An Interbank system: relationships

Hector Castillo hector@bith.net

Table of contents

We were using initially in `interbank.py` random links between banking system. In this study we face the problem to determine for the central bank the best way to priorize one links or anothers with the upper objective to spread and increase the liquidity of the system.

By design $\hat{d} = 1$, which means we limit to one outgoing link for each bank (not limiting the incoming links). Thus borrowers can only get loans from $\hat{d}$, lenders.

Setting up links

Starting links

Each banks choose randomly a lender. Only restriction is that lender should not be itself. Figure 1 represents a picture of the relationships between banks in a precise instant.

In the next instant $t = 1$ the link is changed or not depending on the fitness μ of the current lender and a possible new one (selected again randomly) as Equation 1 indicates:

$$P_t^j = \frac{1}{1 + e^{-\beta}(\mu_t^k - \mu_t^i)} \tag{1}$$

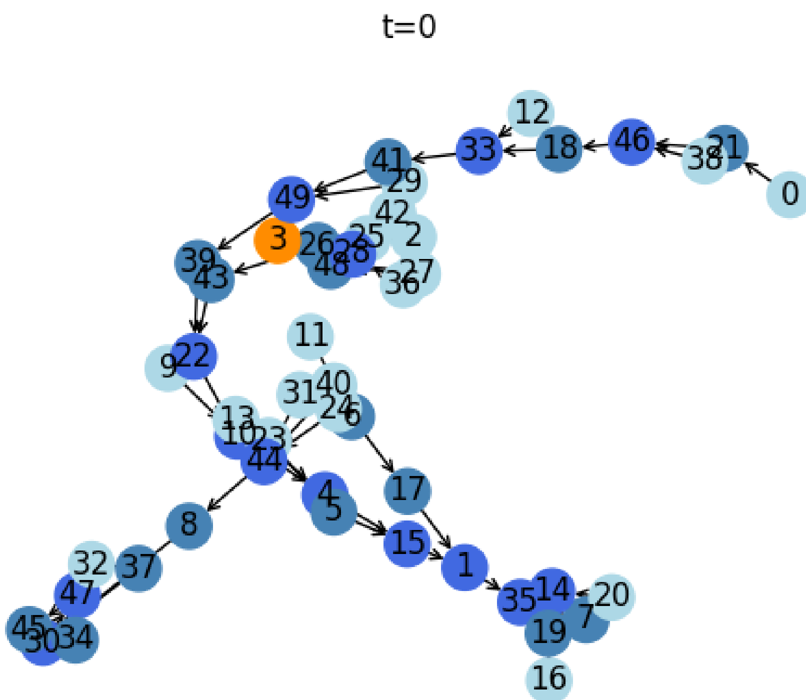


Figure 1: Random initial graph of banks' links

`ShockedMarket`

It is a method though to represent a shocked market in which there are few links between banks: no one trust in another, so the majority of them are isolated and no outgoing link. It is created using a Erdős–Rényi like the example in Figure 2.

Figure 2: Example of an Erdős–Rényi directed graph with $p = 0.01$. Only five connections between nine banks isolated in three islands .

Changes made in the algorithm:

- If initially the bank has no lender, it will never have one: the $t = 0$ situation of lenders are sustained till the end $t = T$.
- Without a lender the balance in this case is harder: deposit shocks conduct faster to bankruptcy.
- If the bank goes bankruptcy, it is created again with the same lender (if it has one).
- Greater the p parameter of the Erdős–Rényi graph generator, more links we will have.

Model behaviour with few relationships (after a shock)

With $p = 0.0001$ we unlikely will obtain any relationship in a Erdős–Rényi. We will start with $p = 0.001$, which has in one of the ten executions we will run, this Figure 3 Erdős–Rényi relationships between banks:

