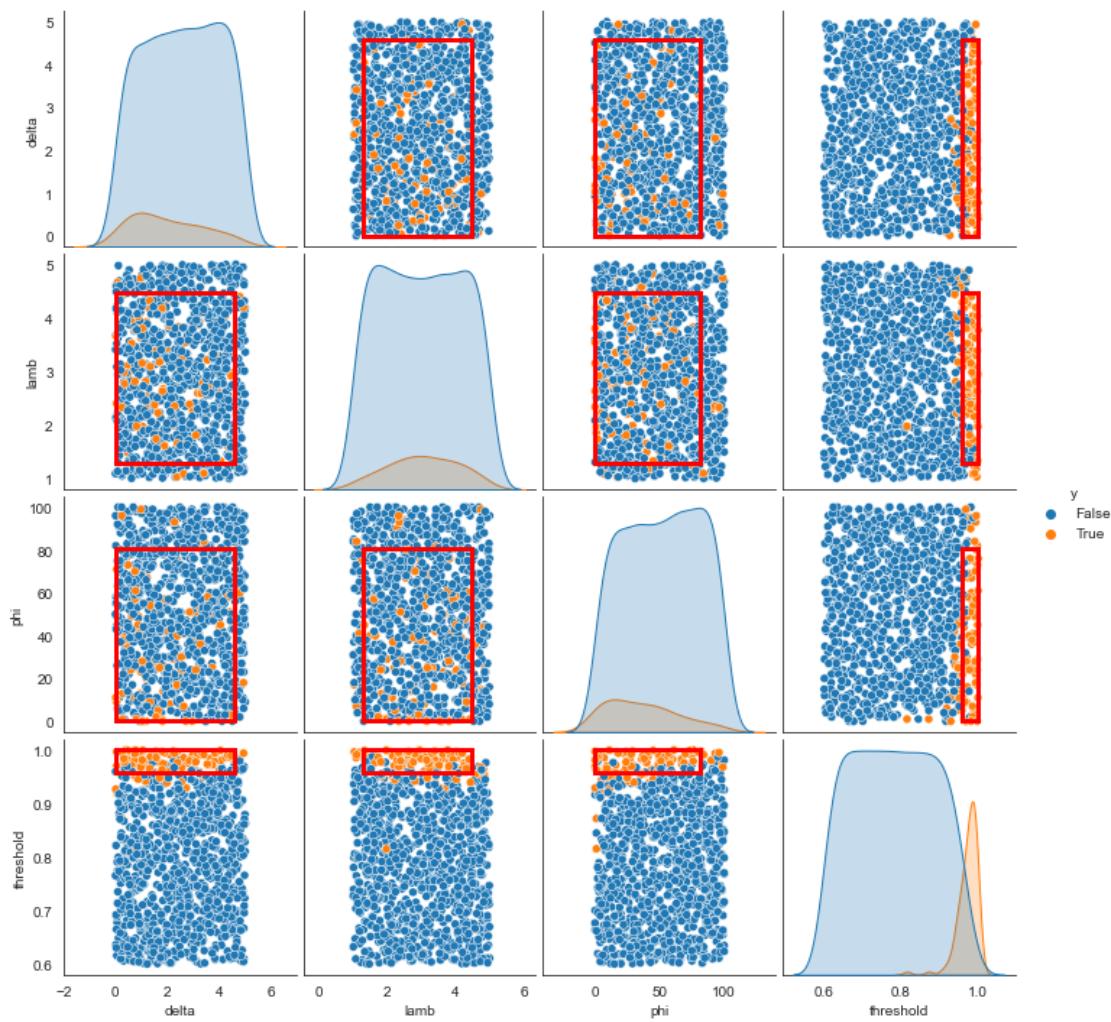
```

coverage      0.631068
density       0.955882
id            50
mass          0.068
mean          0.955882
res_dim       4
Name: 50, dtype: object

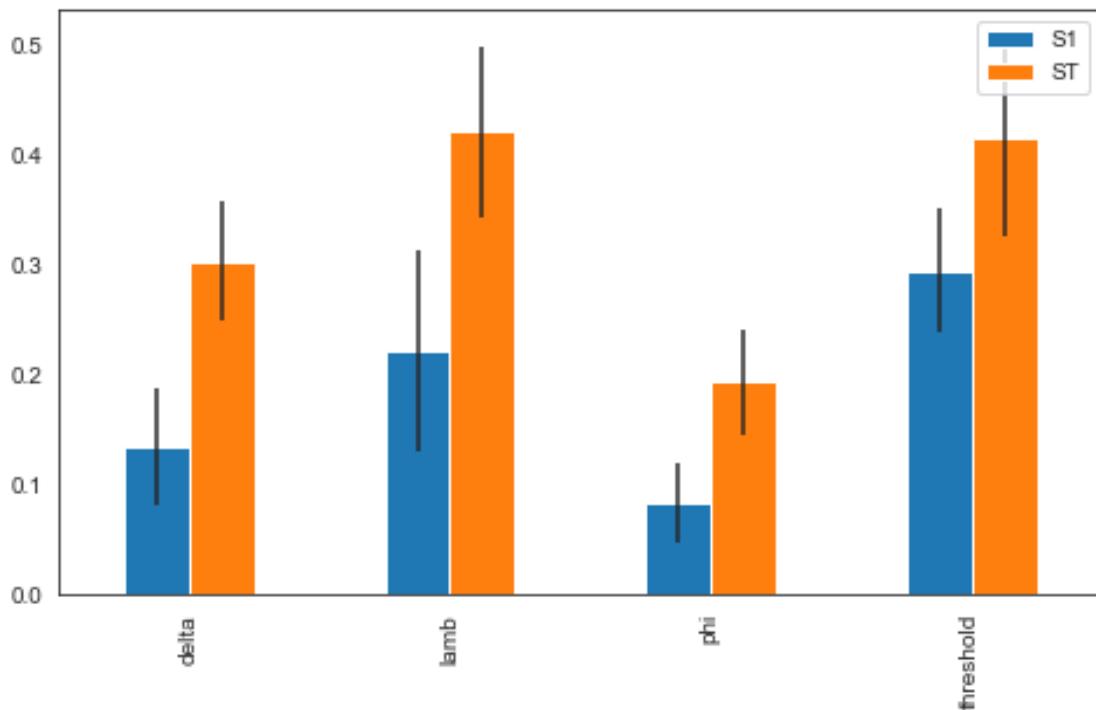
```

