eisenberg-noe-2001-debt-model

October 23, 2021

```
----------------------------------------------------------

DEBT MODEL MODE

Running Debt Model in MANUAL mode with 3 nodes…

Scenario 1 - No firm defaults during first round, MODE == 'MANUAL', NUM_AGENTS =
3, NOMINAL_LIABILITY_MATRIX = np.array([[0,2,1],[3,0,1],[2,5,0]]),
OPERATING_CASH_FLOW_VECTOR = [5, 4, 5]

----------------------------------------------------------

AGENT LABELS

Agent labels ['A', 'B', 'C']

----------------------------------------------------------

NOMINAL LIABILITY MATRIX Data Frame
i.e. what node i expects to pay node j…

   A  B  C
A  0  2  1
B  3  0  1
C  2  5  0



Nominal liabilities for each node:
Liability of Node A to Node B is 2
Liability of Node A to Node C is 1
Liability of Node B to Node A is 3
Liability of Node B to Node C is 1
Liability of Node C to Node A is 2
Liability of Node C to Node B is 5

NOMINAL LIABILITY MATRIX TRANSPOSED Data Frame
i.e. what node j expects to receive from i…
```

```
   A  B  C
A  0  3  2
B  2  0  5
C  1  1  0


Node A expects to receive 3 from Node B
Node A expects to receive 2 from Node C
Node B expects to receive 2 from Node A
Node B expects to receive 5 from Node C
Node C expects to receive 1 from Node A
Node C expects to receive 1 from Node B

-----------------------------------------------------------

OPERATING CASH FLOW VECTOR

Exogenous cash flow for Node A: 5
Exogenous cash flow for Node B: 4
Exogenous cash flow for Node C: 5
[5, 4, 5]

-----------------------------------------------------------

CALCULATING RELATIVE LIABILITIES FOR EACH NODE

***Node A***

- Liabilities for Node A
Liability of Node A to Node B (i.e. P_01) is 2.0
Liability of Node A to Node C (i.e. P_02) is 1.0

- Total obligations for Node A
Total Obligation Vector updated in round 1 for Node A with value 3.0
Total nominal liabilities for Node A (i.e. p_bar_1) is 3.0

- Relative Liabilities of Node A
Relative Liability of Node A to Node B is 0.6666666666666666
Relative Liability of Node A to Node C is 0.3333333333333333
Sum of Relative Liabilities for Node A is 1.0

***Node B***

- Liabilities for Node B
Liability of Node B to Node A (i.e. P_10) is 3.0
Liability of Node B to Node C (i.e. P_12) is 1.0

- Total obligations for Node B
```

```
Total Obligation Vector updated in round 1 for Node B with value 4.0
Total nominal liabilities for Node B (i.e. p_bar_2) is 4.0

- Relative Liabilities of Node B
Relative Liability of Node B to Node A is 0.75
Relative Liability of Node B to Node C is 0.25
Sum of Relative Liabilities for Node B is 1.0

***Node C***

- Liabilities for Node C
Liability of Node C to Node A (i.e. P_20) is 2.0
Liability of Node C to Node B (i.e. P_21) is 5.0

- Total obligations for Node C
Total Obligation Vector updated in round 1 for Node C with value 7.0
Total nominal liabilities for Node C (i.e. p_bar_3) is 7.0

- Relative Liabilities of Node C
Relative Liability of Node C to Node A is 0.2857142857142857
Relative Liability of Node C to Node B is 0.7142857142857143
Sum of Relative Liabilities for Node C is 1.0

------------------------------------------------------------

RELATIVE LIABILITY MATRIX Data Frame

          A         B         C
A  0.000000  0.666667  0.333333
B  0.750000  0.000000  0.250000
C  0.285714  0.714286  0.000000



------------------------------------------------------------

RELATIVE LIABILITY MATRIX Data Frame SANITY CHECK

          A         B         C  Relative Liability Total  CORRECT VALUE?
A  0.000000  0.666667  0.333333                       1.0            True
B  0.750000  0.000000  0.250000                       1.0            True
C  0.285714  0.714286  0.000000                       1.0            True



------------------------------------------------------------

RELATIVE LIABILITY MATRIX TRANSPOSED Data Frame
i.e. what node i expects to receive from j in relative terms…
```

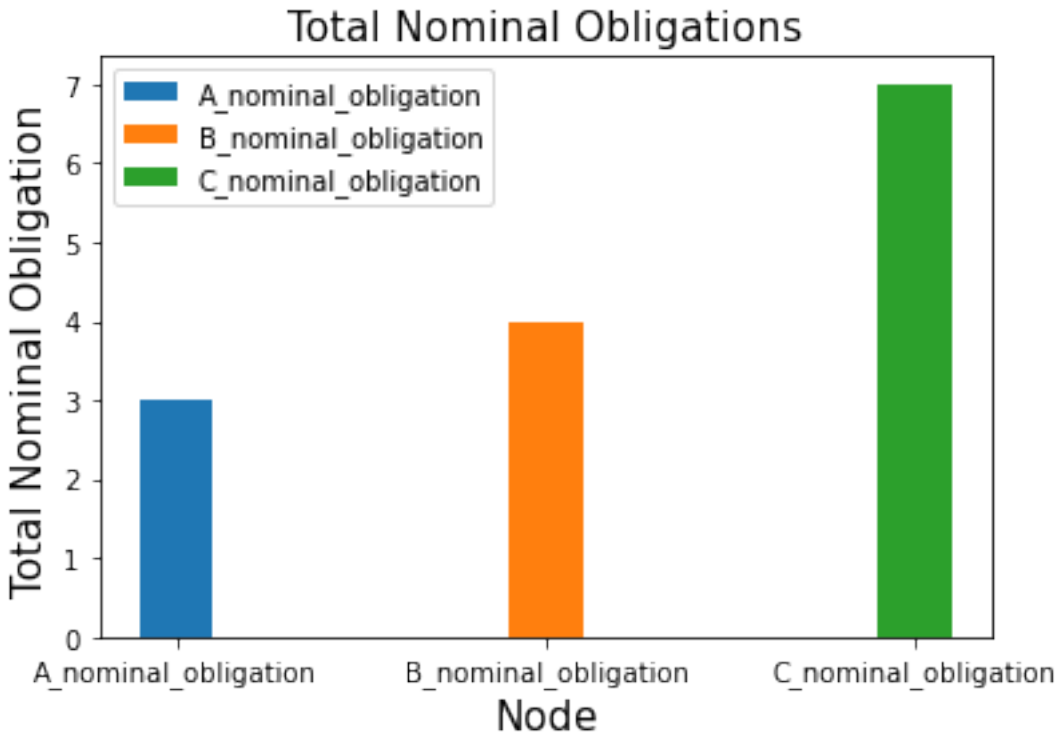
```
          A     B         C
A  0.000000  0.75  0.285714
B  0.666667  0.00  0.714286
C  0.333333  0.25  0.000000


***Expected nominal payments in for Node A - both proportion and total amount***

Node A expects to receive proportion 0.75 from Node B
Node A expects to receive proportion 0.2857142857142857 from Node C
Total payments in to Node A is 5.0

***Expected nominal payments in for Node B - both proportion and total amount***

Node B expects to receive proportion 0.6666666666666666 from Node A
Node B expects to receive proportion 0.7142857142857143 from Node C
Total payments in to Node B is 7.0

***Expected nominal payments in for Node C - both proportion and total amount***

Node C expects to receive proportion 0.3333333333333333 from Node A
Node C expects to receive proportion 0.25 from Node B
Total payments in to Node C is 2.0

------------------------------------------------------------



------------------------------------------------------------

START OF ROUND 1

------------------------------------------------------------

TOTAL OBLIGATION VECTOR

i.e. total nominal obligations for each node i.e. p_bar_i…
Total nominal obligation for Node A (i.e. p_bar_1): 3.0
Total nominal obligation for Node B (i.e. p_bar_2): 4.0
Total nominal obligation for Node C (i.e. p_bar_3): 7.0

------------------------------------------------------------

TOTAL PAYMENT MADE PER NODE

i.e. min[nominal obligations, cashflow (payments in + exogenous cash flow)] for
each node…
```

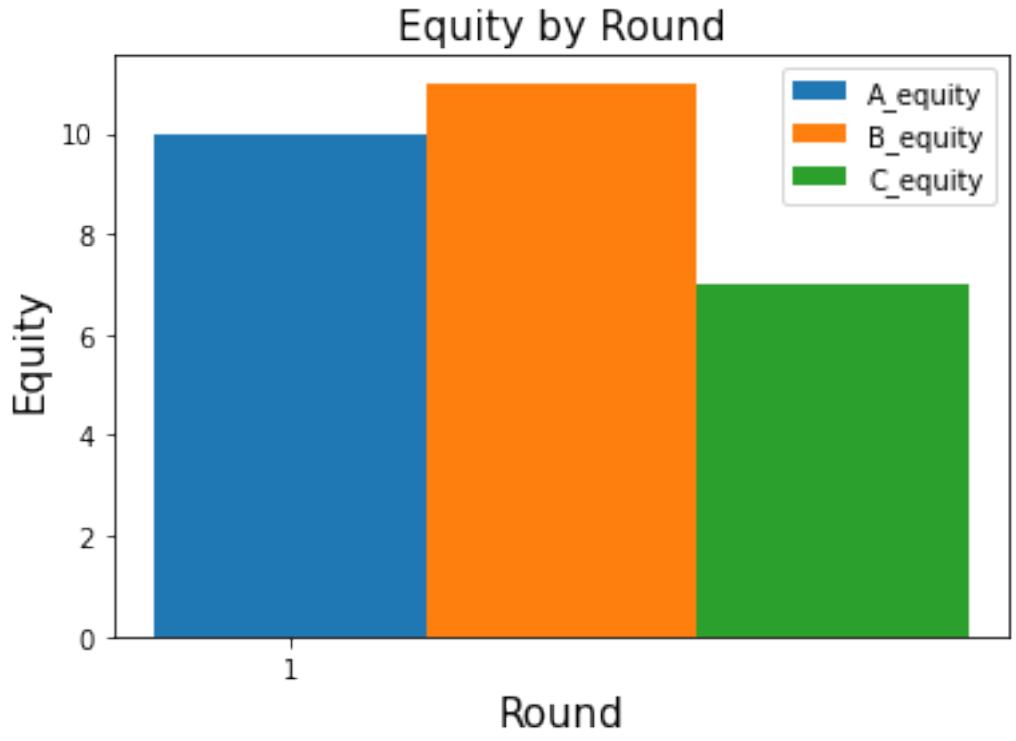
```
***Node A***

- Total payments in for Node A
Total payments in to Node A is 5.0

- Liabilities for Node A
Liability of Node A to Node B (i.e. P_01) is 2.0
Liability of Node A to Node C (i.e. P_02) is 1.0

- Total obligations for Node A
Total nominal liabilities for Node A (i.e. p_bar_1) is 3.0
Payment out is min[payment out, total cash flow] i.e. min[3.0, 10.0]

 - Total Dollar Payment Vector for round 1 and Node A
Total Dollar Payment Vector for round 1 and Node A updated with value 3.0

***Node B***

- Total payments in for Node B
Total payments in to Node B is 7.0

- Liabilities for Node B
Liability of Node B to Node A (i.e. P_10) is 3.0
Liability of Node B to Node C (i.e. P_12) is 1.0

- Total obligations for Node B
Total nominal liabilities for Node B (i.e. p_bar_2) is 4.0
Payment out is min[payment out, total cash flow] i.e. min[4.0, 11.0]

 - Total Dollar Payment Vector for round 1 and Node B
Total Dollar Payment Vector for round 1 and Node B updated with value 4.0

***Node C***

- Total payments in for Node C
Total payments in to Node C is 2.0

- Liabilities for Node C
Liability of Node C to Node A (i.e. P_20) is 2.0
Liability of Node C to Node B (i.e. P_21) is 5.0

- Total obligations for Node C
Total nominal liabilities for Node C (i.e. p_bar_3) is 7.0
Payment out is min[payment out, total cash flow] i.e. min[7.0, 7.0]

 - Total Dollar Payment Vector for round 1 and Node C
Total Dollar Payment Vector for round 1 and Node C updated with value 7.0
```

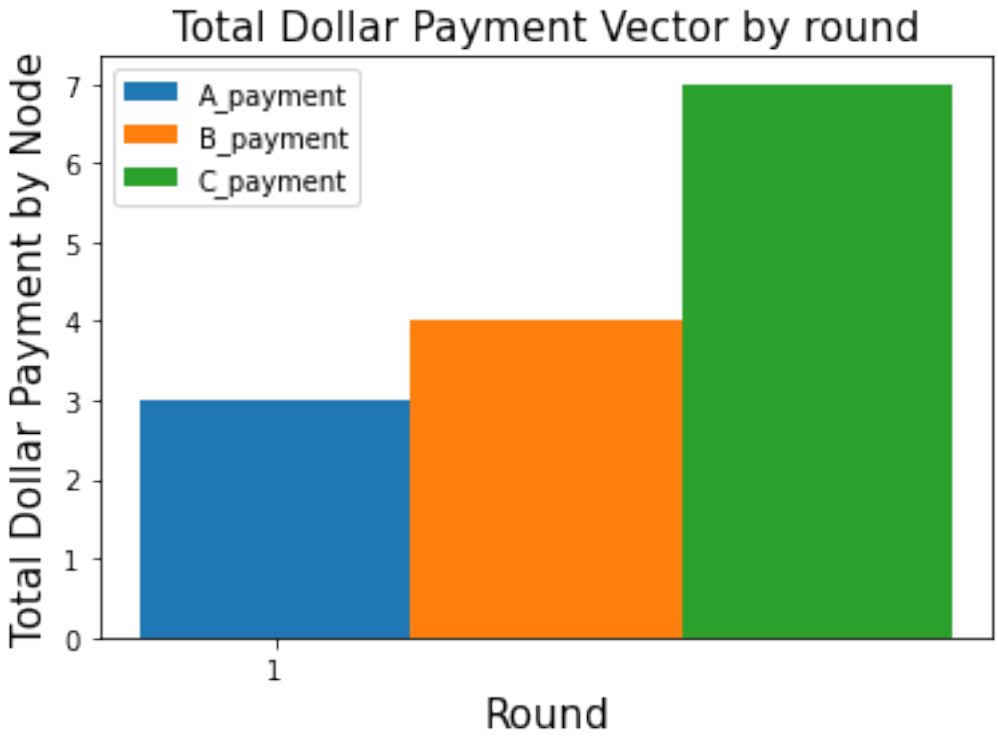
```
-------------------------------------------------------

TOTAL PAYMENT VECTOR

Total payment by Node A (i.e. p_1): 3.0
Total payment by Node B (i.e. p_2): 4.0
Total payment by Node C (i.e. p_3): 7.0
[3.0, 4.0, 7.0]

-------------------------------------------------------

UPDATE EQUITY FOR EACH NODE

Total payments in to Node A is 5.0
Total dollar payment by Node A (i.e. p_1) is 3.0

 - Equity Vector for round 1 and Node A
Equity Vector for round 1 and Node A updated with value 10.0
Total payments in to Node B is 7.0
Total dollar payment by Node B (i.e. p_2) is 4.0

 - Equity Vector for round 1 and Node B
Equity Vector for round 1 and Node B updated with value 11.0
Total payments in to Node C is 2.0
Total dollar payment by Node C (i.e. p_3) is 7.0

 - Equity Vector for round 1 and Node C
Equity Vector for round 1 and Node C updated with value 7.0

-------------------------------------------------------

EQUITY FOR EACH NODE

Equity for Node A: 10.0
Equity for Node B: 11.0
Equity for Node C: 7.0
[10.0, 11.0, 7.0]

-------------------------------------------------------

ROUND 1 DEFAULTERS

{'A': False, 'B': False, 'C': False}
There are no defaulters, algorithm will not proceed for another round.

***Checking limited liability and absolute priority for Node A***

Total dollar payment by Node A (i.e. p_1) is 3.0
```

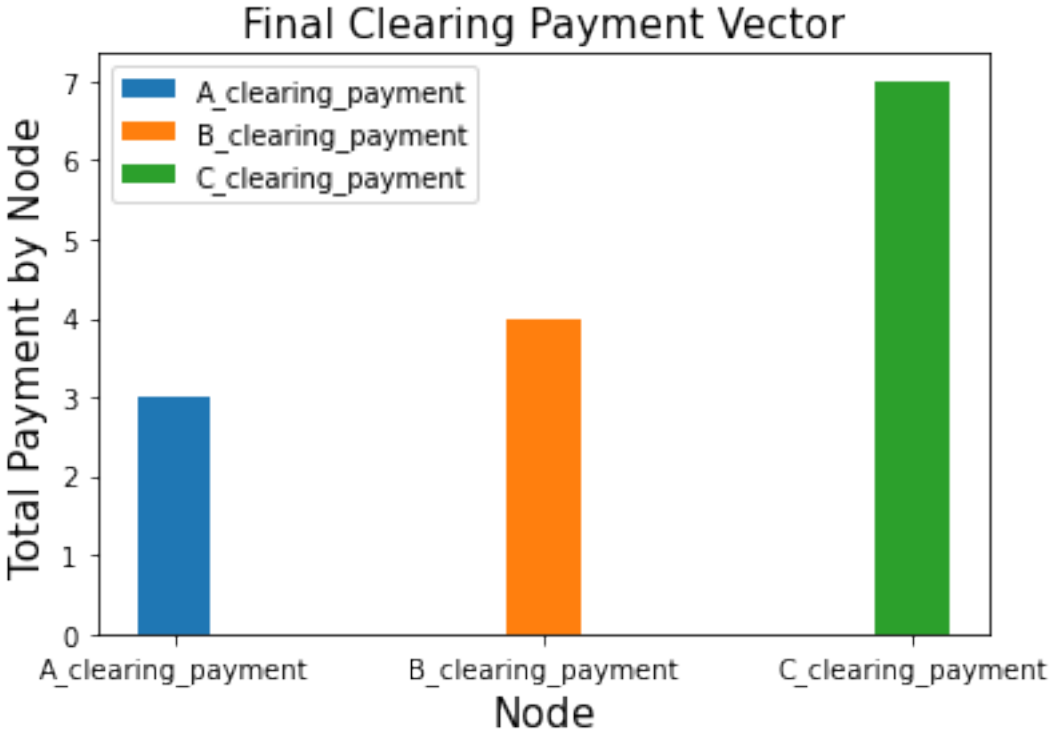
```
Total payments in to Node A is 5.0

- Limited liability is met. Node A made a payment of 3.0 in round 1 which is
less than or equal to the cash flow (payments in + exogenous cash) of 10.0.
Total nominal obligation for Node A (i.e. p_bar_1): 3.0
Total dollar payment by Node A (i.e. p_1) is 3.0
Total payments in to Node A is 5.0

 -Checking absolute priority for Node A in round 1. Nominal obligations is 3.0
and Dollar payments is 3.0
-Absolute priority is satisfied for Node A

- Absolute priority is met by Node A in round 1 i.e. either obligations are paid
in full or all available cash flow (i.e. sum of the payments received by the
node plus the exogenous operating cash flow) is paid to creditors. Nominal
obligations were 3.0,  Dollar payment was 3.0 and Total cash flow was 10.0

Node A in round 1 passes candidate clearing vector payment entry checks.

***Checking limited liability and absolute priority for Node B***

Total dollar payment by Node B (i.e. p_2) is 4.0
Total payments in to Node B is 7.0

- Limited liability is met. Node B made a payment of 4.0 in round 1 which is
less than or equal to the cash flow (payments in + exogenous cash) of 11.0.
Total nominal obligation for Node B (i.e. p_bar_2): 4.0
Total dollar payment by Node B (i.e. p_2) is 4.0
Total payments in to Node B is 7.0

 -Checking absolute priority for Node B in round 1. Nominal obligations is 4.0
and Dollar payments is 4.0
-Absolute priority is satisfied for Node B

- Absolute priority is met by Node B in round 1 i.e. either obligations are paid
in full or all available cash flow (i.e. sum of the payments received by the
node plus the exogenous operating cash flow) is paid to creditors. Nominal
obligations were 4.0,  Dollar payment was 4.0 and Total cash flow was 11.0

Node B in round 1 passes candidate clearing vector payment entry checks.

***Checking limited liability and absolute priority for Node C***

Total dollar payment by Node C (i.e. p_3) is 7.0
Total payments in to Node C is 2.0

- Limited liability is met. Node C made a payment of 7.0 in round 1 which is
less than or equal to the cash flow (payments in + exogenous cash) of 7.0.
```

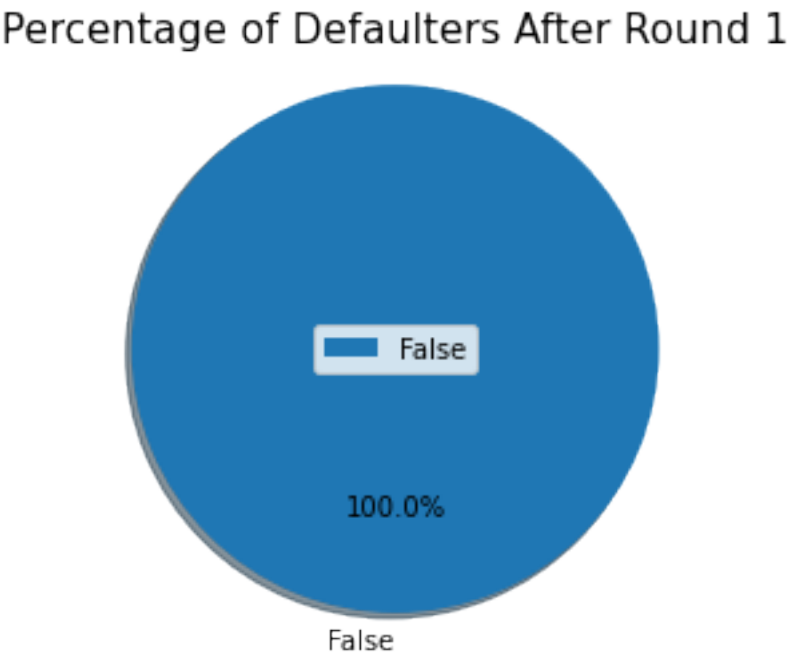
```
Total nominal obligation for Node C (i.e. p_bar_3): 7.0
Total dollar payment by Node C (i.e. p_3) is 7.0
Total payments in to Node C is 2.0

 -Checking absolute priority for Node C in round 1. Nominal obligations is 7.0
and Dollar payments is 7.0
-Absolute priority is satisfied for Node C

- Absolute priority is met by Node C in round 1 i.e. either obligations are paid
in full or all available cash flow (i.e. sum of the payments received by the
node plus the exogenous operating cash flow) is paid to creditors. Nominal
obligations were 7.0,  Dollar payment was 7.0 and Total cash flow was 7.0

Node C in round 1 passes candidate clearing vector payment entry checks.

-----------------------------------------------------------

CLEARING_PAYMENT_VECTOR

Clearing payment vector found in round 1.
[3.0, 4.0, 7.0]
Node A pays: 3.0
Node B pays: 4.0
Node C pays: 7.0

-----------------------------------------------------------

END OF ROUND 1
- Systemic Risk: Node A has not defaulted after 1 rounds. There are 3 nodes in
the  system (0 of which have defaulted i.e. []).
- Systemic Risk: Node B has not defaulted after 1 rounds. There are 3 nodes in
the  system (0 of which have defaulted i.e. []).
- Systemic Risk: Node C has not defaulted after 1 rounds. There are 3 nodes in
the  system (0 of which have defaulted i.e. []).
```


Total Nominal Obligations
A_nominal_obligation
B_nominal_obligation
C_nominal_obligation
Total Nominal Obligation
0
1
2
3
4
5
6
7
A_nominal_obligation
B_nominal_obligation
C_nominal_obligation
Node


Equity by Round
A_equity
B_equity
C_equity
Equity
0
2
4
6
8
10
1
Round


Total Dollar Payment Vector by round
A_payment
B_payment
C_payment
Total Dollar Payment by Node
0
1
2
3
4
5
6
7
1
Round


Final Clearing Payment Vector
A_clearing_payment
B_clearing_payment
C_clearing_payment
Total Payment by Node
0
1
2
3
4
5
6
7
A_clearing_payment
B_clearing_payment
C_clearing_payment
Node




```
Node A has NOT defaulted in round 1
Node B has NOT defaulted in round 1
Node C has NOT defaulted in round 1
```

[225]:
```
'\nUnused  plots\n# if you wish to track each node\'s default values\nfor round
in DEFAULTERS_VECTOR:\n    # iterate over total dollar payment vector for a
round, return index and each individual value\n    for index, value in
enumerate(defaulters_vector_for_round):\n        # assign a node key based on
index e.g. index 0 is A_default, index 1 is B_default\n        node_key =
AGENT_LABELS[index] + "_default" \n        \n        # update list of keys for
total dollar payments i.e. A_default, B_default etc\n
DEFAULT_LABELS.append(node_key)\n        \n        # update list of values for
node e.g. list of defaults by round boolean for node A identified by A_default
\n        GRAPH_DICT[node_key].append(value)\n\n# plot defaults\nfor graph_key
in graph_dict_keys:\n    # check for payment labels e.g. A_payment, B_payment
etc\n    if graph_key in DEFAULT_LABELS:\n        # return list of default
indicators for a node\n        default_indicators_for_node =
GRAPH_DICT[graph_key]\n        print(graph_key)\n
print(default_indicators_for_node)\n                \n        # return count of
default indicators for node\n        length_default_indicators_for_node =
len(default_indicators_for_node)\n        \n        # return corresponding
rounds made by node, starting from 1\n        default_inidcator_rounds =
list(range(1, length_default_indicators_for_node + 1))\n        #
print("default_inidcator_rounds ", default_inidcator_rounds)\n        \n
# for each payment made by the node, add a bar to the graph\n
```

```
plt.bar(width_adjusted_x_values, dollar_payment_values_for_node, width=width,
label=graph_key)\n        #dollar_payment_legend.append(bar1)\n\n'
```