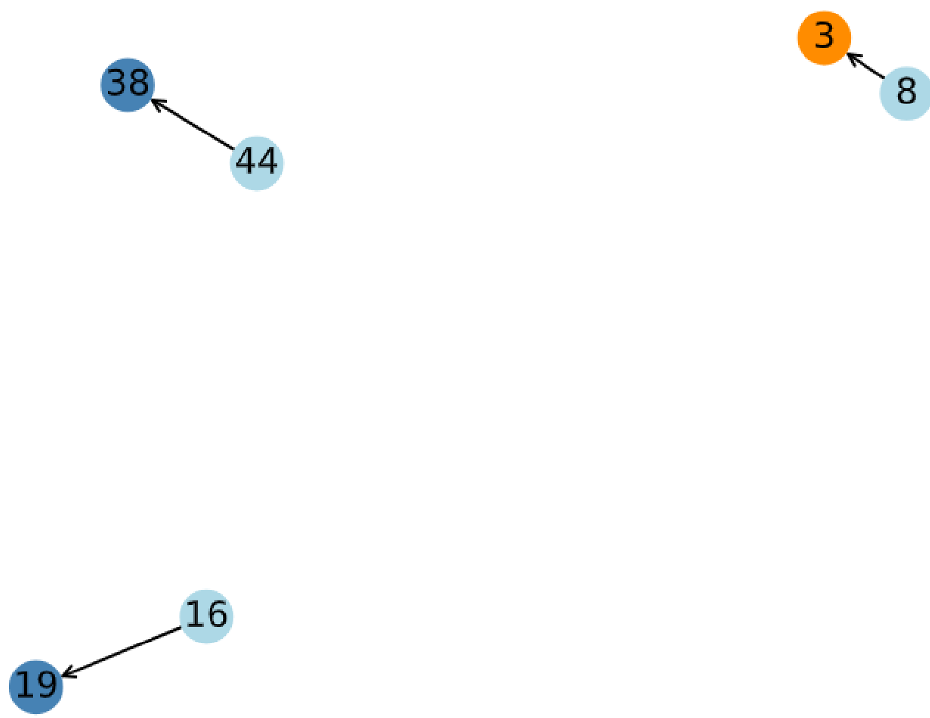


Figure 3: $p = 0.001$

When we increase p, the links also grow, like Figure 4:

And when we arrive to $p = 0.1$ the number of connections are enough to be all the combinations Notice that in this case, for each instance ONLY one one the possible links is choosen from the different options for each bank by random (it means that no bank has more than one output connection at the same instant). So the the Erdős–Rényi graph of **?@fig-p01** is transformed in **?@fig-p01b**.