	box 50		qp values
	min	max	
phi	0.000000	81.000000	$[-1.0, 0.007056184858491923]$
delta	0.002380	4.571105	$[-1.0, 0.10475397014768047]$
threshold	0.957283	0.999750	$[9.802706556340941e-52, -1.0]$
lamb	1.298928	4.465743	$[0.1172155665422155, 0.29652484105792665]$

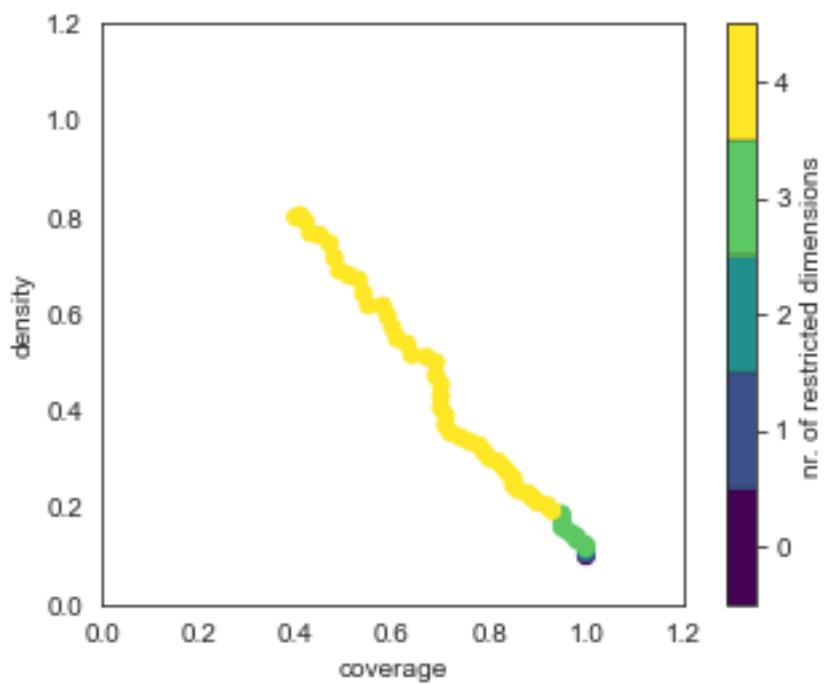




avg: accuracy



sokoban

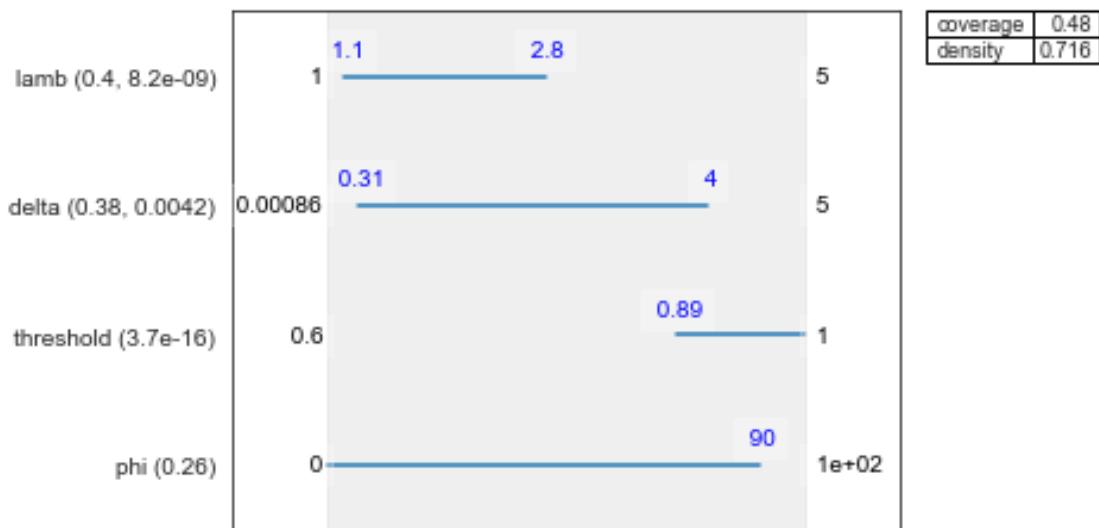


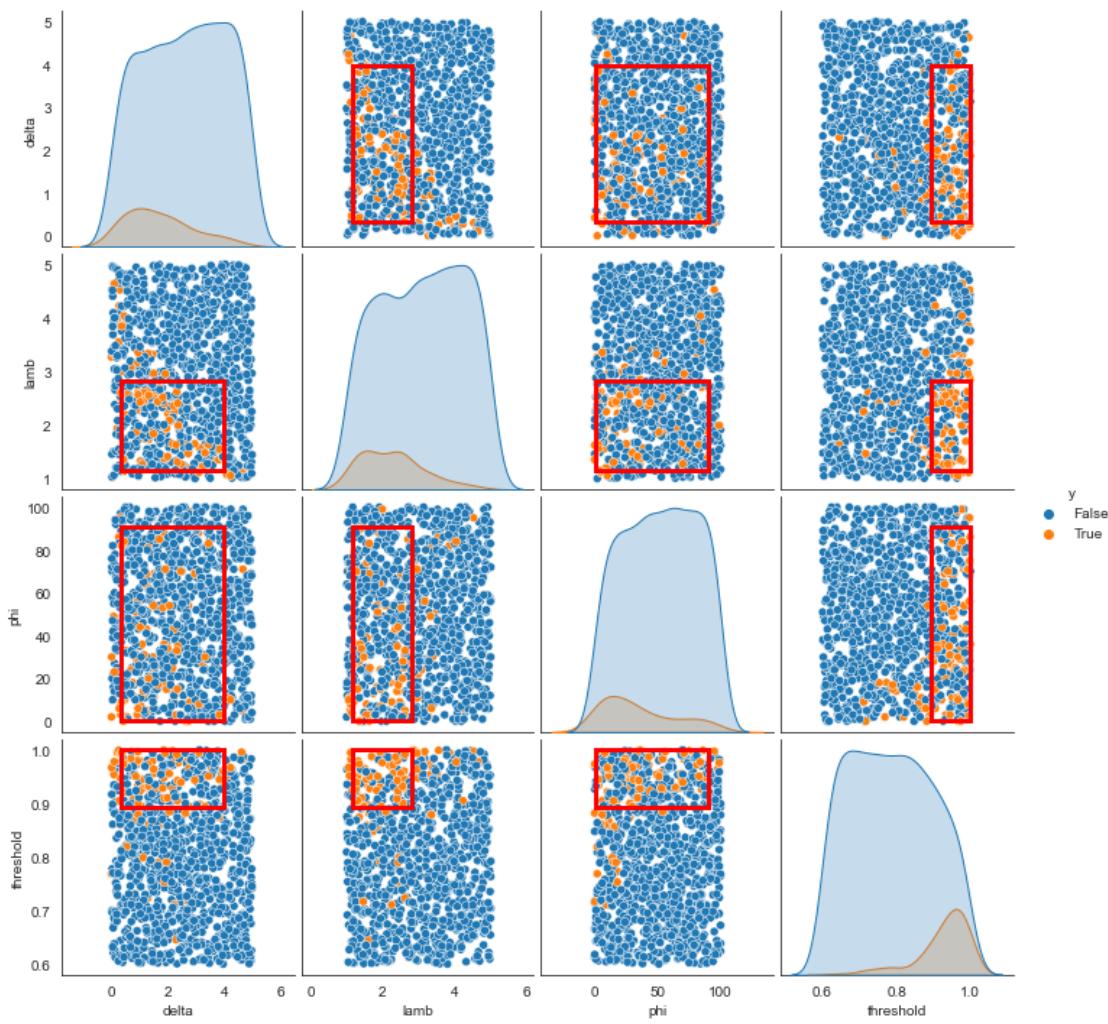
