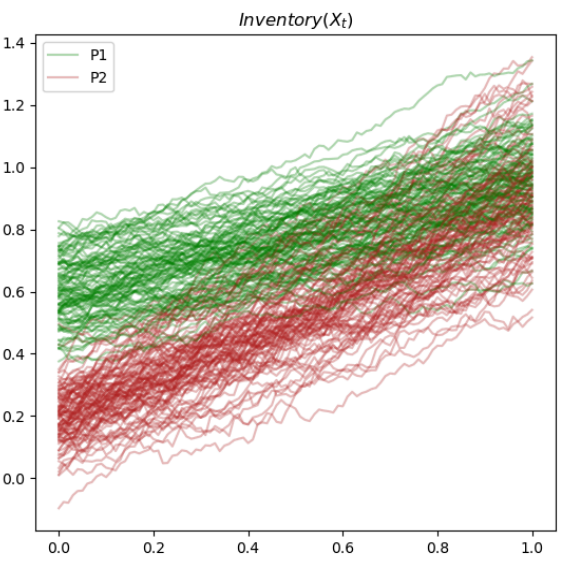
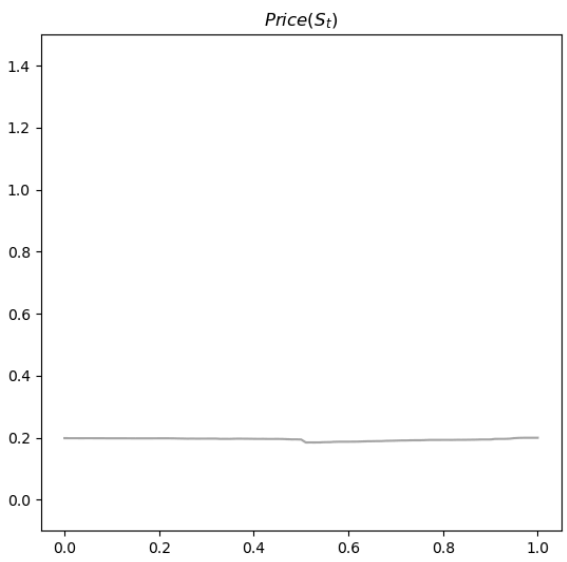
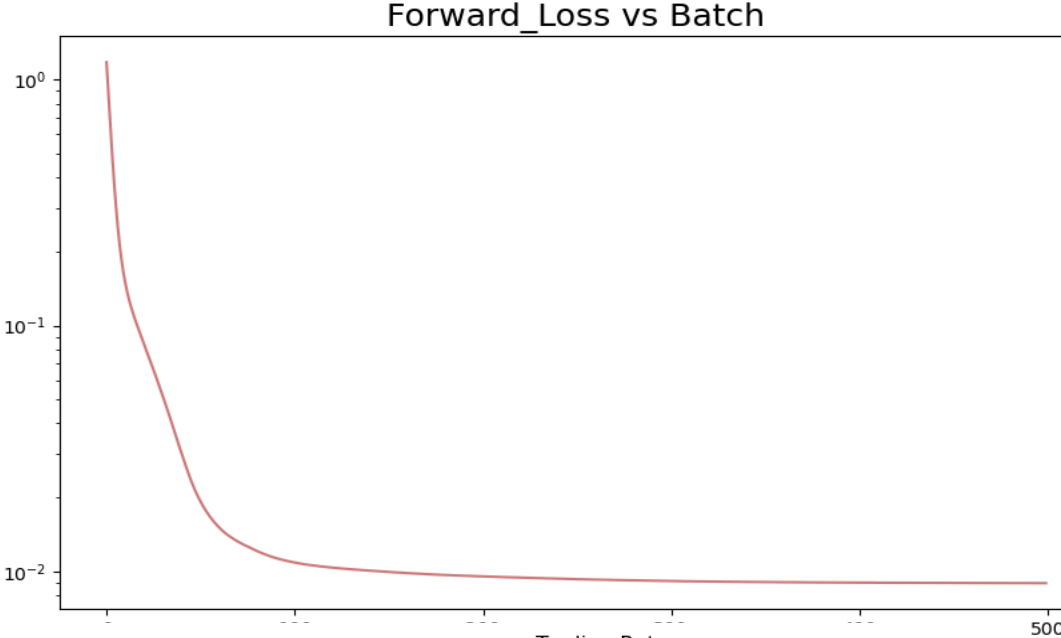
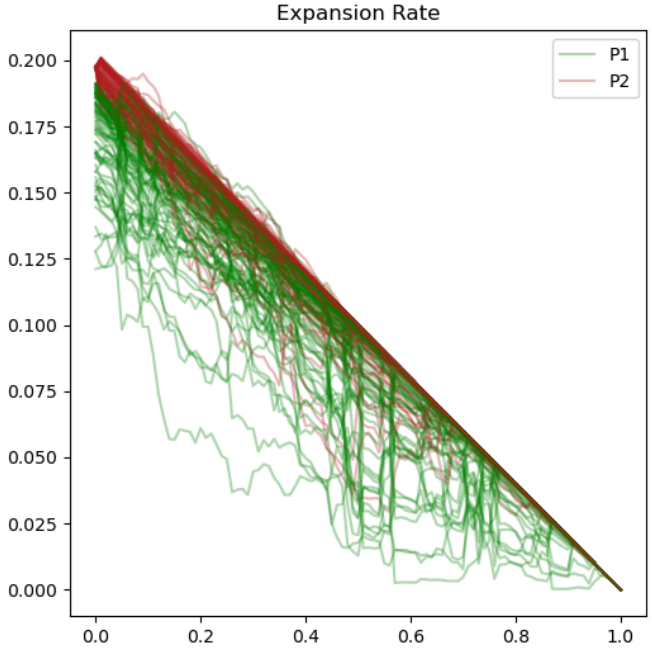
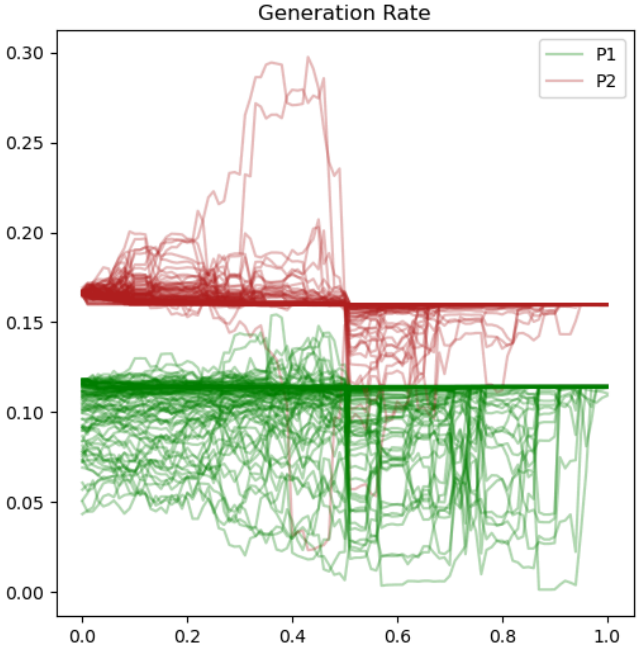
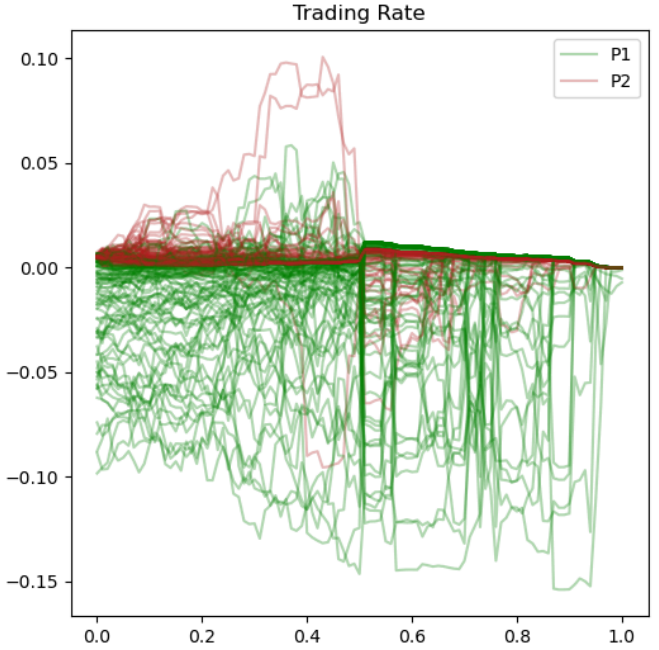








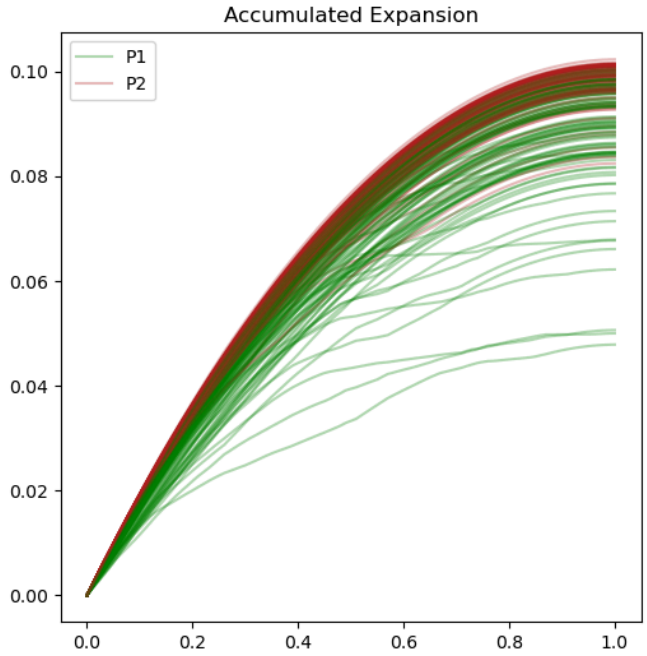


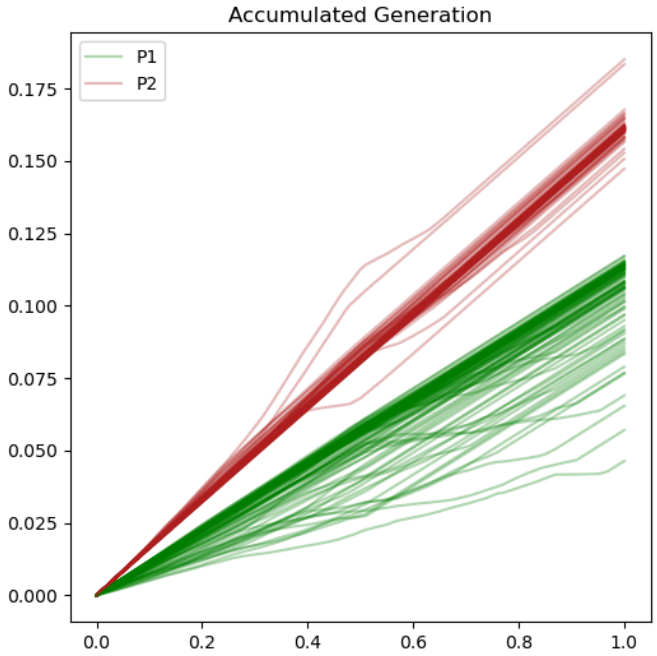


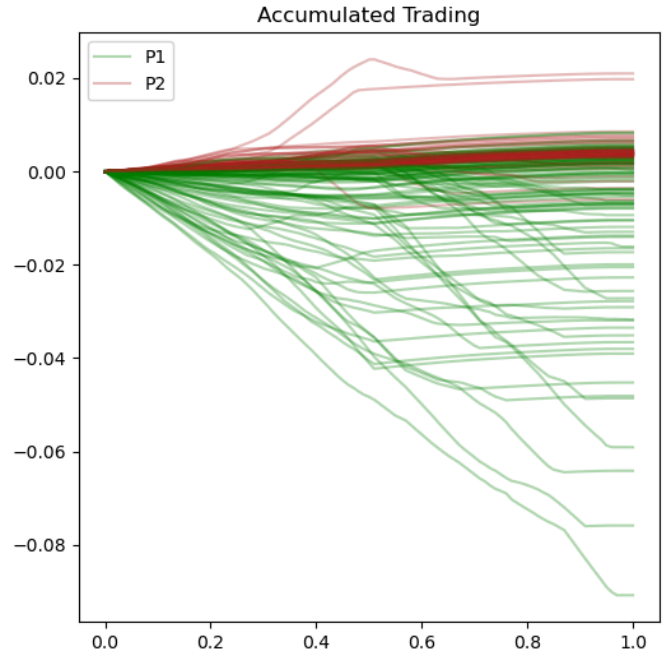

```
target_type='sigmoid',trick='clamp',loss_type='MSELoss',delta=0.03,w=0.2,lr=0.001)
```

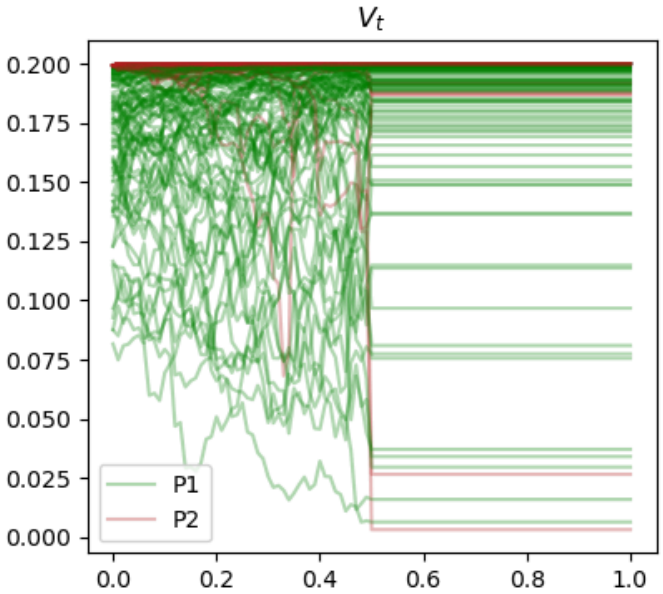
```
scaler_type='sigmoid'
```

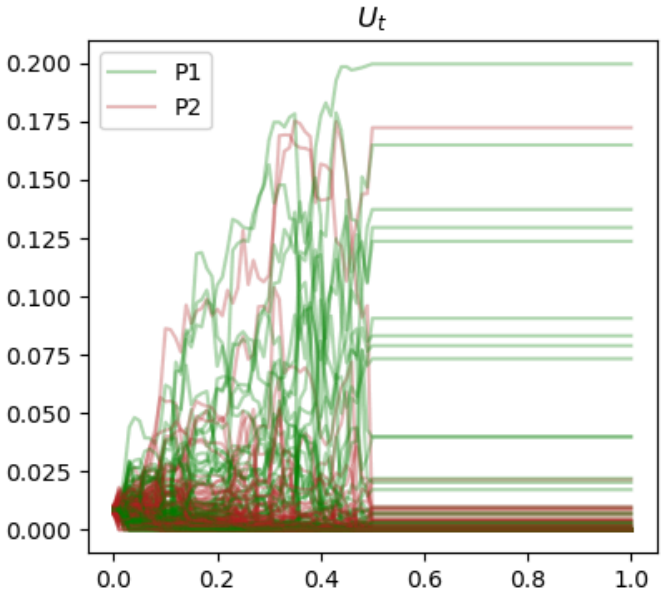
```
500 steps
Started @ August 05 - 15:26:44
Saved @ August 05 - 20:12:32
```

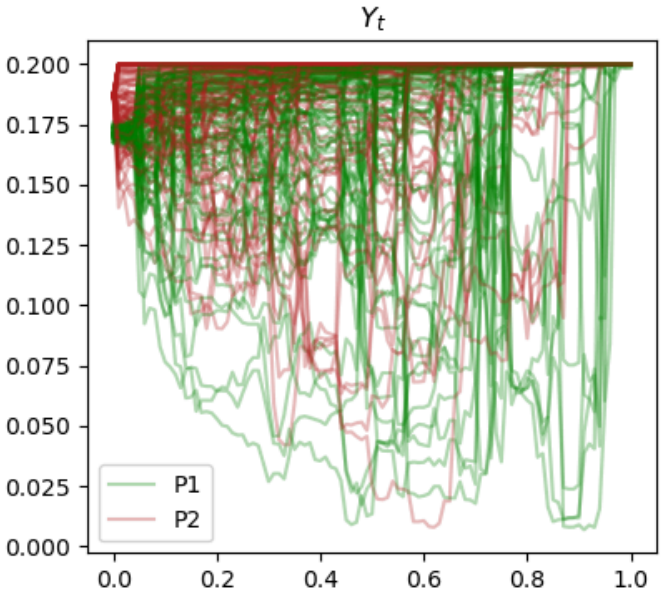

Accumulated Expansion
P1
P2
0.10
0.08
0.06
0.04
0.02
0.00
0.0
0.2
0.4
0.6
0.8
1.0

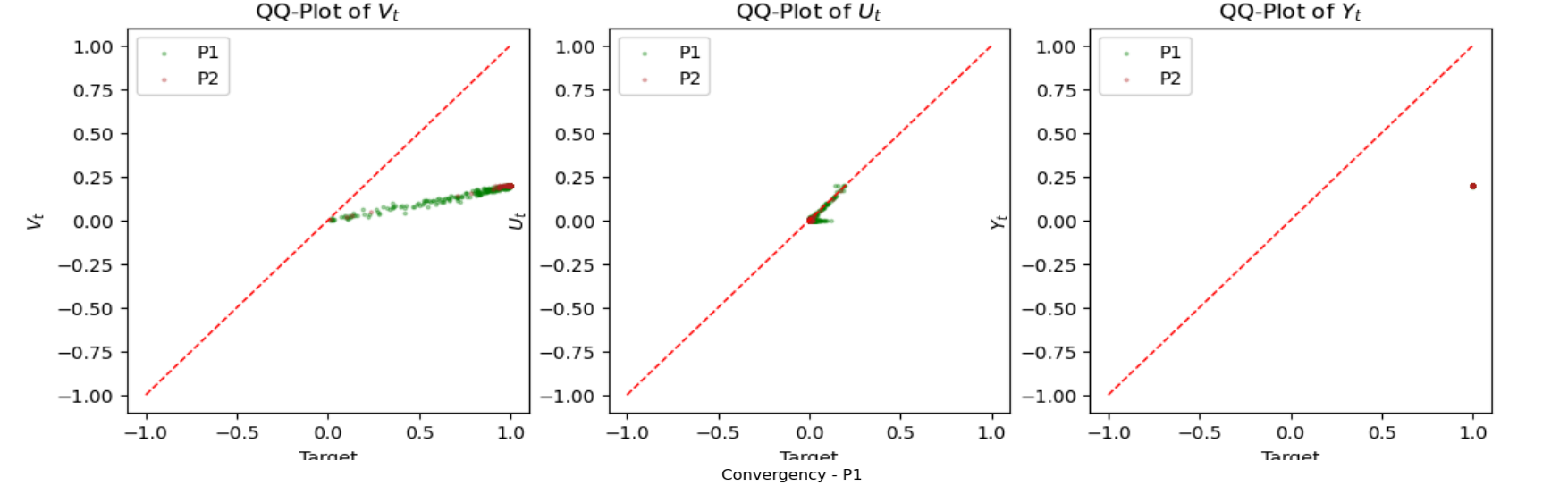

Accumulated Generation
P1
P2
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
0.0
0.2
0.4
0.6
0.8
1.0

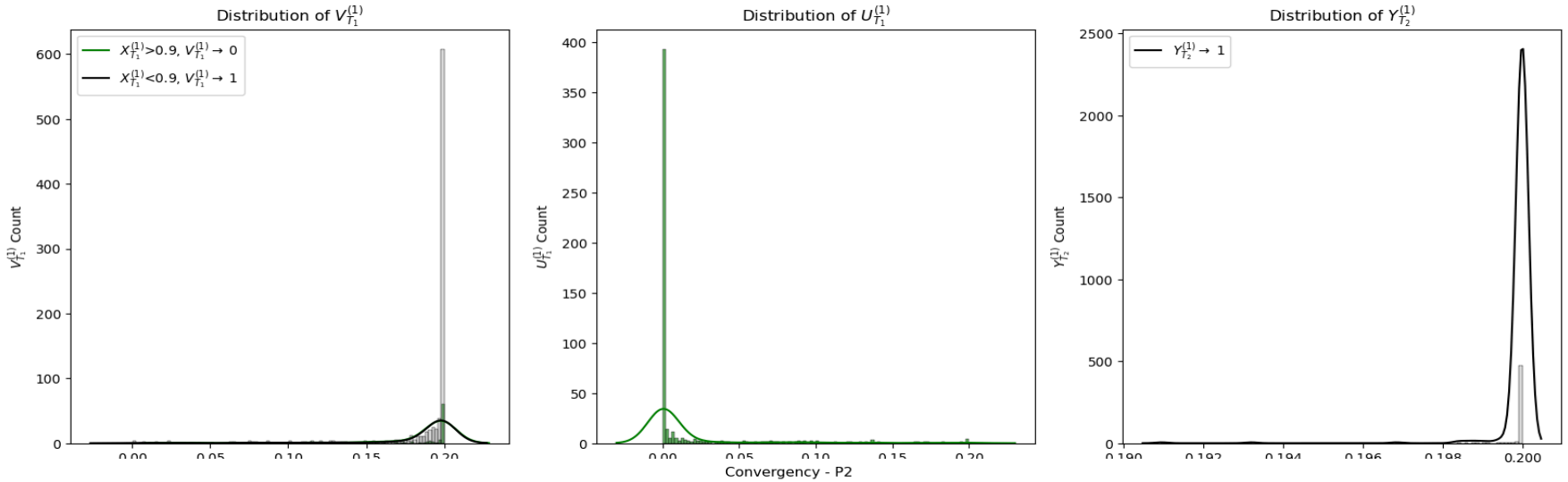

Accumulated Trading
P1
P2
0.02
0.00
−0.02
−0.04
−0.06
−0.08
0.0
0.2
0.4
0.6
0.8
1.0

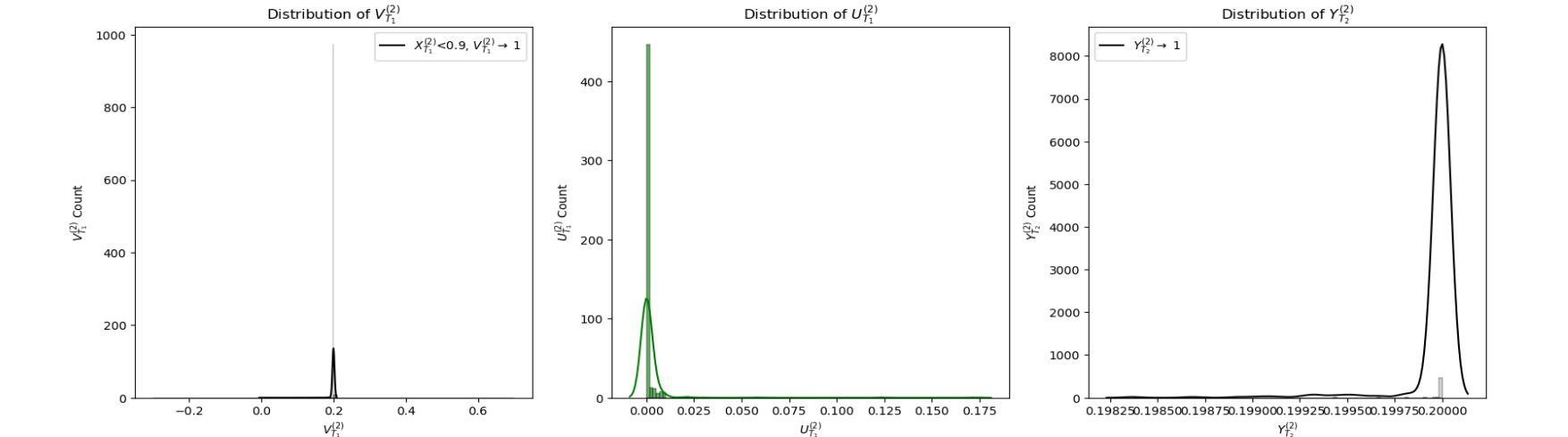

V_t
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
P1
P2
0.0
0.2
0.4
0.6
0.8
1.0


U_t
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
P1
P2
0.0
0.2
0.4
0.6
0.8
1.0


Y_t
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
P1
P2
0.0
0.2
0.4
0.6
0.8
1.0


QQ-Plot of V_t
QQ-Plot of U_t
QQ-Plot of Y_t
P1
P2
V_t
U_t
Y_t
Target
Convergency - P1


Distribution of $V_{T_1}^{(1)}$
Distribution of $U_{T_1}^{(1)}$
Distribution of $Y_{T_2}^{(1)}$
$X_{T_1}^{(1)}$>0.9, $V_{T_1}^{(1)} \to 0$
$X_{T_1}^{(1)}$<0.9, $V_{T_1}^{(1)} \to 1$
$Y_{T_2}^{(1)} \to 1$
$V_{T_1}^{(1)}$ Count
$U_{T_1}^{(1)}$ Count
$Y_{T_2}^{(1)}$ Count
Convergency - P2


Distribution of $V_{T_1}^{(2)}$
Distribution of $U_{T_1}^{(2)}$
Distribution of $Y_{T_2}^{(2)}$
$X_{T_1}^{(2)}$<0.9, $V_{T_1}^{(2)} \to 1$
$Y_{T_2}^{(2)} \to 1$
$V_{T_1}^{(2)}$ Count
$U_{T_1}^{(2)}$ Count
$Y_{T_2}^{(2)}$ Count

In [ ]:
```
import numpy as np
import torch as torch
import torch.nn as nn
import torch.nn.functional as F
import torch.optim as optim
import seaborn as sns
import pandas as pd
import matplotlib.pyplot as plt
from datetime import datetime
import random
from scipy.stats import norm

import os
import pathlib

from Model import *
from utils import *

torch.autograd.set_detect_anomaly(True)
start_time=datetime.now().strftime('%B %d - %H:%M:%S')
```

In [ ]:
```
#Global parameters
GlobalParams1=Params(param_type='k1',target_type='sigmoid',trick='clamp',loss_type='MSELoss',delta=0.03,w=0.2,lr=0.001)
dB1 = SampleBMIncr(GlobalParams=GlobalParams1)
init_x1 =  Sample_Init(GlobalParams=GlobalParams1)
init_c1= torch.zeros_like(init_x1)

GlobalParams2=Params(param_type='k2',target_type='sigmoid',trick='clamp',loss_type='MSELoss',delta=0.03,w=0.2,lr=0.001)
dB2 = SampleBMIncr(GlobalParams=GlobalParams2)   ## TODO: same dB?????
init_x2 =  Sample_Init(GlobalParams=GlobalParams2)
init_c2= torch.zeros_like(init_x2)

NT1=GlobalParams1.NT1
NT2=GlobalParams1.NT2
dt=GlobalParams1.dt
device=GlobalParams1.device
learning_rate = GlobalParams1.lr

#Forward Loss
forward_losses = []

#How many batches
MaxBatch= 500

#How many optimization steps per batch
OptimSteps= 25

#Train on a single batch?
single_batch = True
```

```
#Set up main models for y0 and z (z will be list of models)
v0_model_main1 = Network(scaler_type='sigmoid')
u0_model_main1 = Network(scaler_type='sigmoid')
y0_model_main1 = Network(scaler_type='sigmoid')

zv_models_main1 = [Network() for i in range(NT1)]
zu_models_main1 = [Network() for i in range(NT1)]
zy_models_main1 = [Network() for i in range(NT2)]
main_models1=Main_Models(GlobalParams=GlobalParams1)
main_models1.create(v0_model=v0_model_main1,
                    u0_model=u0_model_main1,
                    y0_model=y0_model_main1,
                    zv_models=zv_models_main1,
                    zu_models=zu_models_main1,
                    zy_models=zy_models_main1,
                    forward_loss=forward_losses,
                    dB=dB1,
                    init_x=init_x1,
                    init_c=init_c1)

v0_model_main2 = Network(scaler_type='sigmoid')
u0_model_main2 = Network(scaler_type='sigmoid')
y0_model_main2 = Network(scaler_type='sigmoid')

zv_models_main2 = [Network() for i in range(NT1)]
zu_models_main2 = [Network() for i in range(NT1)]
zy_models_main2 = [Network() for i in range(NT2)]
main_models2=Main_Models(GlobalParams=GlobalParams2)
main_models2.create(v0_model=v0_model_main2,
                    u0_model=u0_model_main2,
                    y0_model=y0_model_main2,
                    zv_models=zv_models_main2,
                    zu_models=zu_models_main2,
                    zy_models=zy_models_main2,
                    forward_loss=forward_losses,
                    dB=dB2,
                    init_x=init_x2,
                    init_c=init_c2)

pop1_dict={'dB':dB1,
           'init_x':init_x1 ,
           'init_c':init_c1 ,
           'GlobalParams':GlobalParams1,
           'main_models':main_models1}

pop2_dict={'dB':dB2,
           'init_x':init_x2 ,
           'init_c':init_c2 ,
           'GlobalParams':GlobalParams2,
           'main_models':main_models2}
```

In [ ]:

```
#Define optimization parameters
params=[]
params = list(main_models1.v0_model.parameters())+\
         list(main_models1.u0_model.parameters())+\
         list(main_models1.y0_model.parameters())+\
         list(main_models2.v0_model.parameters())+\
         list(main_models2.u0_model.parameters())+\
         list(main_models2.y0_model.parameters())
for i in range(NT1):
    params += list(main_models1.zv_models[i].parameters())
    params += list(main_models1.zu_models[i].parameters())
    params += list(main_models2.zv_models[i].parameters())
    params += list(main_models2.zu_models[i].parameters())

for i in range(NT2):
    params += list(main_models1.zy_models[i].parameters())
    params += list(main_models2.zy_models[i].parameters())

#Set up optimizer and scheduler
optimizer = optim.Adamax(params, lr=learning_rate)
scheduler = torch.optim.lr_scheduler.StepLR(optimizer, step_size=100, gamma=0.95)

for k in range(0,MaxBatch):

    print("Batch Number: ", k+1)
    sloss=0
    #optimize main network wrt the foward loss
    for l in range(0,OptimSteps):
        optimizer.zero_grad()
        loss = get_foward_loss(pop1_dict=pop1_dict, pop2_dict=pop2_dict)
        loss.backward()
        # torch.nn.utils.clip_grad_norm_(parameters=params,max_norm=0.7)
        optimizer.step()
        scheduler.step()
        nloss = loss.detach().numpy()
        sloss += nloss
        # print('OptimStep: '+ str(l+1))
        # print('forward_loss: ' + str(nloss))
    avgloss = sloss/OptimSteps
    print("Average Error Est: ", avgloss)
    forward_losses.append(avgloss)

    #Generate a new batch if using multiple batches
    if(not single_batch):

        dB1 = SampleBMIncr(GlobalParams=GlobalParams1)
        init_x1 =  Sample_Init(GlobalParams=GlobalParams1)
        init_c1= torch.zeros_like(init_x1)
        pop1_dict={'dB':dB1,
                'init_x':init_x1 ,
                'init_c':init_c1 ,
```

```
                'GlobalParams':GlobalParams1,
                'main_models':main_models1}

        dB2 = SampleBMIncr(GlobalParams=GlobalParams2)   ## TODO: same dB?????
        init_x2 =  Sample_Init(GlobalParams=GlobalParams2)
        init_c2= torch.zeros_like(init_x2)
        pop2_dict ={'dB':dB2,
                    'init_x':init_x2 ,
                    'init_c':init_c2 ,
                    'GlobalParams':GlobalParams2,
                    'main_models':main_models2}
```

Save The Models

In [ ]:
```
print(f"{len(main_models1.loss)} steps\nStarted @ {start_time}\nSaved @ {datetime.now().strftime('%B %d - %H:%M:%S')}")   ## to examine whether
dir_path=pathlib.Path(os.getcwd(),
                      'Results',
                      'Best Models Saved',
                      'sigmoid_sig_0.001lr_0.03delta_500steps_MSE_0.2w')
dir_path.mkdir()
path1=pathlib.Path(dir_path,'pop1.pt')
path2=pathlib.Path(dir_path,'pop2.pt')
main_models1.save_entire_models(path=path1)
main_models2.save_entire_models(path=path2)
```

```
500 steps
Started @ August 05 - 15:26:44
Saved @ August 05 - 20:12:32
```