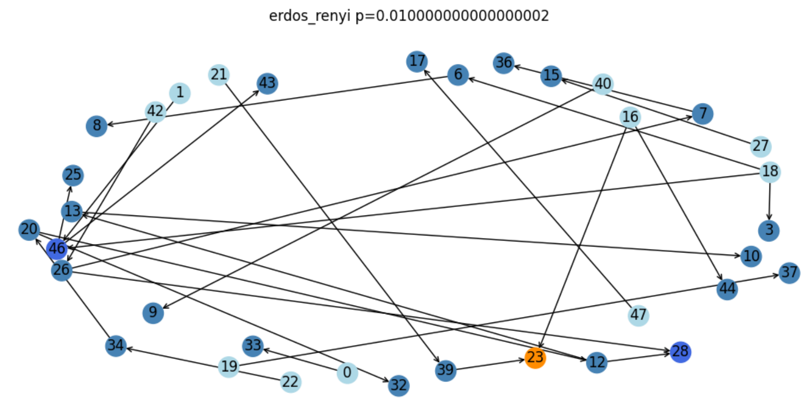
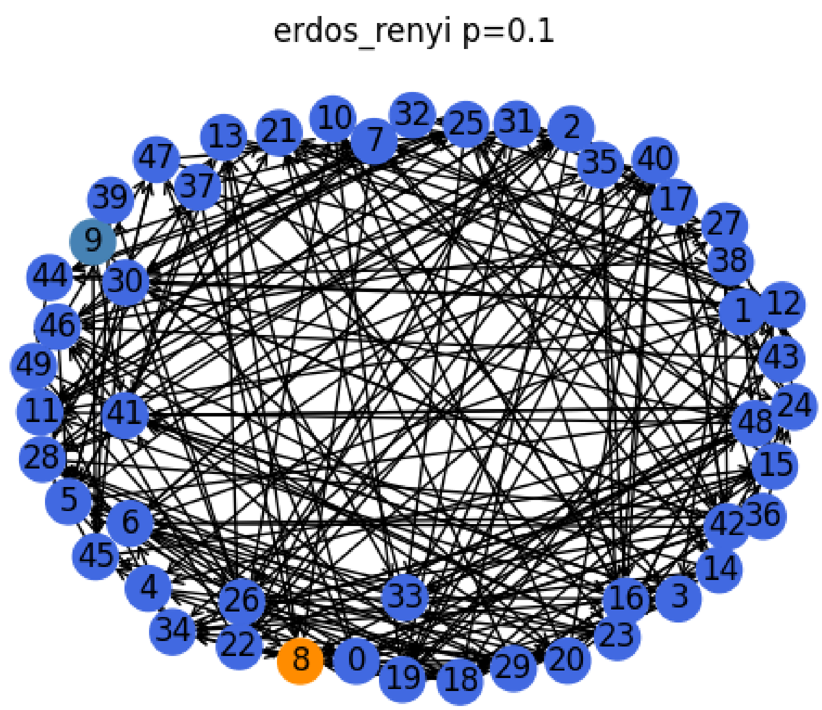
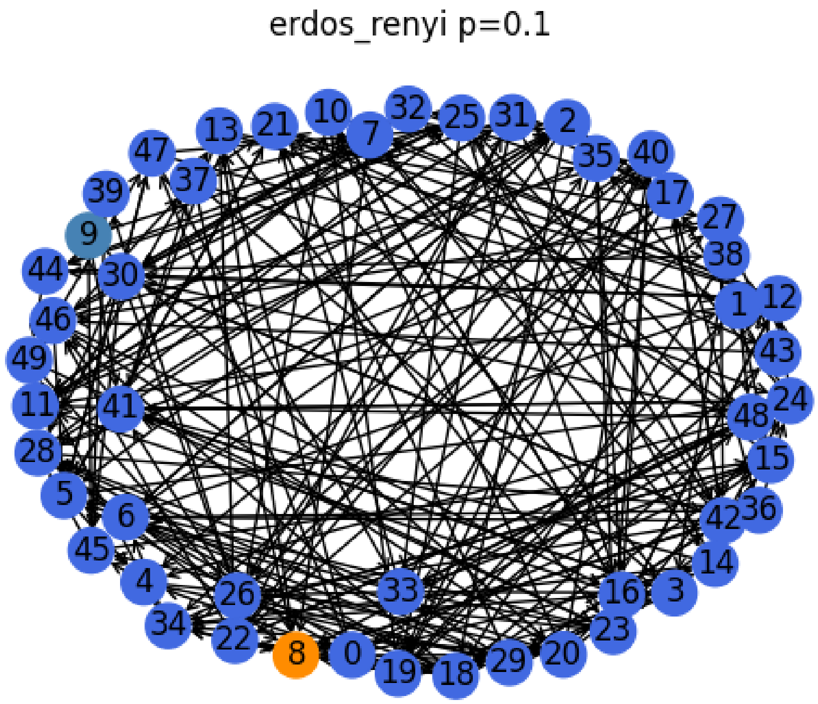


Figure 4: $p = 0.01$





Moving from $p = 0.001$ to $p = 0.1$ with a total of 100 steps (+0.001 in each), we obtain this evolution of the liquidity, plotting the average of 10 different simulations for each step in Figure 5.

The problem with the current algorithm is when we face to a failure, we recreate a bank with the same initial strenght, as in Figure 7 notices the absence of lenders with $p = 0.005$ in this case and in the other hand, many failures.

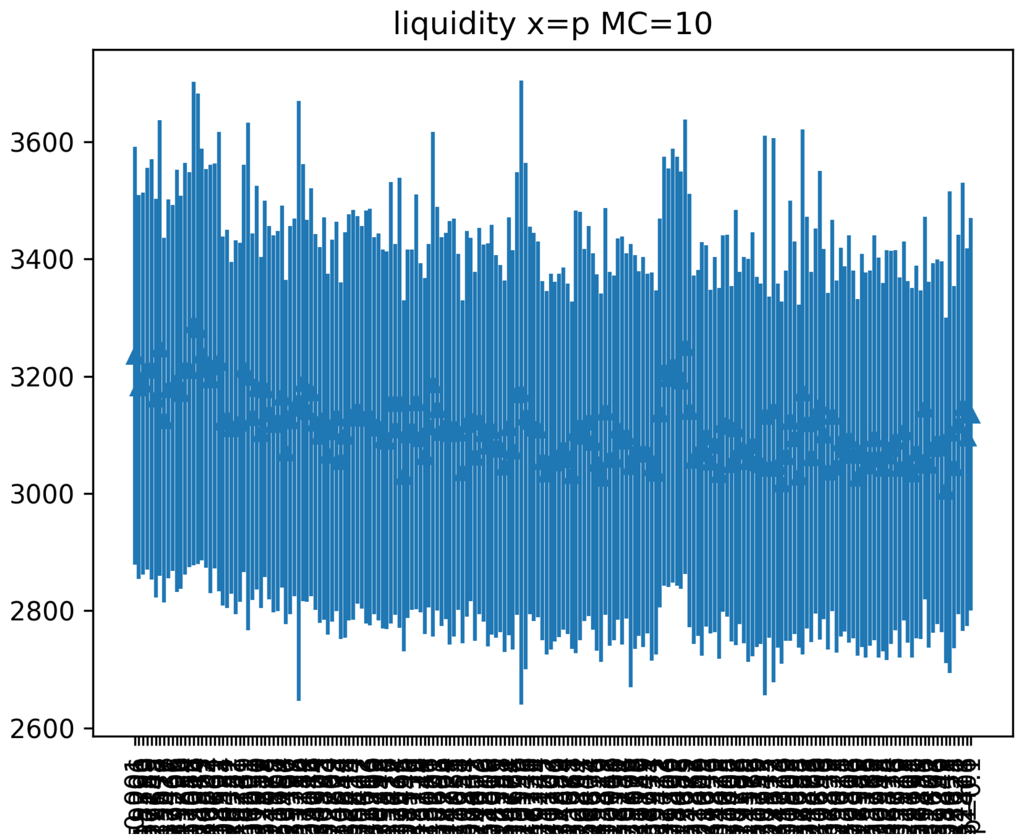


Figure 5: Liquidity of the simulation

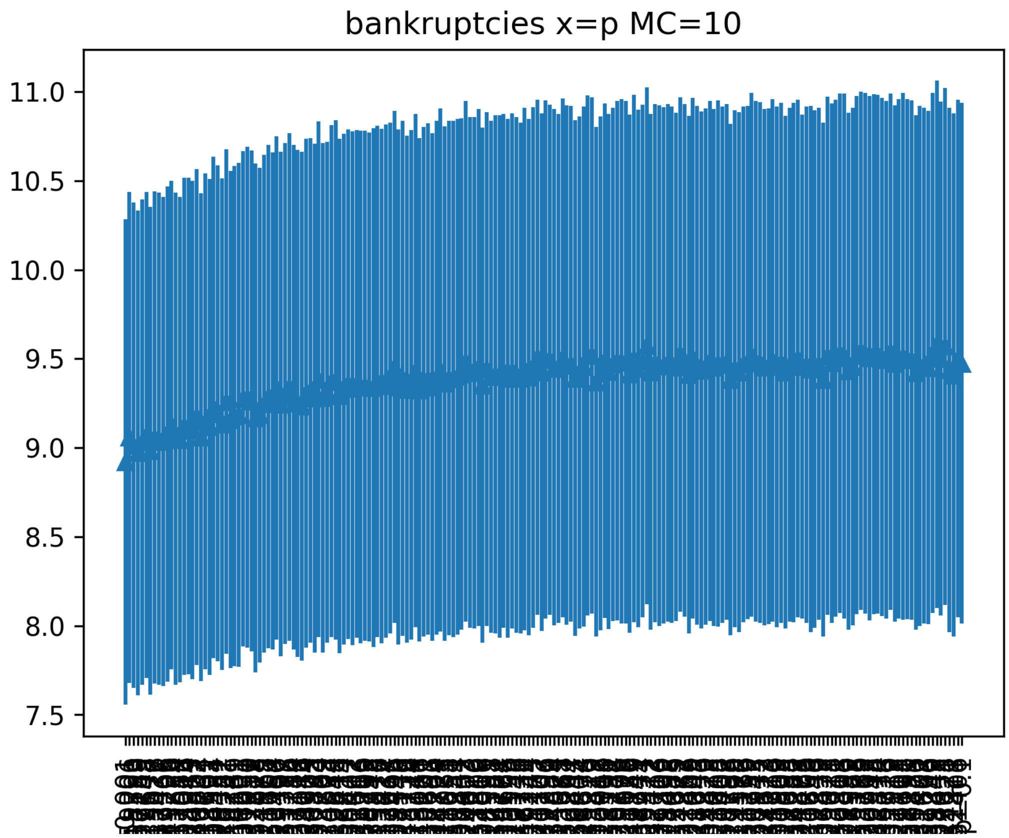


Figure 6: Bankruptcies

```
NFO-interbank-  t=010/-----  bank#22.1  C=160.3 L=120.0          | D=265.3 E=15.00          s=160.3
NFO-interbank-  t=010/-----  bank#23.1  C=64.92 L=105.4          | D=165.5 E= 4.84          s=64.92
NFO-interbank-  t=010/-----  bank#24.4  C=17.94 L=120.0          | D=122.9 E=15.00
NFO-interbank-  t=010/-----  bank#25.4  C= 6.42 L=103.0          | D=106.3 E= 3.10          s= 6.42
NFO-interbank-  t=010/-----  bank#26.3  C= 9.11 L=120.0          | D=114.1 E=15.00          s= 9.11
NFO-interbank-  t=010/-----  bank#27.3  C= 0.00 L=106.8          | D=101.0 E= 5.82          d= 3.93 no lender
NFO-interbank-  t=010/-----  bank#28.2  C=42.66 L=120.0          | D=147.6 E=15.00
NFO-interbank-  t=010/-----  bank#29.2  C=61.24 L=120.0          | D=166.2 E=15.00          s=61.24
NFO-interbank-  t=010/-----  bank#30.2  C= 6.79 L=120.0          | D=111.7 E=15.00
NFO-interbank-  t=010/-----  bank#31.4  C= 0.00 L=93.91          | D= 0.00 E=-3.26          d= 7.83 FAILED
NFO-interbank-  t=010/-----  bank#32.3  C=102.6 L=116.6          | D=206.6 E=12.65          s=102.6
NFO-interbank-  t=010/-----  bank#33.2  C=155.2 L=120.0          | D=260.2 E=15.00          s=155.2
NFO-interbank-  t=010/-----  bank#34.1  C=15.84 L=117.6          | D=120.1 E=13.36
NFO-interbank-  t=010/-----  bank#35.1  C=93.24 L=120.0          | D=198.2 E=15.00          s=93.24
NFO-interbank-  t=010/-----  bank#36.2  C=10.11 L=120.0          | D=115.1 E=15.00          s=10.11
NFO-interbank-  t=010/-----  bank#37.1  C=70.11 L=120.0          | D=175.1 E=15.00          s=70.11
NFO-interbank-  t=010/-----  bank#38.2  C= 0.00 L=93.57          | D= 0.00 E=-25.9          d= 7.93 FAILED
NFO-interbank-  t=010/-----  bank#39.1  C=22.72 L=120.0          | D=127.7 E=15.00
NFO-interbank-  t=010/-----  bank#40    C=43.71 L=120.0          | D=148.7 E=15.00          s=43.71
NFO-interbank-  t=010/-----  bank#41.2  C=86.51 L=120.0          | D=191.5 E=15.00          s=86.51
NFO-interbank-  t=010/-----  bank#42.3  C=80.82 L=120.0          | D=185.8 E=15.00          s=80.82
NFO-interbank-  t=010/-----  bank#43.2  C=92.00 L=120.0          | D=197.0 E=15.00          s=92.00
NFO-interbank-  t=010/-----  bank#44.4  C= 2.44 L=120.0          | D=107.4 E=15.00
NFO-interbank-  t=010/-----  bank#45.1  C=39.09 L=103.8          | D=139.2 E= 3.70
NFO-interbank-  t=010/-----  bank#46.2  C=87.82 L=120.0          | D=192.8 E=15.00          s=87.82
NFO-interbank-  t=010/-----  bank#47.3  C= 0.00 L=95.24          | D= 0.00 E=-2.33          d= 7.43 FAILED
NFO-interbank-  t=010/-----  bank#48.4  C= 0.00 L=41.10          | D= 0.00 E=-40.2          d=23.67 FAILED
NFO-interbank-  t=010/-----  bank#49.1  C=67.39 L=120.0          | D=172.3 E=15.00
NFO-interbank-  t=010/-----  bank#0.4   C=30.00 L=120.0          | D=135.0 E=15.00
NFO-interbank-  t=010/-----  bank#1.3   C=36.78 L=120.0          | D=141.7 E=15.00          s=51.43
NFO-interbank-  t=010/-----  bank#2.4   C=30.00 L=120.0          | D=135.0 E=15.00          d= 5.24 no lender
NFO-interbank-  t=010/-----  bank#3.6   C=30.00 L=120.0          | D=135.0 E=15.00          d= 7.99 no lender
NFO-interbank-  t=010/-----  bank#4.3   C=37.66 L=120.0          | D=142.6 E=15.00          s=40.37
NFO-interbank-  t=010/-----  bank#5.3   C=45.05 L=120.0          | D=150.0 E=15.00
```

Figure 7: Evolution of one instance of the model with $p = 0.005$ in $t = 10$