```

coverage      0.48
density      0.716418
id           50
mass         0.067
mean         0.716418
res_dim      4
Name: 50, dtype: object

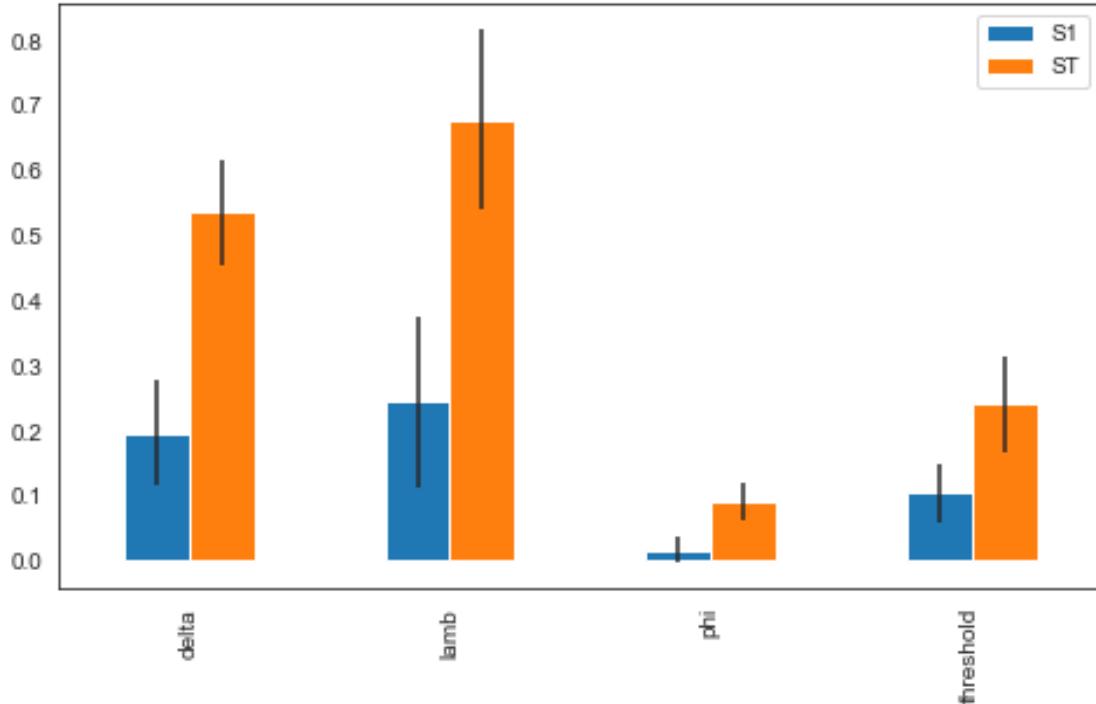
```

