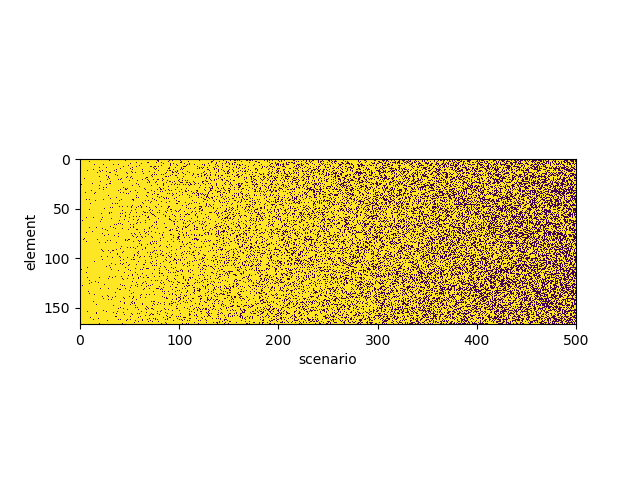
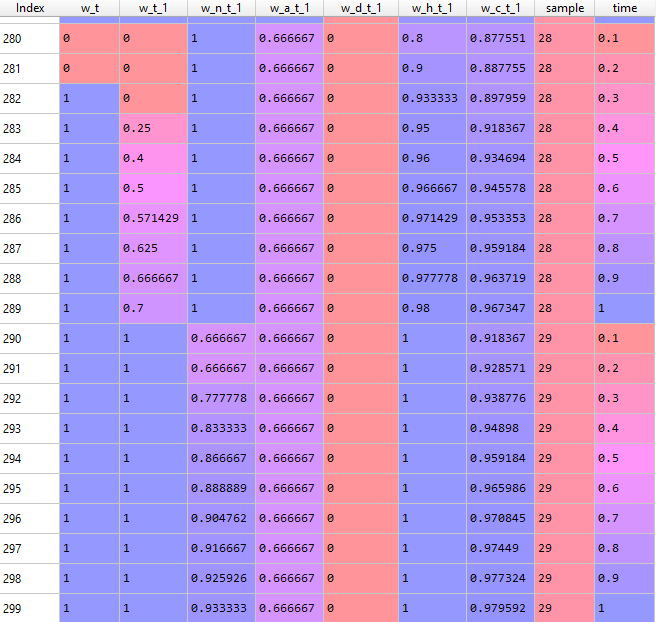
# Data

* 450 scenarios with random disruption



* Optimal plans for each scenario by INDP with *Rc*=4
* Each scenario produces T=10 data points for each node



* 80-20 train-test split

# Model 1

## Model form

where

w\_t = state of a given node at time t given that w\_{t-1}=0

w\_{t-1},n = sum of the state of the neighbor nodes for a given node at time t-1

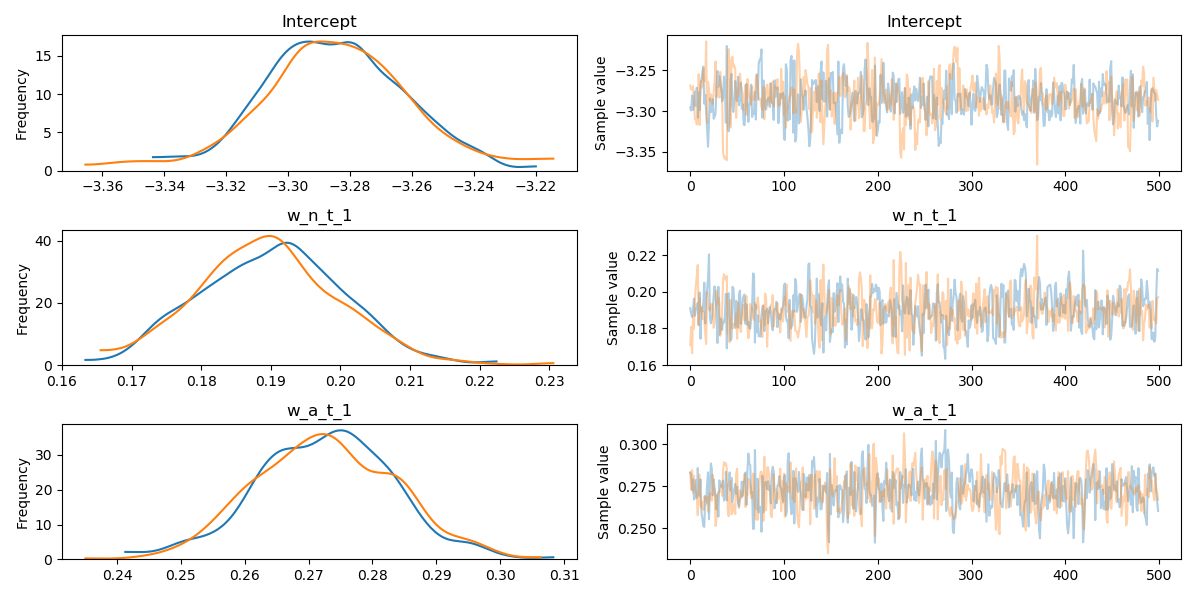
w\_{t-1},a = sum of the state of the connected arcs for a given node at time t-1

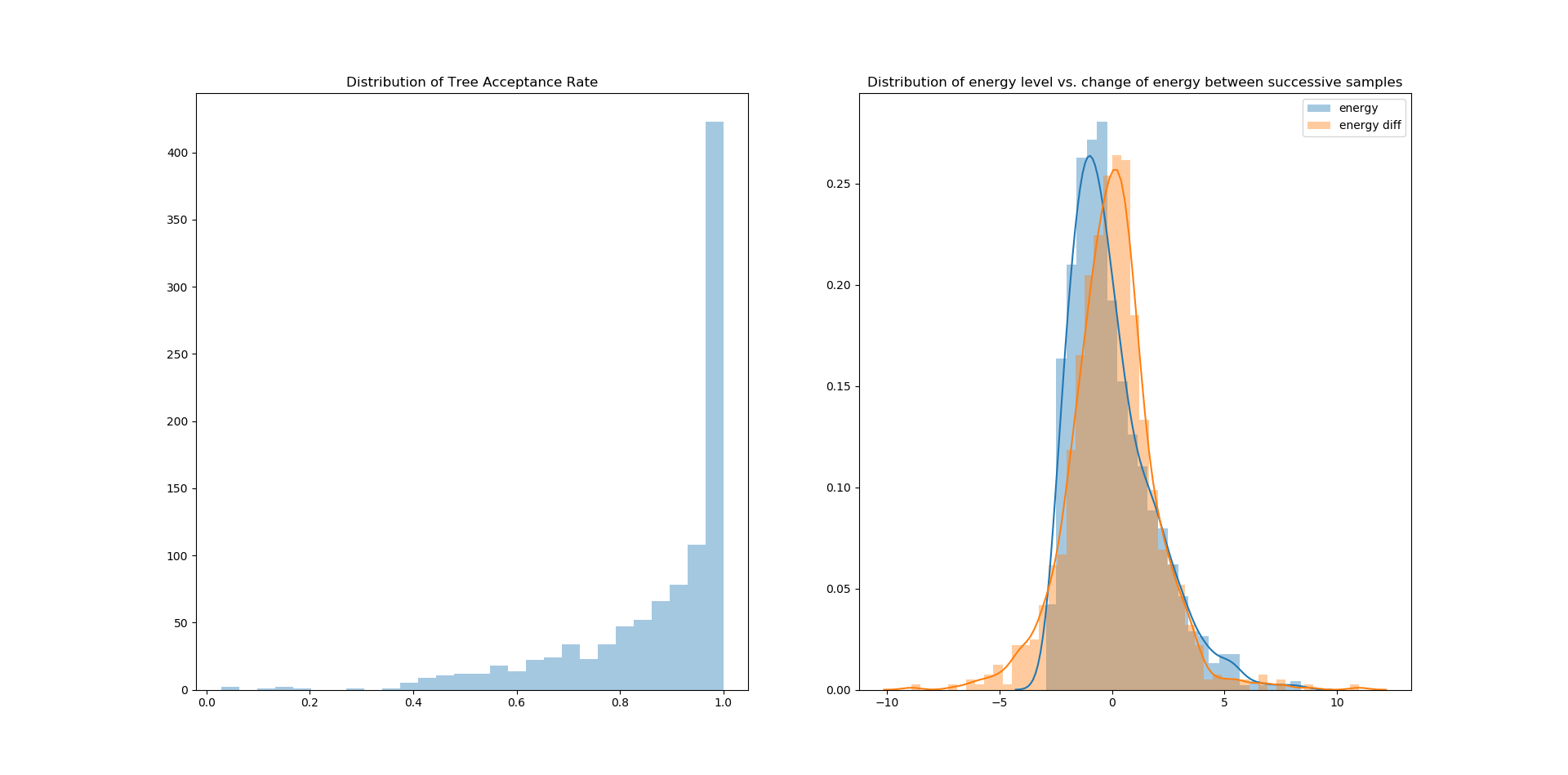
This model is trained for all nodes over all data point except when w\_t\_1\_i=1 or y\_t\_1=1

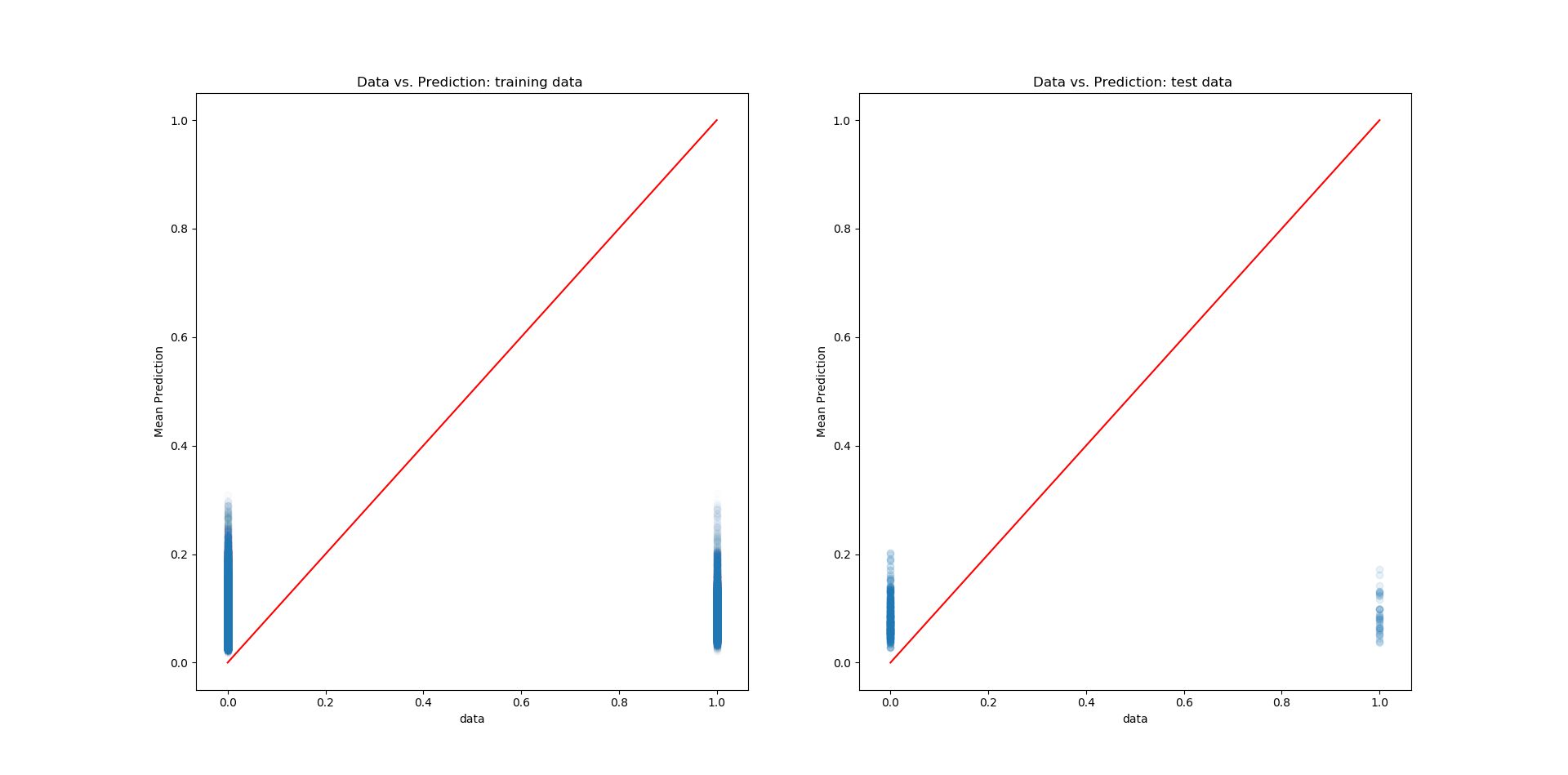
## Estimated Parameters

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | mean | sd | mc\_error | hpd\_2.5 | hpd\_97.5 | n\_eff | Rhat |
| Intercept | -3.2852 | 0.0237 | 0.0011 | -3.331 | -3.2358 | 497.2648 | 0.9991 |
| w\_n\_t\_1 | 0.1898 | 0.01 | 0.0004 | 0.1708 | 0.2088 | 558.3604 | 0.9996 |
| w\_a\_t\_1 | 0.2724 | 0.0108 | 0.0005 | 0.2526 | 0.2957 | 504.7184 | 0.999 |
| Training | data | R2: | 0.012254 |  |  |  |  |
| Test | data | R2: | 0.003821 |  |  |  |  |

## Figures







## Results

Not acceptable. Horrible prediction.

# Model 2

## Model form

where

w\_t = state of a given node at time t given that w\_{t-1}=0

w\_{t-1},n = sum of the state of the neighbor nodes for a given node at time t-1

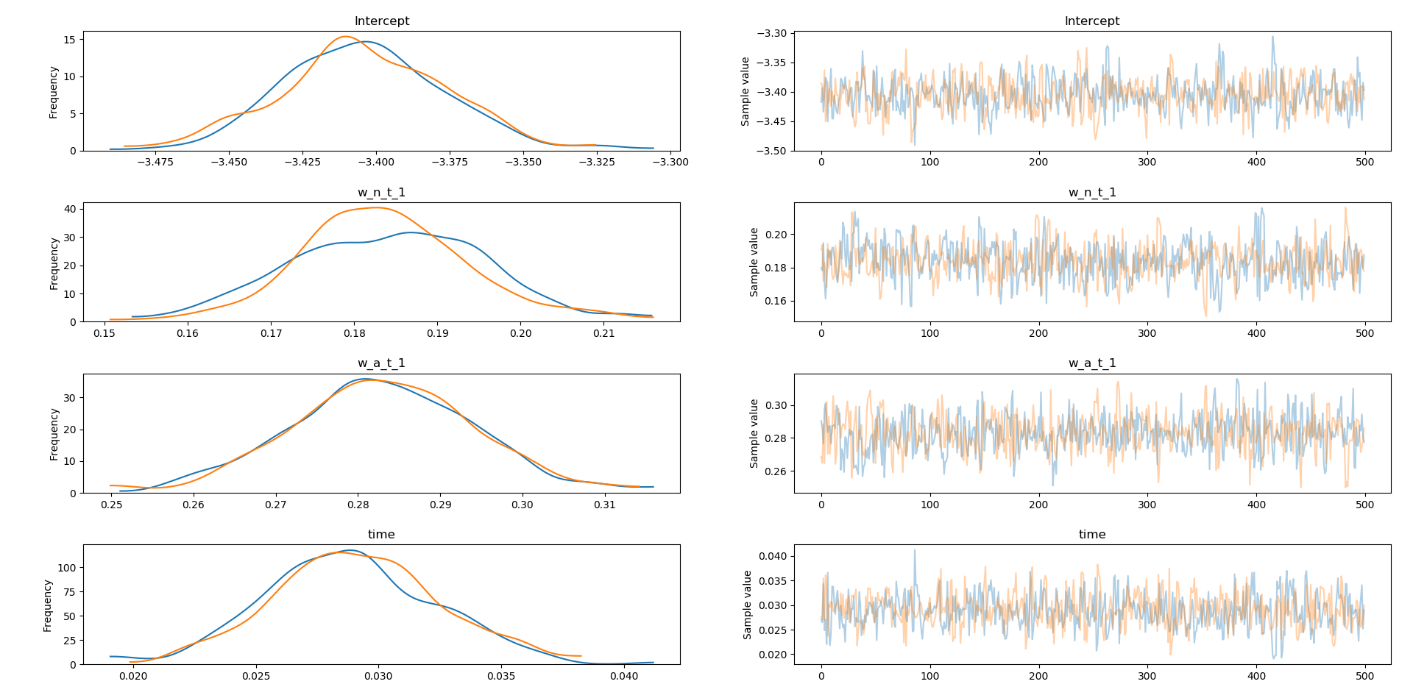
w\_{t-1},a = sum of the state of the connected arcs for a given node at time t-1

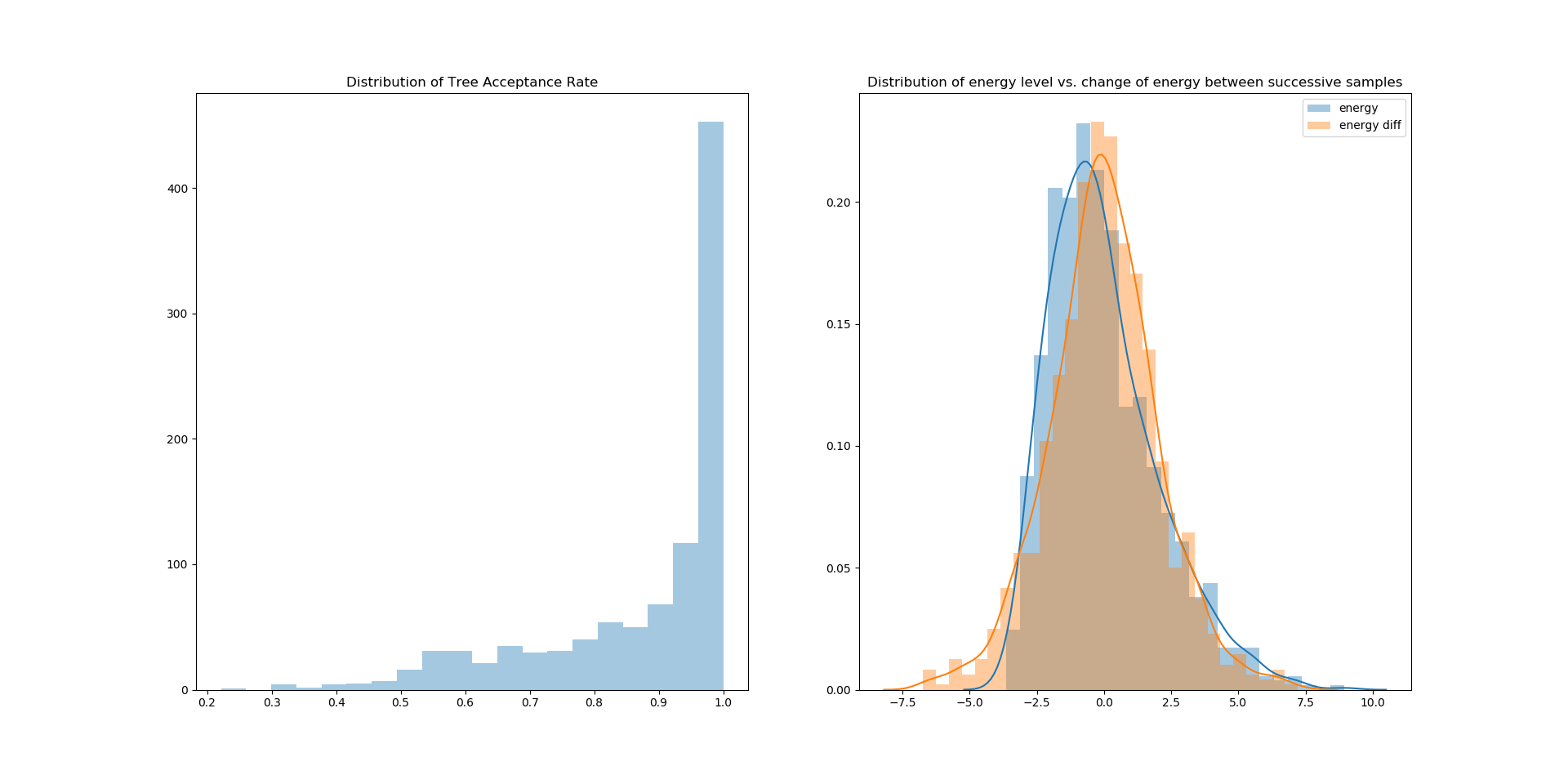
This model is trained for all nodes over all data point except when w\_t\_1\_i=1 or y\_t\_1=1

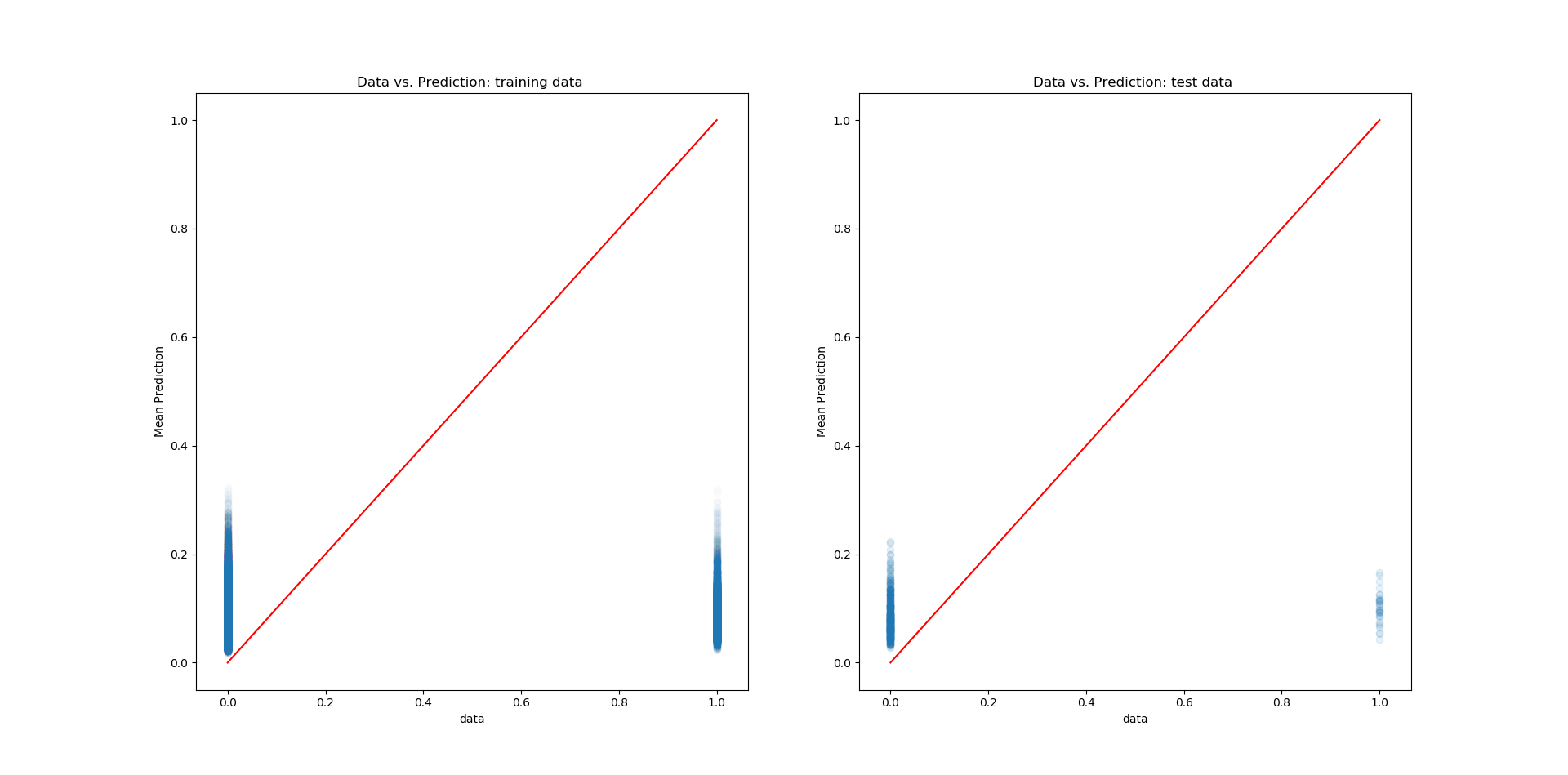
## Estimated Parameters

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | mean | sd | mc\_error | hpd\_2.5 | hpd\_97.5 | n\_eff | Rhat |
| Intercept | -3.4047 | 0.0278 | 0.0011 | -3.4569 | -3.3523 | 542.9692 | 0.9991 |
| w\_n\_t\_1 | 0.1837 | 0.011 | 0.0005 | 0.1616 | 0.2049 | 557.9893 | 0.9994 |
| w\_a\_t\_1 | 0.2828 | 0.0112 | 0.0005 | 0.2581 | 0.3022 | 625.2732 | 0.999 |
| t | 0.0289 | 0.0034 | 0.0001 | 0.0222 | 0.0355 | 650.4939 | 1.0015 |
| Training | data | R2: | 0.012326012 |  |  |  |  |
| Test | data | R2: | 0.010251768 |  |  |  |  |

## Figures







## Results

Not acceptable. Horrible prediction.

# Model 3

## Model form

where

w\_t = state of a given node at time t given that w\_{t-1}=0

w\_{t-1},n = sum of the state of the neighbor nodes for a given node at time t-1

w\_{t-1},a = sum of the state of the connected arcs for a given node at time t-1

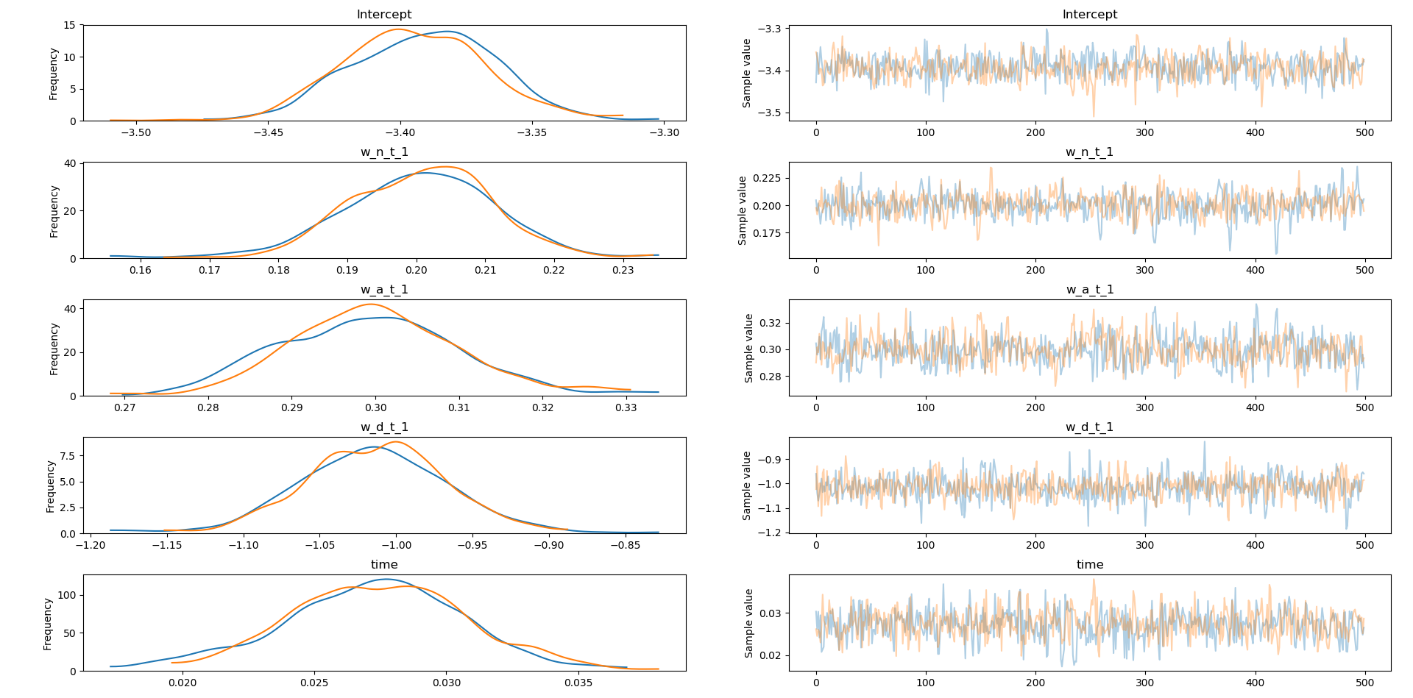
w\_{t-1},d = sum of the (1-state) of the dependee nodes for a given node at time t-1

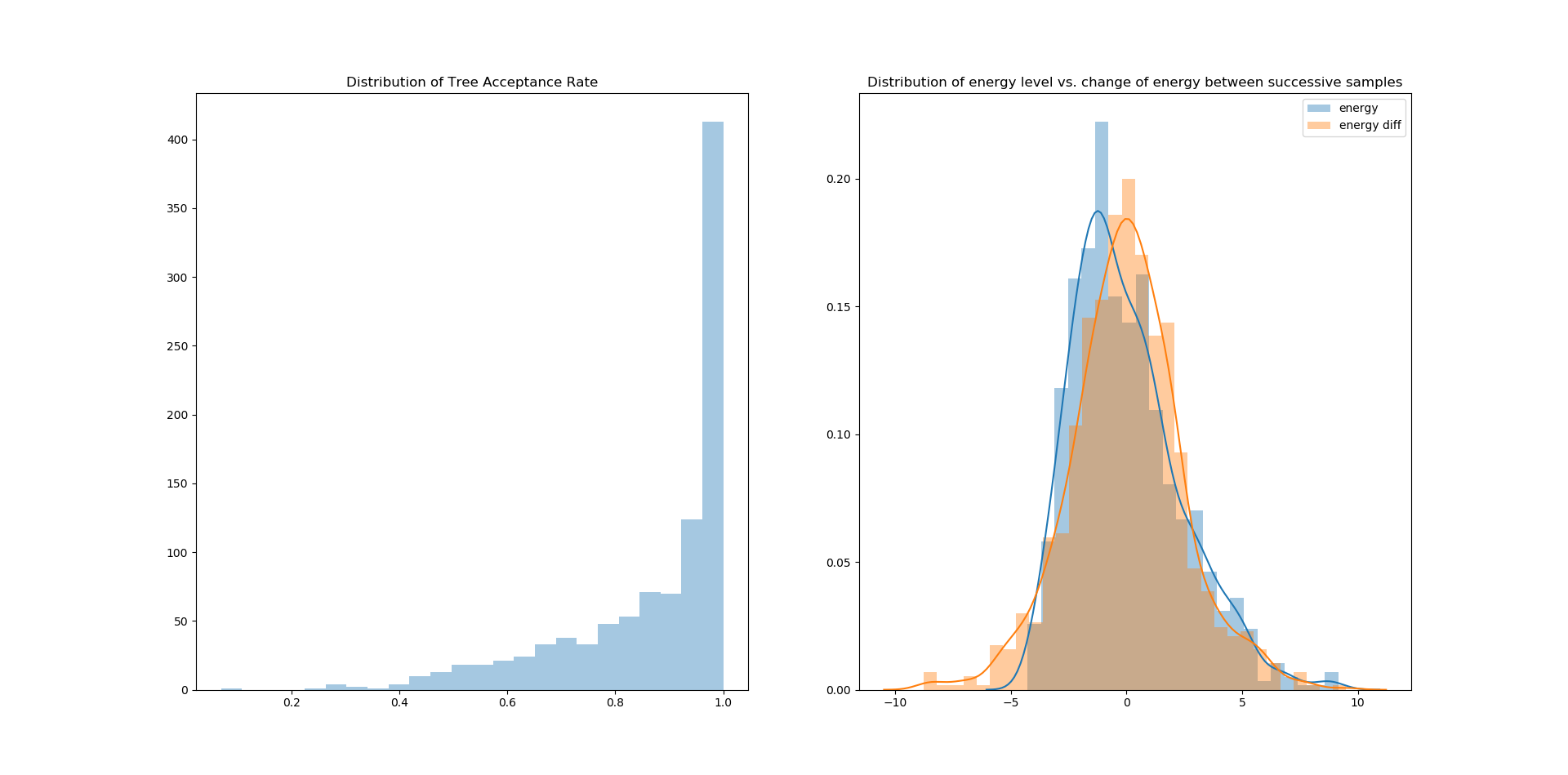
This model is trained for all nodes over all data point except when w\_t\_1\_i=1 or y\_t\_1=1

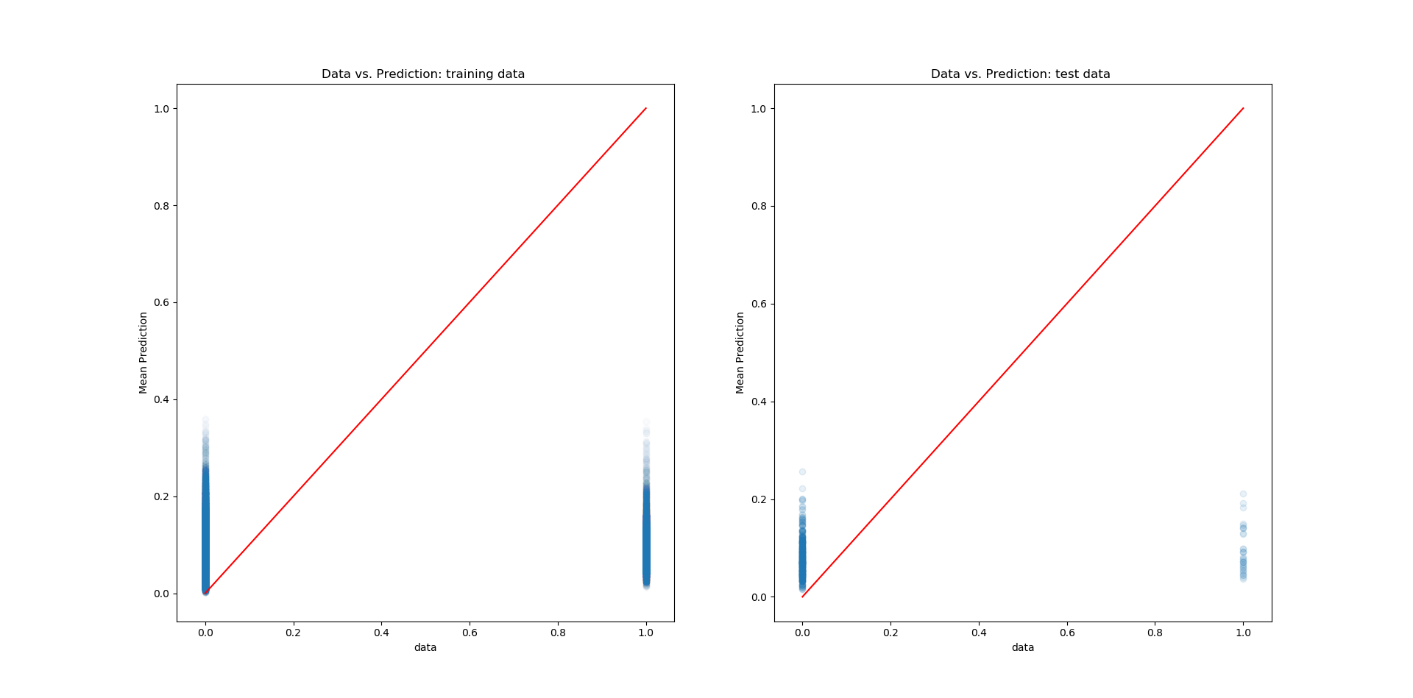
## Estimated Parameters

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | mean | sd | mc\_error | hpd\_2.5 | hpd\_97.5 | n\_eff | Rhat |
| Intercept | -3.3934 | 0.0271 | 0.0009 | -3.444 | -3.3421 | 671.7112 | 1.0056 |
| w\_n\_t\_1 | 0.2004 | 0.0108 | 0.0004 | 0.1812 | 0.222 | 635.4401 | 0.9998 |
| w\_a\_t\_1 | 0.2996 | 0.0105 | 0.0005 | 0.2792 | 0.3201 | 474.2668 | 1.0011 |
| w\_d\_t\_1 | -1.015 | 0.0473 | 0.0015 | -1.1051 | -0.9233 | 948.5553 | 0.9996 |
| time | 0.0273 | 0.0034 | 0.0001 | 0.0207 | 0.0339 | 795.0016 | 1.0035 |
| Training | data | R2: | 0.0166226 |  |  |  |  |
| Test | data | R2: | 0.0021912 |  |  |  |  |

## Figures







## Results

Not acceptable. Horrible prediction.

# Model 4

## Model form

where

p\_i = probability of being 1 for node i

N\_i = neighborhood of node i

## Estimated Parameters

## Figures

## Results

Not acceptable. Horrible prediction.

# Model 5

## Model form

where

w\_t\_i = state of a node i at time t given that w\_{t-1}=0

w\_{t-1},n = sum of the state of the neighbor nodes for a given node at time t-1

w\_{t-1},a = sum of the state of the connected arcs for a given node at time t-1

w\_{t-1},d = sum of the state of the dependee nodes for a given node at time t-1

This model is trained for each node over all data point except when w\_t\_1\_i=1 or y\_t\_1=1

## Results

Not acceptable. Horrible prediction.

# Model 6

## Model form

where

w\_t,i = state of a node i at time t

w\_t\_1,i = state of a node i at time t-1

w\_{t-1},n = sum of the state of the neighbor nodes for a given node at time t-1

w\_{t-1},a = sum of the state of the connected arcs for a given node at time t-1

w\_{t-1},d = sum of the state of the dependee nodes for a given node at time t-1

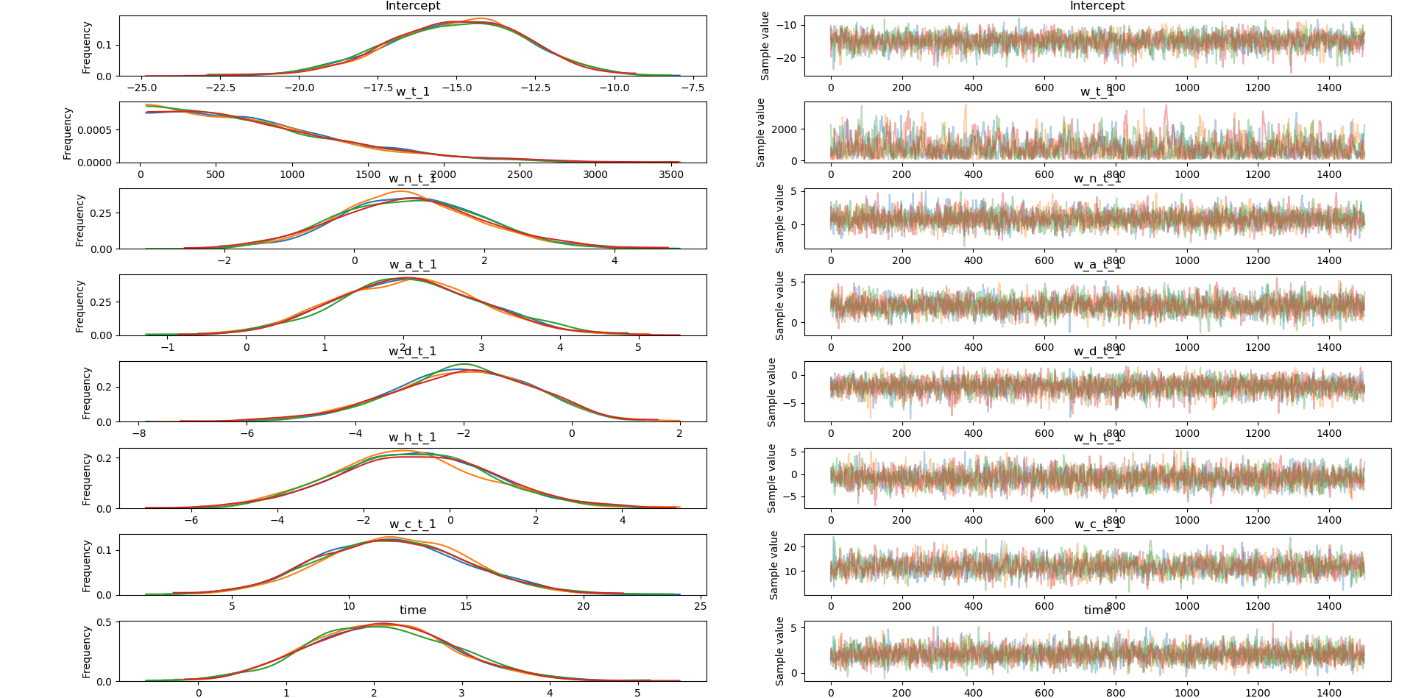
y\_t,i = state of an arc i at time t

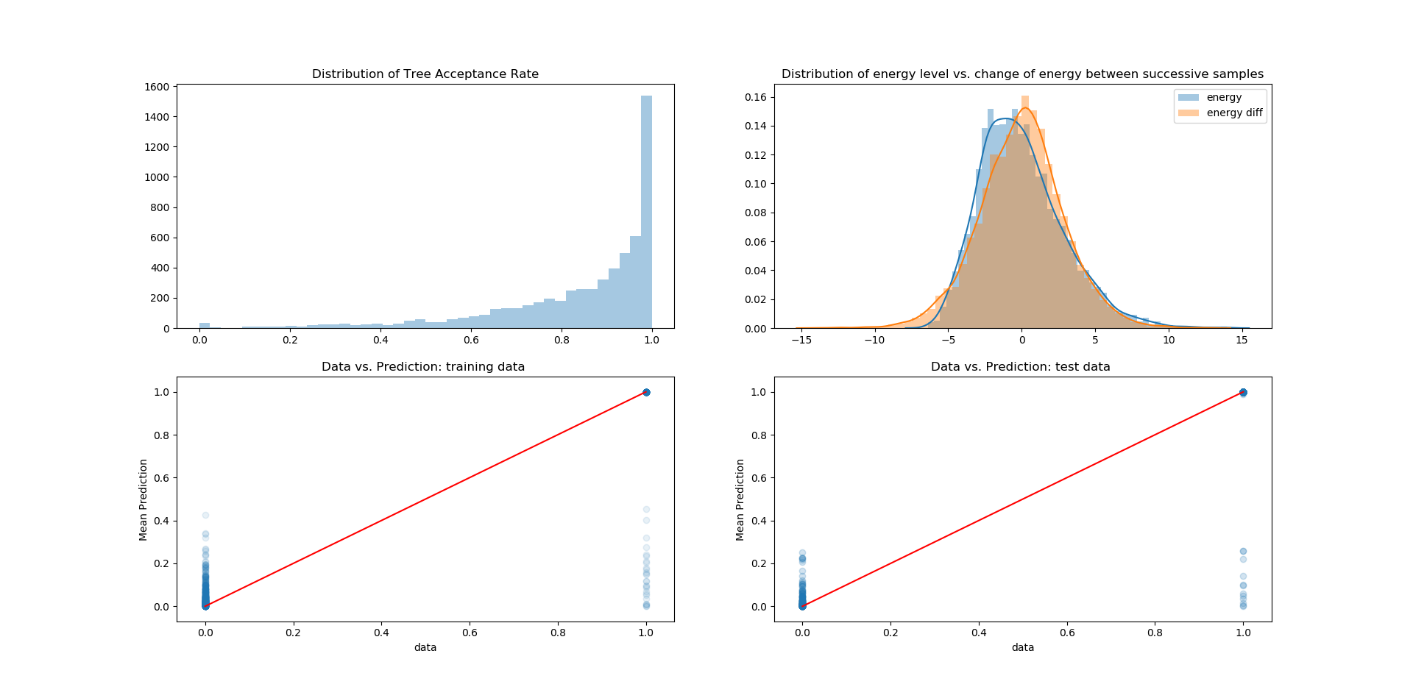
y\_{t-1},i = state of an arc i at time t-1

y\_{t-1},n = sum of the state of the connected nodes for a given arc at time t-1

This model is trained for each node and arcs over all data point including when w\_t\_1\_i=1 or y\_t\_1=1

## Results





Suspiciously good fit

# Model 7

## Model form

where

w\_t,i = state of a node i at time t

w\_t\_1,i = state of a node i at time t-1

w\_{t-1},n = sum of the state of the neighbor nodes for a given node at time t-1

w\_{t-1},a = sum of the state of the connected arcs for a given node at time t-1

w\_{t-1},h = sum of the state of the nodes (in the same layer) with highest absolute demand or supply at time t-1

w\_{t-1},c = sum of the state of all nodes (in the same layer) at time t-1

w\_{t-1},d = sum of the state of the dependee nodes for a given node at time t-1

This model is trained for each node over data points except when w\_t\_i=1 and w\_t\_1\_i=1.

## Results

Not good fits

# Model 8

## Model form

where

w\_t,i = state of a node i at time t

w\_{<t },i = sum of the states of a node i for time<t

w\_{<t },n = sum of the state of the neighbor nodes for a given node for time<t

w\_{<t },a = sum of the state of the connected arcs for a given node for time<t

w\_{<t },h = sum of the state of the nodes (in the same layer) with highest absolute demand or supply for time<t

w\_{<t },c = sum of the state of all nodes (in the same layer) at for time<t

w\_{<t },d = sum of the state of the dependee nodes for a given node for time<t

This model is trained for each node over data points except when w\_t\_i=1 and w\_t\_1\_i=1.

## Estimated Parameters

## Figures

## Results

Not good fits

# Model 9

## Model form

where

w\_t,i = state of a node i at time t

w\_{t-1},n = state of the neighbor node n at time t-1

w\_{t-1},a = state of the connected arcs a at time t-1

w\_{t-1},h = state of the node h (in the same layer) with highest absolute demand or supply at time t-1

w\_{t-1},d = state of the dependee node d at time t-1

This model is trained for each node over data points except when w\_t\_i=1 and w\_t\_1\_i=1.

## Results

Not good fits

# Model 10

## Model form

where

w\_t,i = state of a node i at time t

~~w\_{<t },i = sum of the states of a node i for time<t~~

w\_{<t },n = sum of the state of the neighbor nodes for a given node for time<t

w\_{<t },a = sum of the state of the connected arcs for a given node for time<t

w\_{<t },h = sum of the state of the nodes (in the same layer) with highest absolute demand or supply for time<t

w\_{<t },c = sum of the state of all nodes (in the same layer) for time<t

w\_{<t },d = sum of the state of the dependee nodes for a given node for time<t

y\_t,i = state of an arc i at time t

~~y\_{<t},i = state of an arc i for time<t~~

y\_{<t},n = sum of the state of the connected nodes for a given arc at for time<t

y\_{<t },c = sum of the state of all arcs (in the same layer) for time<t

This model is trained for each node over data points except when w\_t\_i=1 and w\_t\_1\_i=1 (the same for arcs).

## Results

Improves upon previous models but still not an acceptable fit

# Model 11

## Model form

where

w\_t,i = state of a node i at time t

w\_t\_1,i = state of a node i at time t-1

w\_{t-1},n = (normalized) sum of the state of the neighbor nodes for a given node at time t-1

w\_{t-1},a = (normalized) sum of the state of the connected arcs for a given node at time t-1

w\_{t-1},c = (normalized) sum of the state of all nodes (in the same layer) at time t-1

w\_{t-1},d = (normalized) sum of the state of the dependee nodes for a given node at time t-1

c\_{t-1},n = Node reconstruction cost for the entire interdependent network at time t-1

c\_{t-1},us = Under supply penalties for the entire interdependent network at time t-1

c\_{t-1},f = Flow cost for the entire interdependent network at time t-1

c\_{t-1},a = Arc reconstruction cost for the entire interdependent network at time t-1

This model is trained for each node over data points except when w\_t\_i=1 and w\_t\_1\_i=1.

## Results

Acceptable

Considering only local cost (for each layer) results in poorer predictions compared to the case with all global and local variables (average R2=12% as opposed to 15% on test data and average R2=26% as opposed to 34% on training data)

Considering only global costs results in almost the same predictions as of the case when all global and local variables are considered.

# Model 12

## Model form

where

w\_t,i = state of a node i at time t

w\_t\_1,i = state of a node i at time t-1

w\_{t-1},n = (normalized) sum of the state of the neighbor nodes for a given node at time t-1

w\_{t-1},a = (normalized) sum of the state of the connected arcs for a given node at time t-1

w\_{t-1},c = (normalized) sum of the state of all nodes (in the same layer) at time t-1

y\_{t-1},c = (normalized) sum of the state of all arcs (in the same layer) at time t-1

w\_{t-1},d = (normalized) sum of the state of the dependee nodes for a given node at time t-1

c\_{t-1},n = Node reconstruction cost for the entire interdependent network at time t-1

c\_{t-1},us = Under supply penalties for the entire interdependent network at time t-1

c\_{t-1},f = Flow cost for the entire interdependent network at time t-1

c\_{t-1},a = Arc reconstruction cost for the entire interdependent network at time t-1

R\_c = Number of available resources

This model is trained for each node over data points except when w\_t\_i=1 and w\_t\_1\_i=1.

## Results

Acceptable (better than Model 11 in terms of R^2)

# Model 13

## Model form

where

w\_t,i = state of a node i at time t

w\_t\_1,i = state of a node i at time t-1

w\_{t-1},n = (normalized) sum of the state of the neighbor nodes for a given node at time t-1

w\_{t-1},a = (normalized) sum of the state of the connected arcs for a given node at time t-1

w\_{t-1},c = (normalized) sum of the state of all nodes (in the same layer) at time t-1

w\_{t-1},d = (normalized) sum of the state of the dependee nodes for a given node at time t-1

c\_{t-1},n = Node reconstruction cost for the entire interdependent network at time t-1

c\_{t-1},us = Under supply penalties for the entire interdependent network at time t-1

c\_{t-1},f = Flow cost for the entire interdependent network at time t-1

c\_{t-1},a = Arc reconstruction cost for the entire interdependent network at time t-1

R\_c = Number of available resources

y\_t,i = state of an arc i at time t

y\_{t-1},i = state of an arc i at time t-1

y\_{t-1},c = (normalized) sum of the state of all arcs (in the same layer) at time t-1

y\_{t-1},n = (normalized) sum of the state of the connected nodes for a given arc at time t-1

This model is trained for each node over data points except when w\_t\_i=1 and w\_t\_1\_i=1 (or y\_t\_i=1 and y\_t\_1\_i=1).

## Results

Acceptable R^2 for nodes (around 50%) and low R^2 for arcs (around 20%)

# Model 14

## Model form

where

w\_t,i = state of a node i at time t

w\_t\_1,i = state of a node i at time t-1

w\_{t-1},n = (normalized) sum of the state of the neighbor nodes for a given node at time t-1

w\_{t-1},a = (normalized) sum of the state of the connected arcs for a given node at time t-1

w\_{t},c = (normalized) sum of the state of all nodes (in the same layer) at time t

w\_{t-1},c = (normalized) sum of the state of all nodes (in the same layer) at time t-1

w\_{t-1},d = (normalized) sum of the state of the dependee nodes for a given node at time t-1

c\_{t-1},n = Node reconstruction cost for the entire interdependent network at time t-1

c\_{t-1},us = Under supply penalties for the entire interdependent network at time t-1

c\_{t-1},f = Flow cost for the entire interdependent network at time t-1

c\_{t-1},a = Arc reconstruction cost for the entire interdependent network at time t-1

R\_c = Number of available resources

y\_t,i = state of an arc i at time t

y\_{t-1},i = state of an arc i at time t-1

y\_{t-1},c = (normalized) sum of the state of all arcs (in the same layer) at time t-1

y\_{t-1},n = (normalized) sum of the state of the connected nodes for a given arc at time t-1

This model is trained for each node over data points except when w\_t\_i=1 and w\_t\_1\_i=1 (or y\_t\_i=1 and y\_t\_1\_i=1).

## Results

Acceptable R^2 for nodes (around 50%) and lower R^2 for arcs (around 24%)

# Model 15

## Model form

where

w\_t,i = state of a node i at time t

w\_t\_1,i = state of a node i at time t-1

w\_{t-1},n = (normalized) sum of the state of the neighbor nodes for a given node at time t-1

w\_{t-1},h = (normalized) sum of the state of the nodes (in the same layer) with highest absolute demand or supply at time t-1

w\_{t-1},c = (normalized) sum of the state of all nodes (in the same layer) at time t-1

w\_{t-1},d = (normalized) sum of the state of the dependee nodes for a given node at time t-1

c\_{t-1},n = (normalized) Node reconstruction cost for the entire interdependent network at time t-1

c\_{t-1},t = (normalized) Total cost for the entire interdependent network at time t-1

c\_{t-1},f = (normalized) Flow cost for the entire interdependent network at time t-1

R\_c = (normalized) Number of available resources

This model is trained for each node over data points (from the initial scenarios with only nodes damaged) except when w\_t\_i=1 and w\_t\_1\_i=1.

## Results

Good R^2 for nodes (around 71%)