	box 50		qp values
	min	max	
phi	0.000000	90.500000	$[-1.0, 0.25740137754695797]$
threshold	0.892190	0.999889	$[3.6924019823425327e-16, -1.0]$
delta	0.314841	3.973954	$[0.37541441915255575, 0.004228446740785658]$
lamb	1.144148	2.823730	$[0.40466722861694526, 8.166445984241457e-09]$

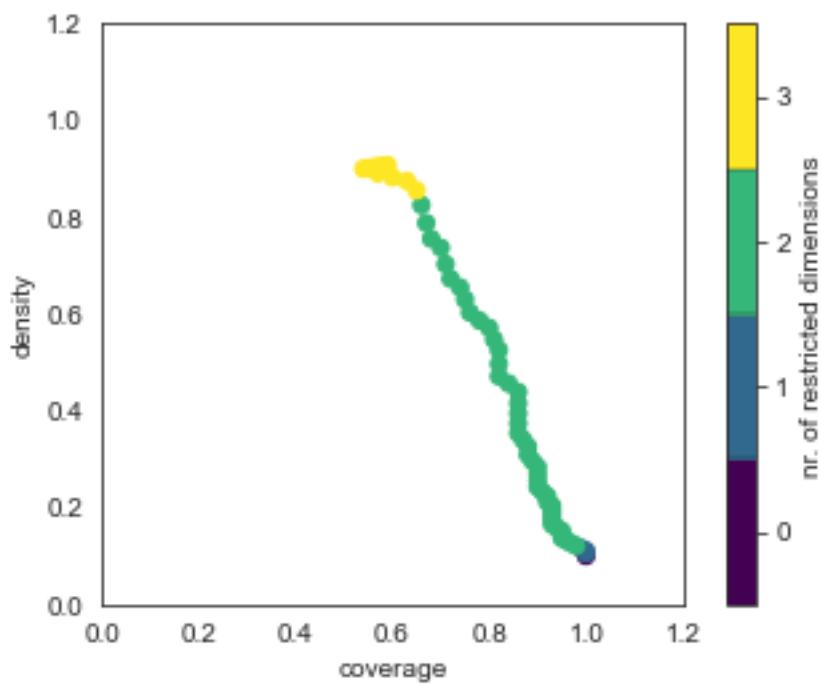




avg: accuracy

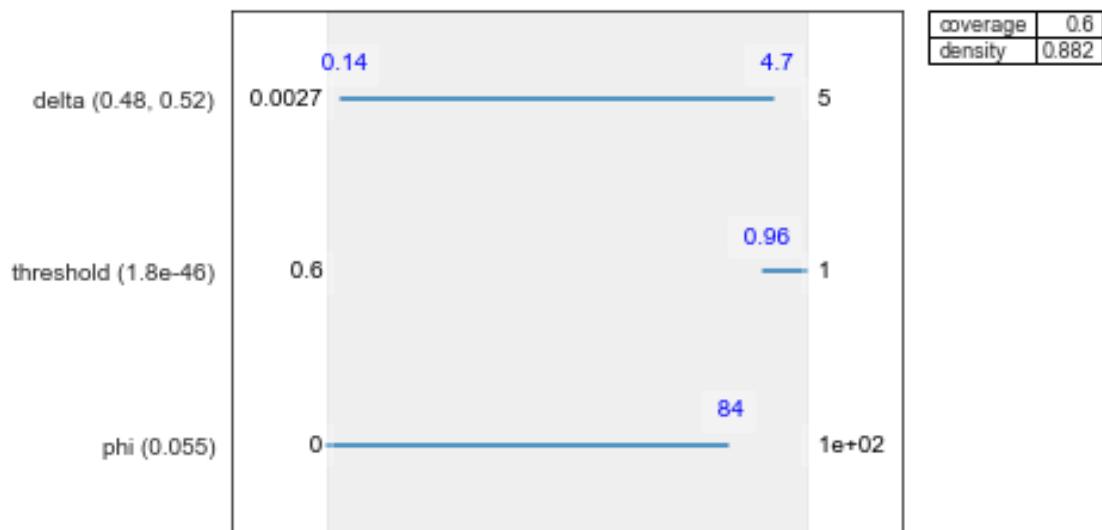


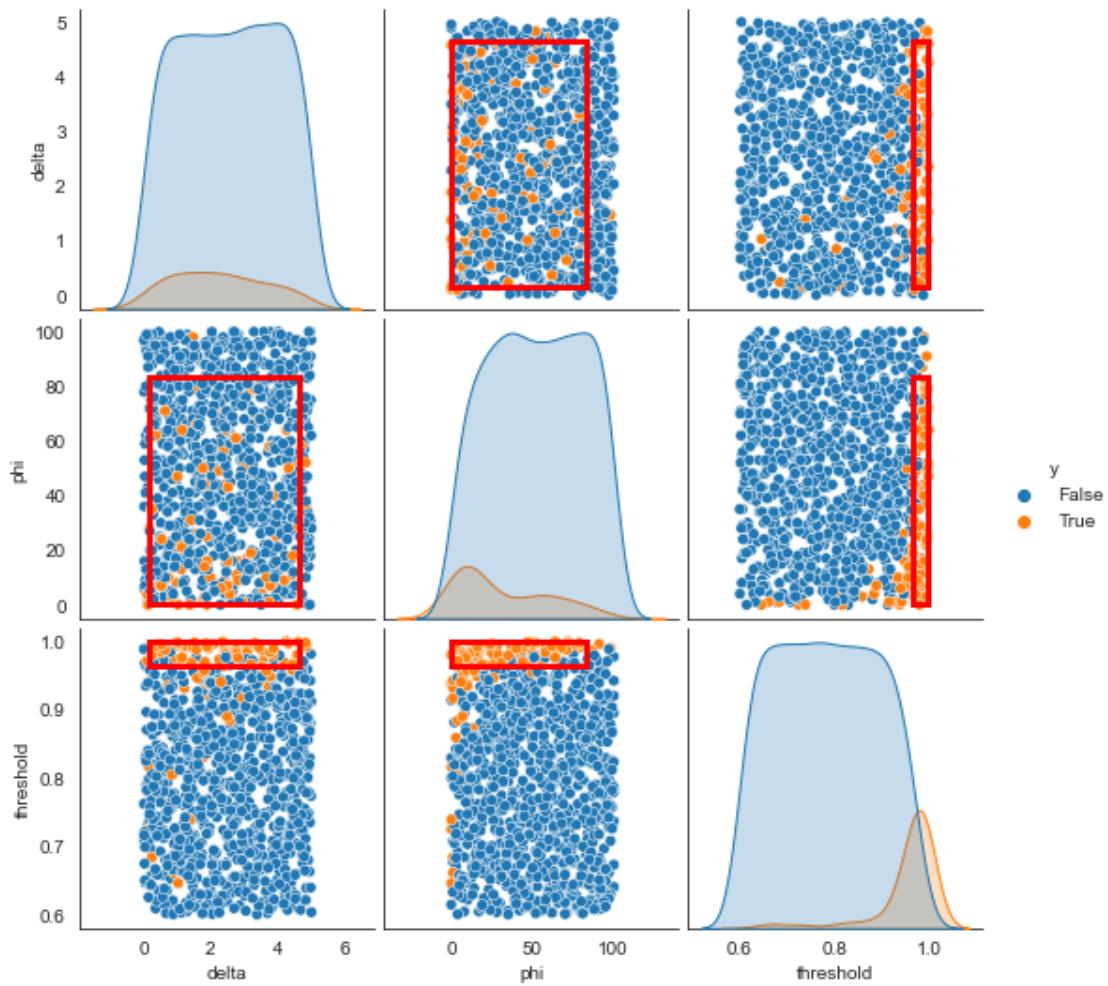
zeno-travel



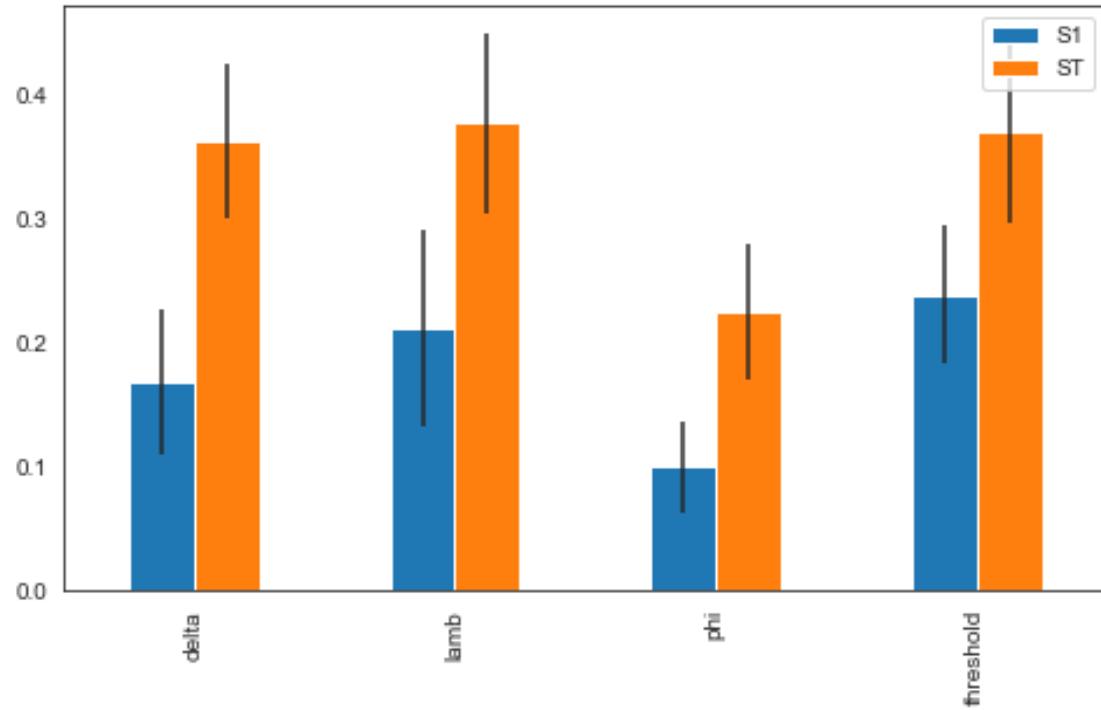
```
coverage      0.6
density      0.882353
id           50
mass         0.068
mean         0.882353
res_dim      3
Name: 50, dtype: object
```

```
      box 50
          min      max      qp values
phi     0.000000 83.500000 [-1.0, 0.05476180730086377]
threshold 0.964518 0.999696 [1.8288661934704696e-46, -1.0]
delta    0.142859 4.651094 [0.4830500081787835, 0.5185574432063291]
```





avg: accuracy



[]: