Are Financial Networks Highly Complex?

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FINANCIAL TIMES

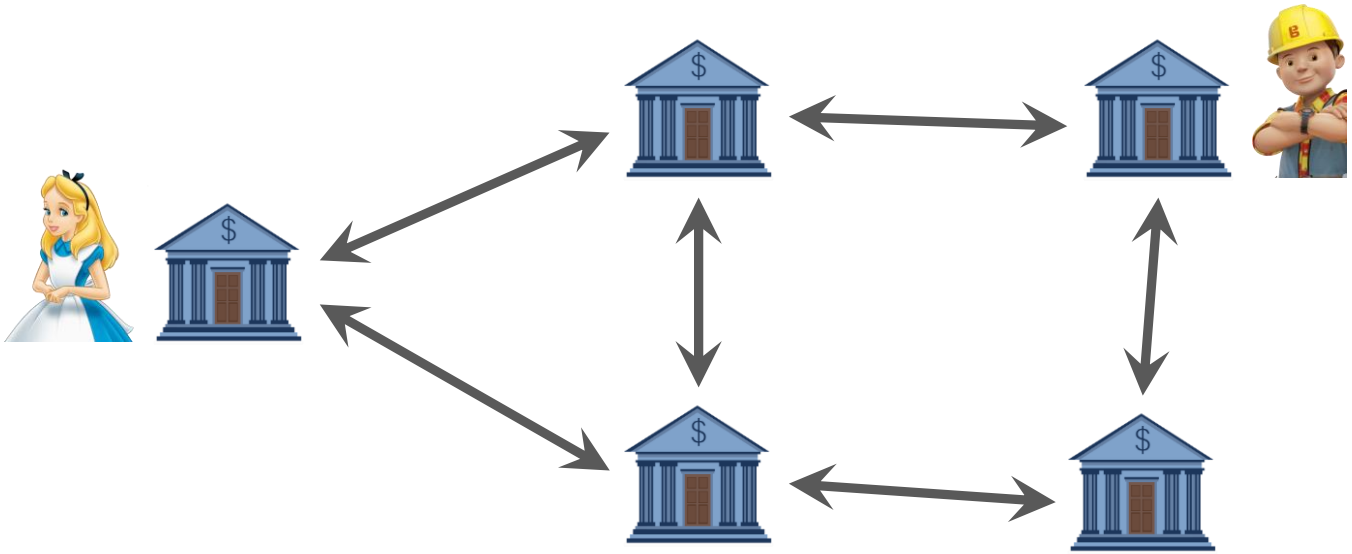
Are financial markets too complex?

The global credit market has plummeted and the collapse of various hedge funds has raised fears that the credit market conflagration could become a true economic crisis.

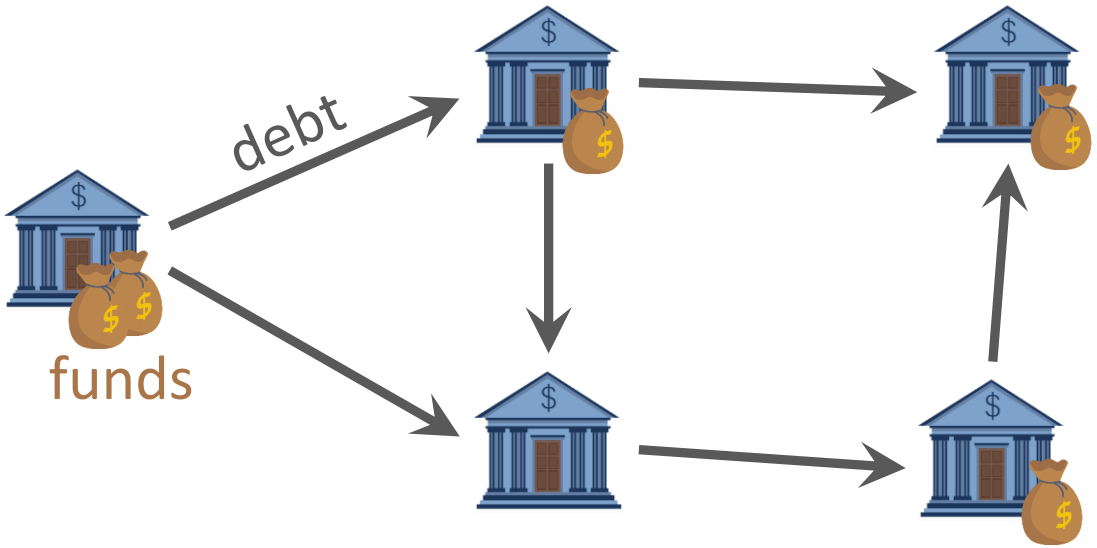
Richard Bookstaber, a former academic, who went on to head risk management for Morgan Stanley, and now runs a large hedge fund at FrontPoint Partners, argues in his book *A Demon of Our Own*

Financial Networks

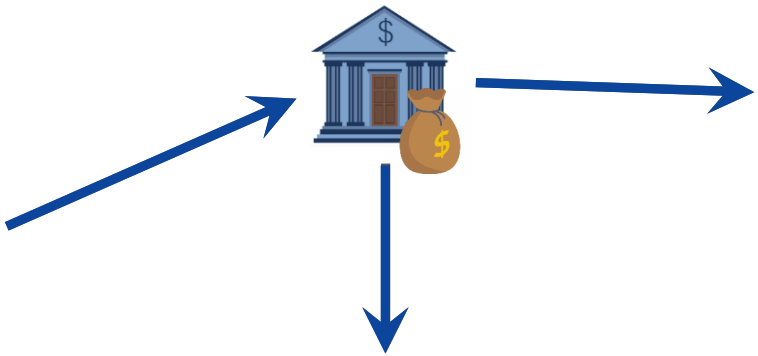
Financial Network



Financial Network



Assets, Liabilities, Default, and Recovery Rate



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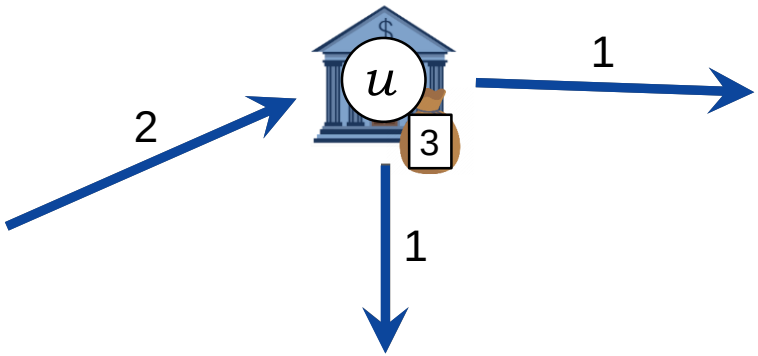

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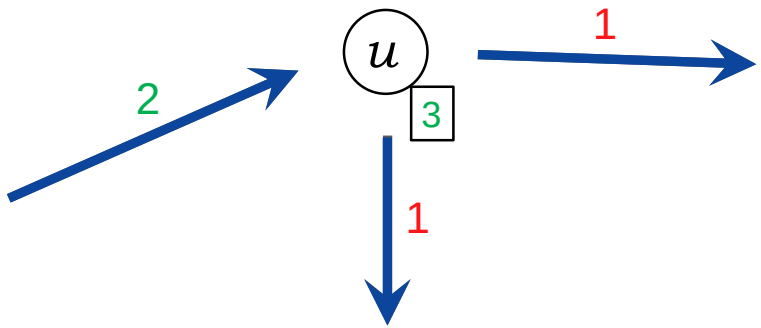
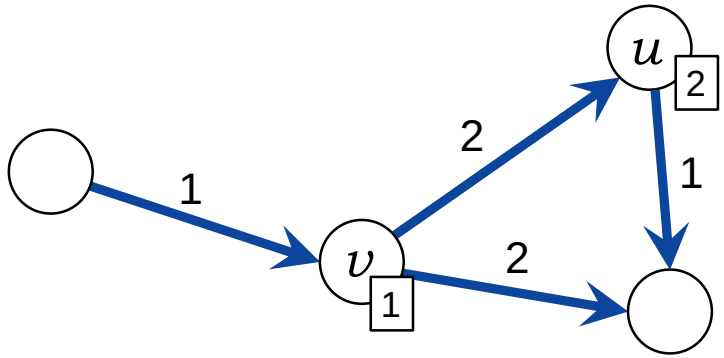
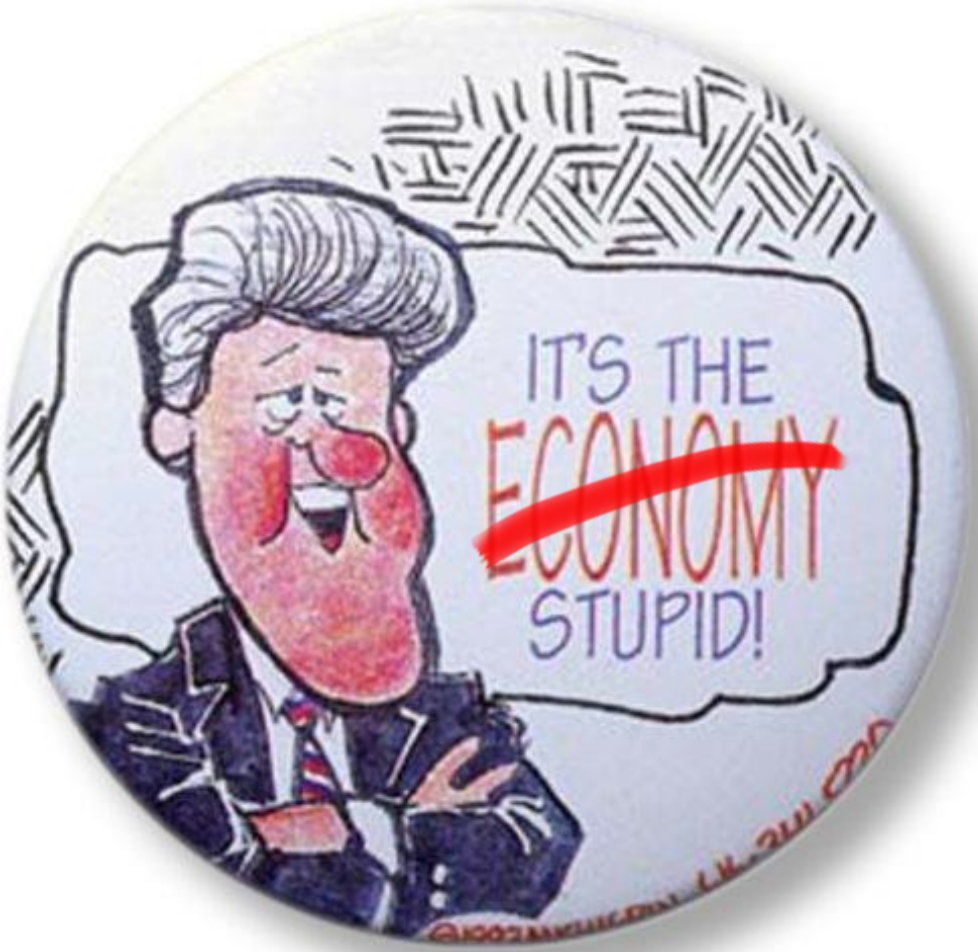


Assets, Liabilities, Default, and Recovery Rate



$$a_u \geq l_u \Rightarrow r_u = 1$$

$$a_v < l_v \Rightarrow r_v = \frac{a_v}{l_v} = \frac{2}{4} = \frac{1}{2}$$



NETWORK

economic crisis (2008)

=

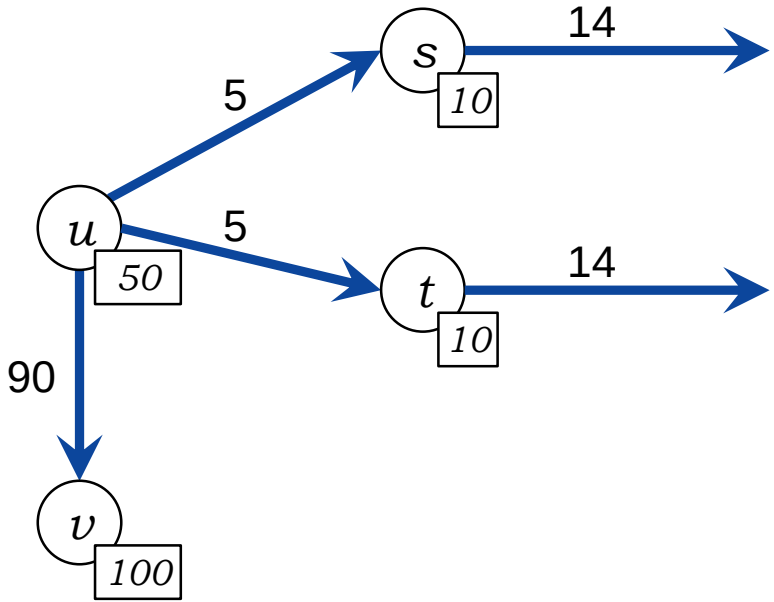
many companies involved

=

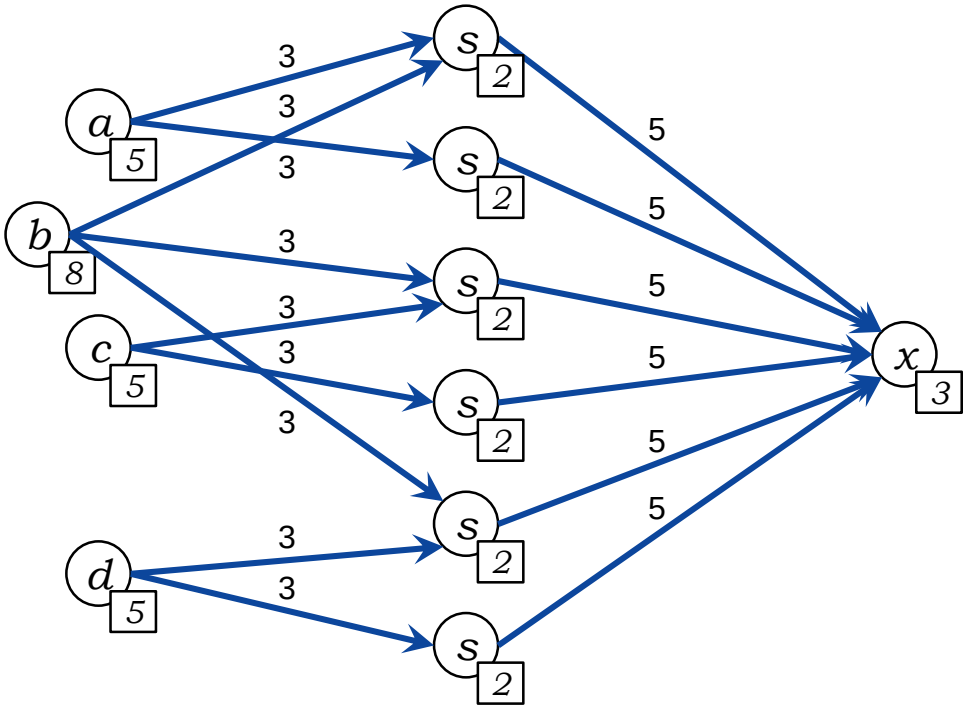
network


Bailouts

Too Big to Fail?

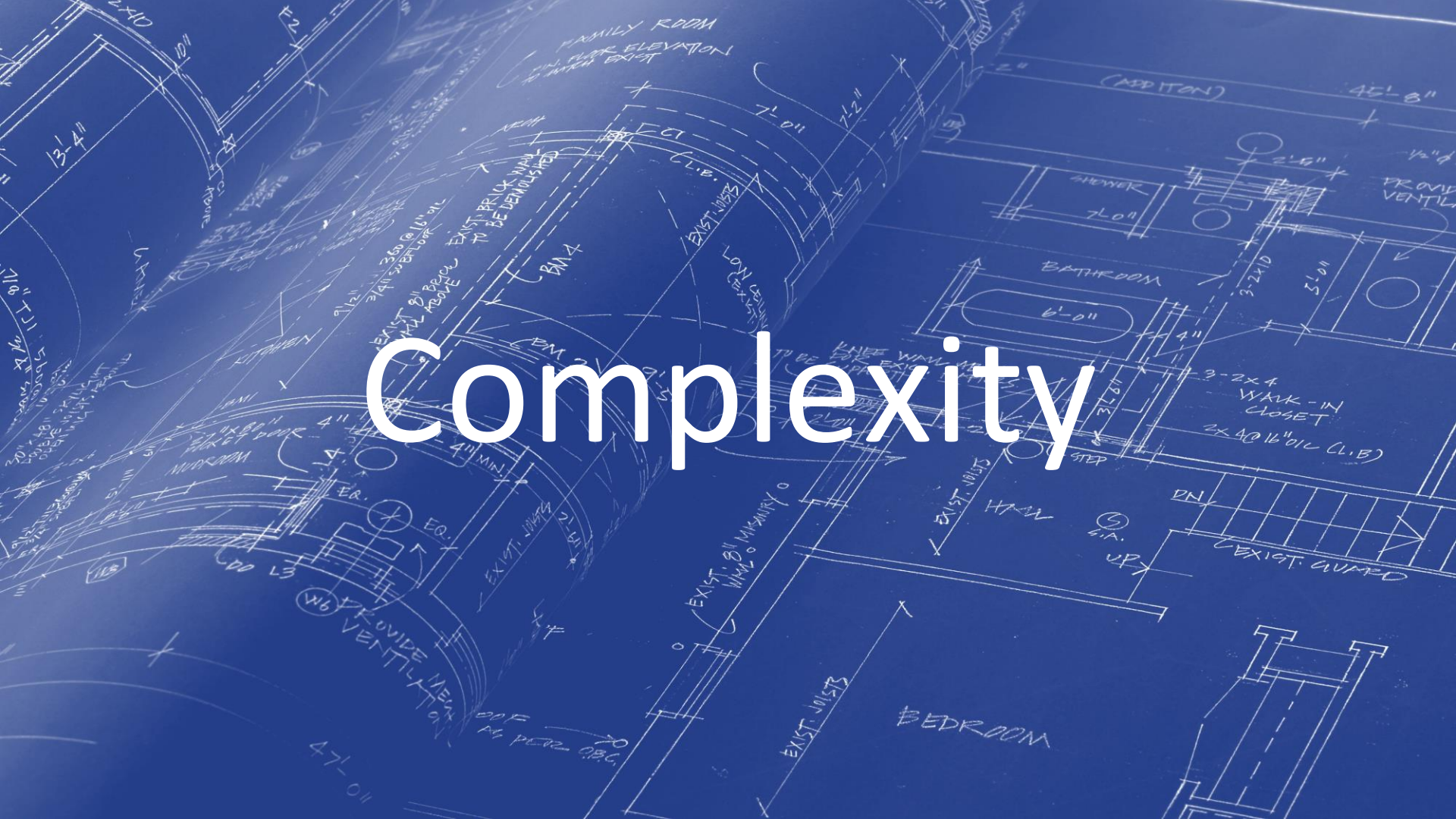


Bailouts on a Budget (of 3)



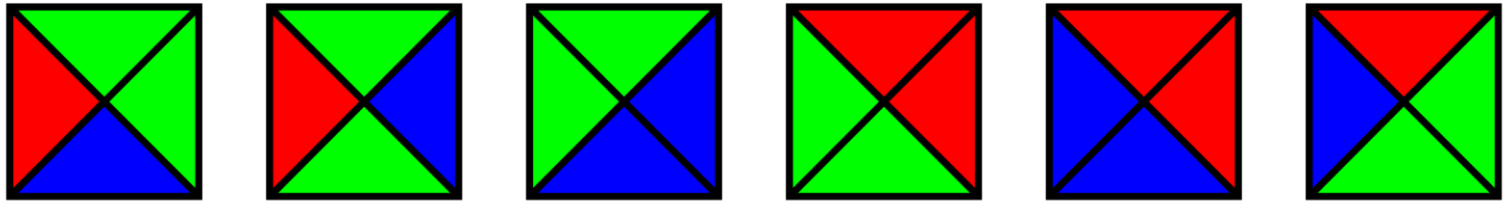
Bailouts are NP hard.*

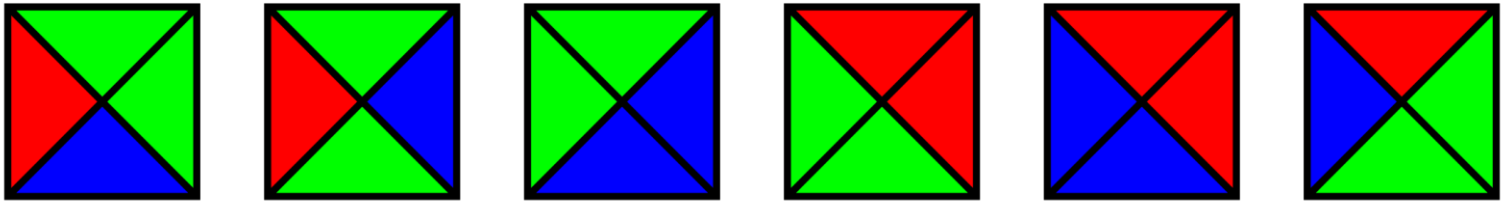
*in some models.

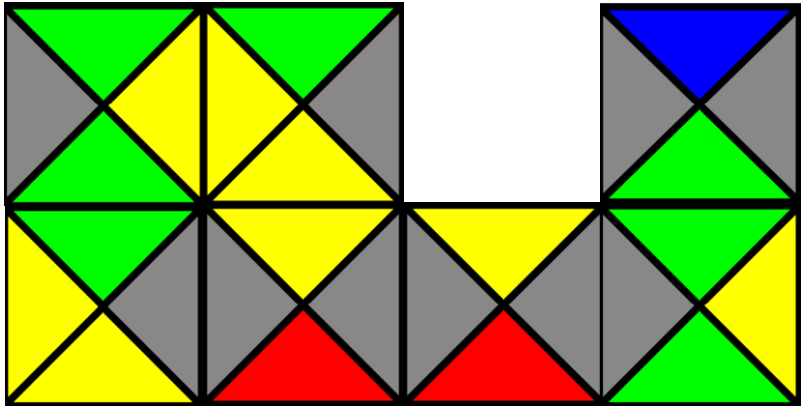

Complexity

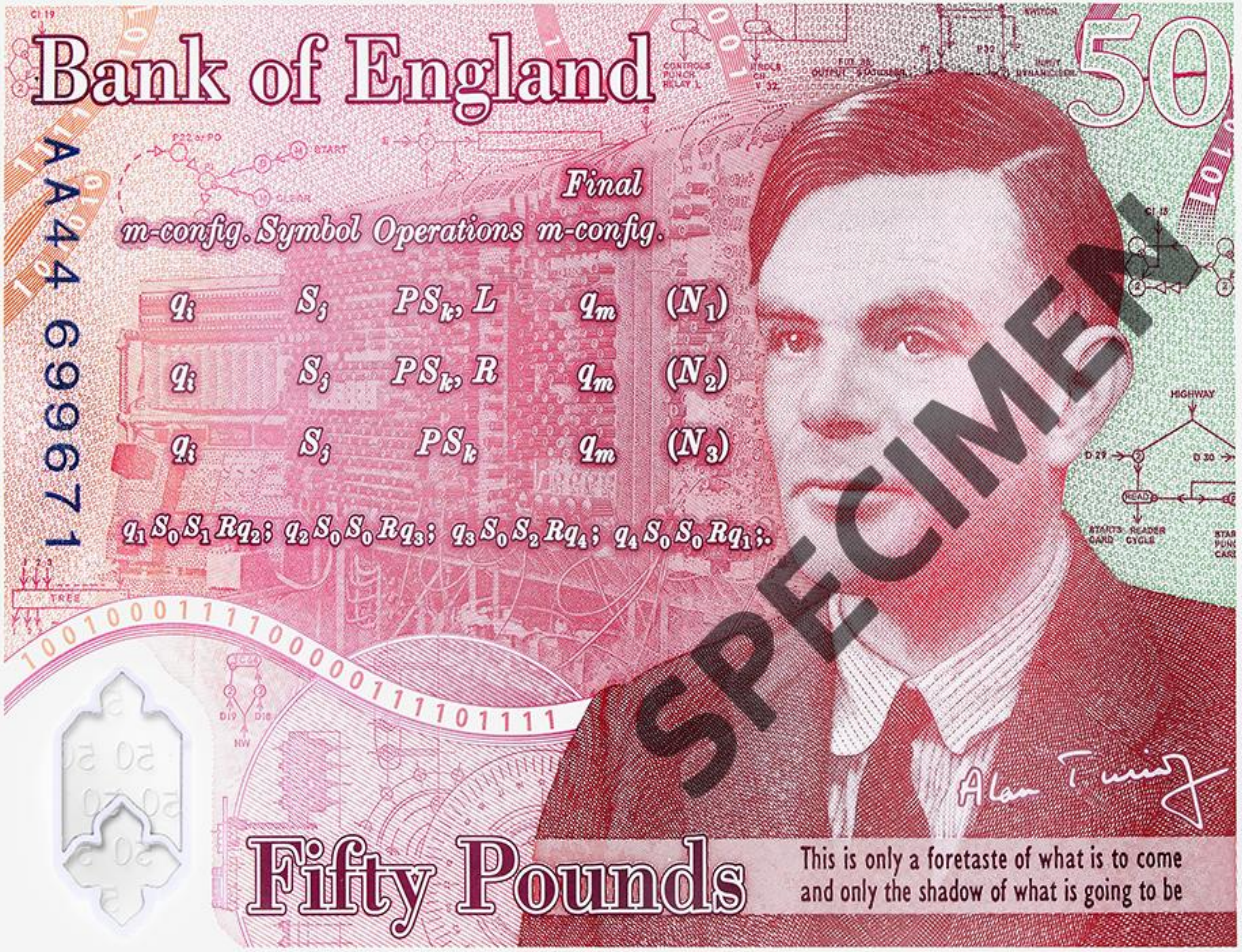
David Hilbert

Kurt Gödel









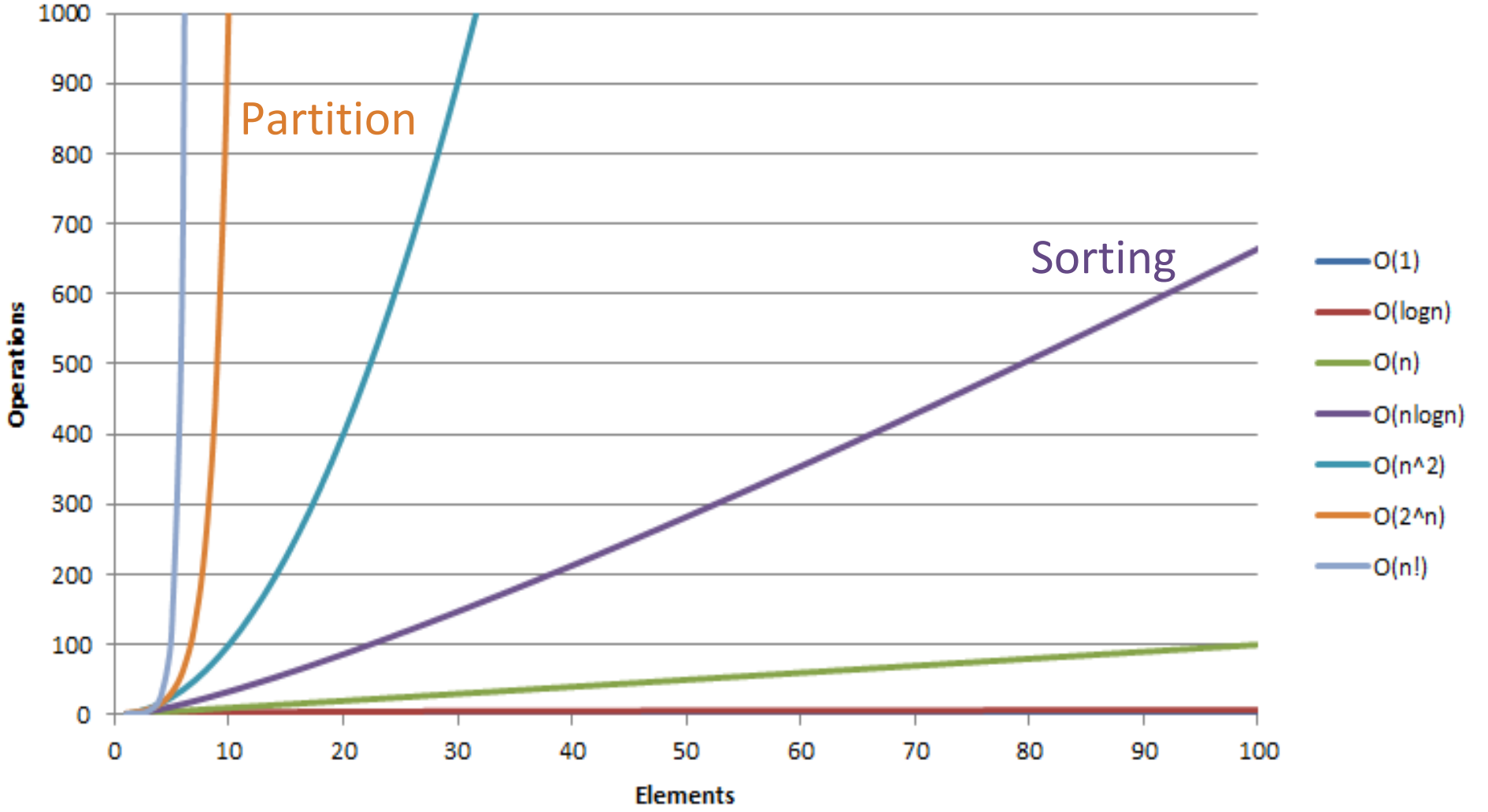
Background

Sorting


Partition

Sorting	vs.	Partition
<0.01s	22 Players	<0.01s

Sorting	vs.	Partition
<0.01s	22 Players	<0.01s
<0.01s	222 Players	…


Partition
Sorting
Operations
Elements
1000
900
800
700
600
500
400
300
200
100
0
0
10
20
30
40
50
60
70
80
90
100
O(1)
O(logn)
O(n)
O(nlogn)
O(n^2)
O(2^n)
O(n!)

Bailouts are NP hard.*

*in some models.

Conditional Debt

Debt = “Long” Position (Positive)

Conditional Debt = “Short” (Negative)

Short Positions

ABS: Asset-Backed Securities

CDO: Collateralized Dept Obligations

CDS: Credit Default Swaps

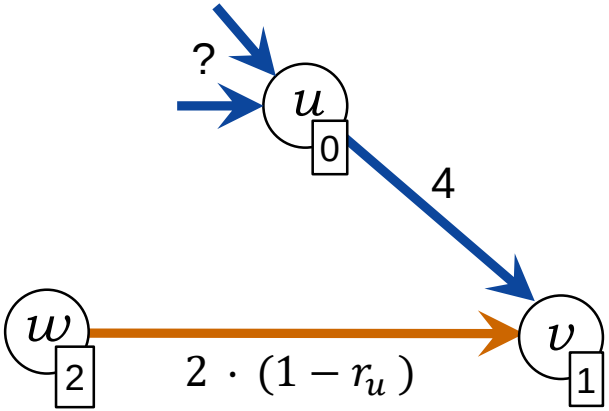
CLS: Collateralized Loan Obligations

MBS: Mortgage-Backed Securities

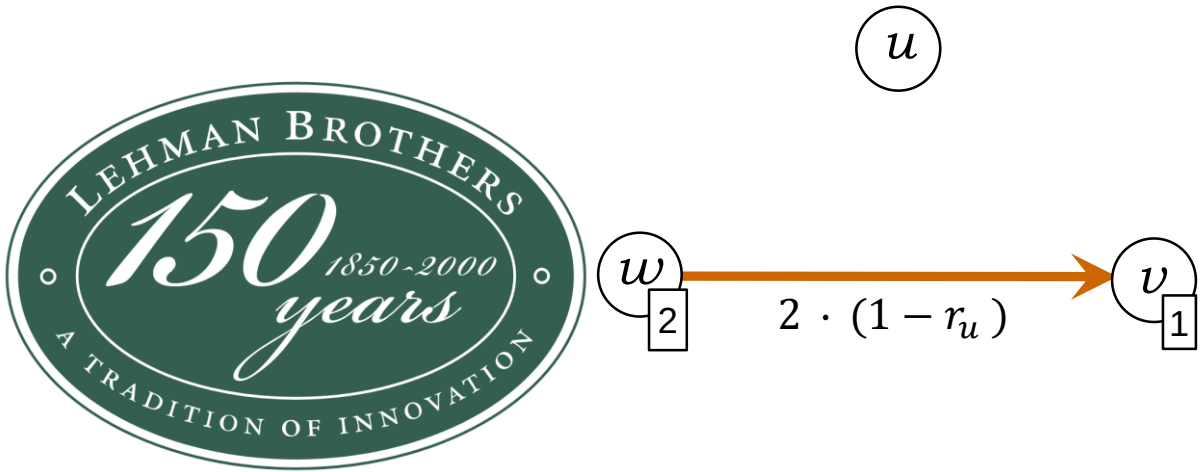
…

“Financial Weapons of Mass Destruction” (Warren Buffet)

Conditional Debt Contracts

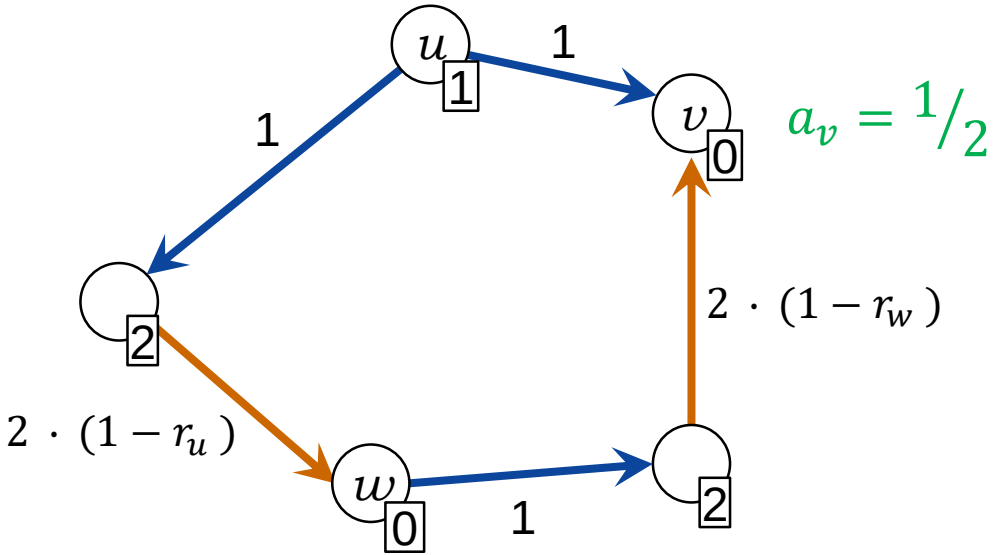


Conditional Debt Contracts

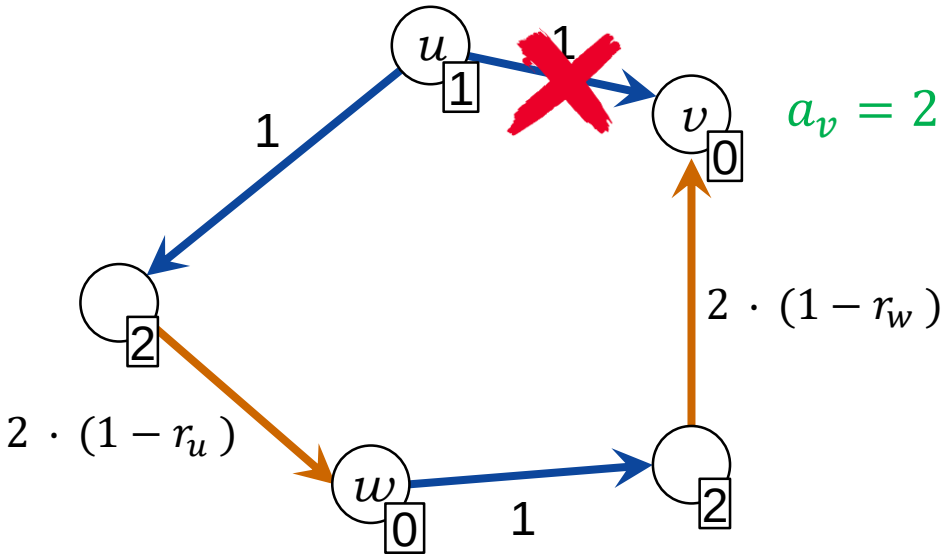


Improve Situation

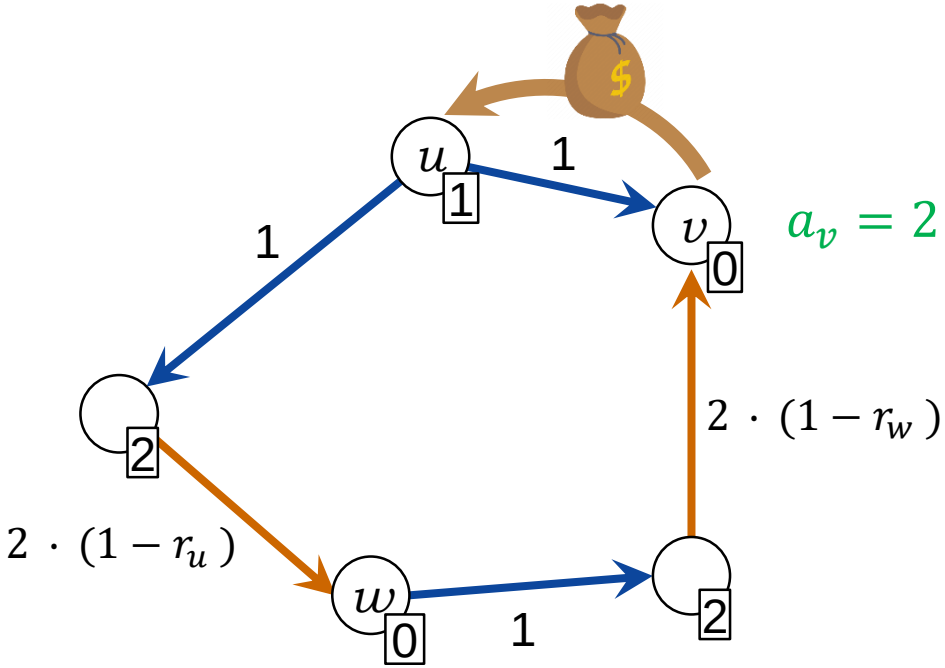
Can Bank v Improve?



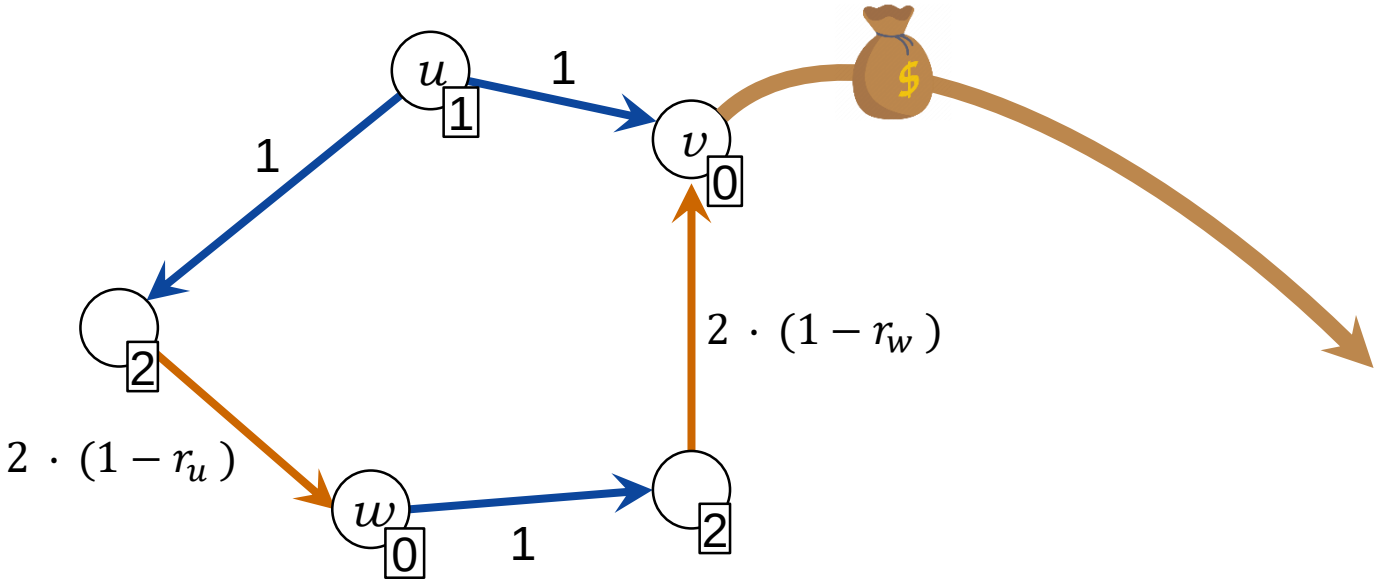
Can Bank v Improve?



Can Bank v Improve?



Can Bank v Improve?



A Loss Can Be a Win.

The Atlantic

BUSINESS

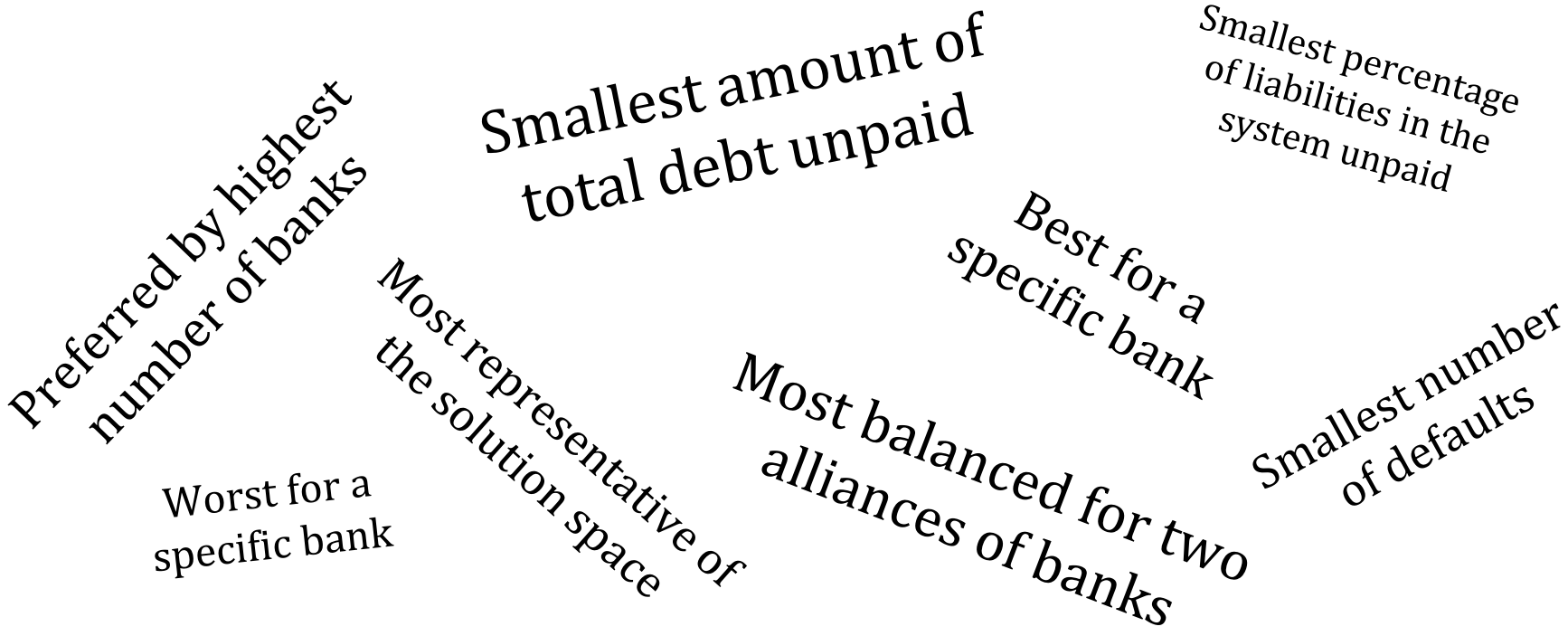
How to Make Money for Nothing Like Wall Street

Credit default swaps might not be financial WMDs anymore, but Wall Street can still game them to make guaranteed profits.

MATTHEW O'BRIEN OCTOBER 24, 2013

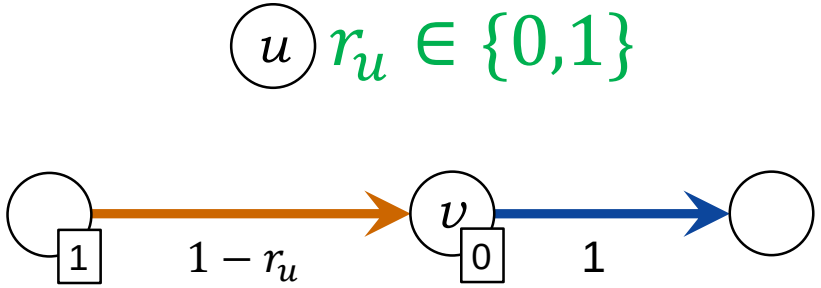

Optimization

Optimize What?



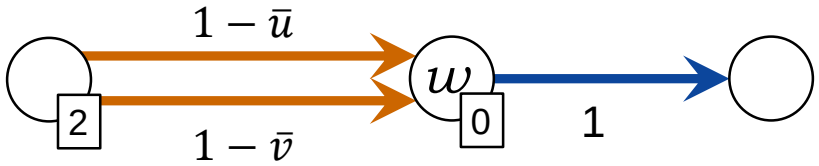
All these (and more) are NP hard.

Building Circuits: NOT Gate



$$r_v = NOT\ r_u$$

Building Circuits: OR Gate

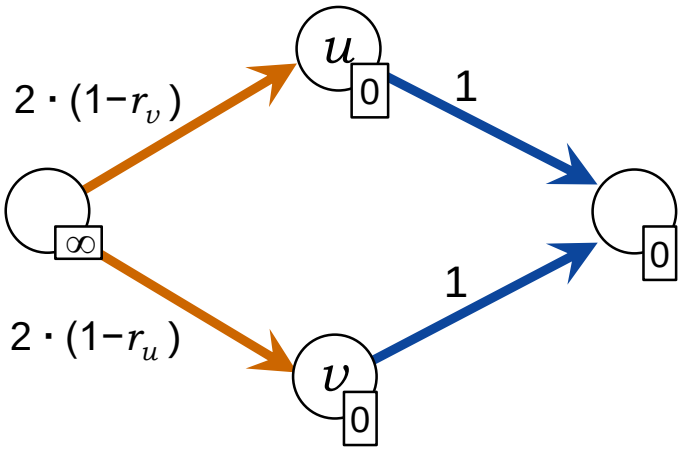


$$r_w = r_u \ OR \ r_v$$

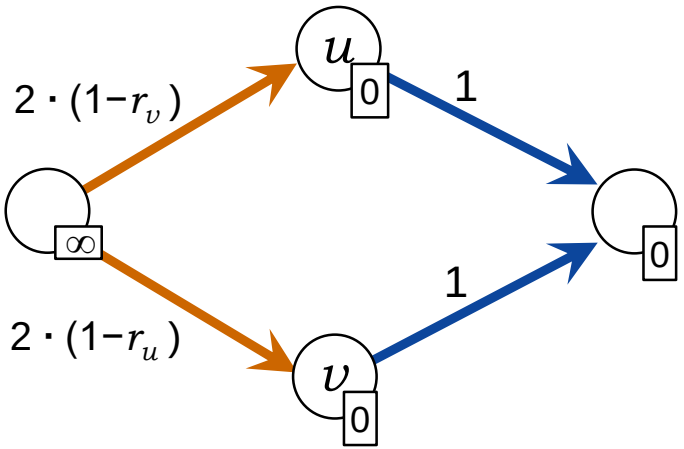
Financial Networks are Computers.

Sequential Defaults

An Example



An Example

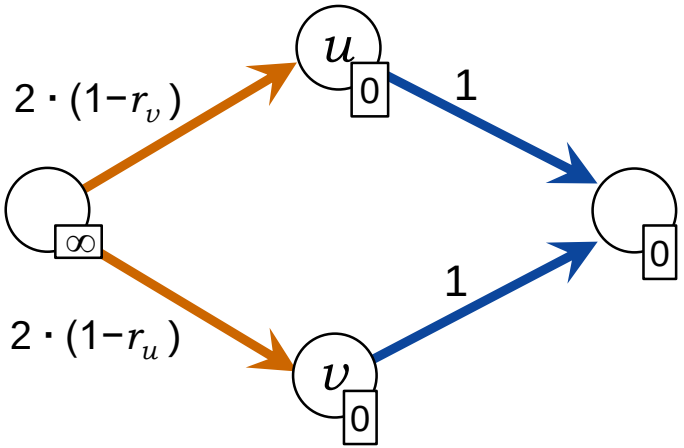


$r_u = 0,\ r_v = 1$

$r_u = 1,\ r_v = 0$

$r_u = \frac{2}{3},\ r_v = \frac{2}{3}$

An Example

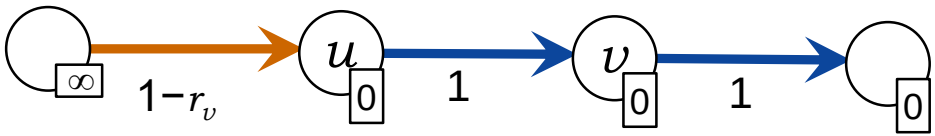


$r_u = 0,\ r_v = 1$

$r_u = 1,\ r_v = 0$

~~$r_u = \frac{2}{3},\ r_v = \frac{2}{3}$~~

Resurrection!



Basic Properties

Defaults are reversible

Some equilibria not reachable

Might not stabilize

Depends on order of updates

Basic Properties

Defaults are reversible

Some equilibria not reachable

Might not stabilize → stabilization time?

Depends on order of updates → best order?

Basic Properties

Defaults are reversible

Some equilibria not reachable

Might not stabilize → stabilization time? → $\theta(2^n)$

Depends on order of updates → best order?

Basic Properties

Defaults are reversible

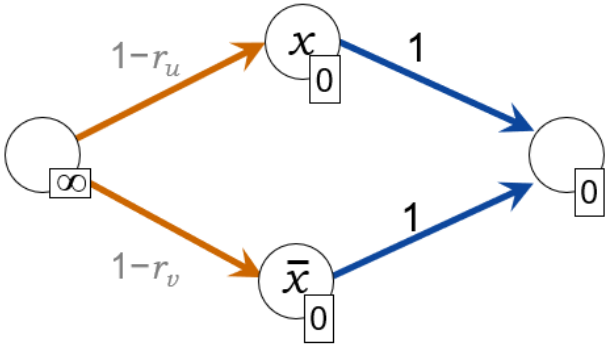
Some equilibria not reachable

Might not stabilize → stabilization time? → $\theta(2^n)$

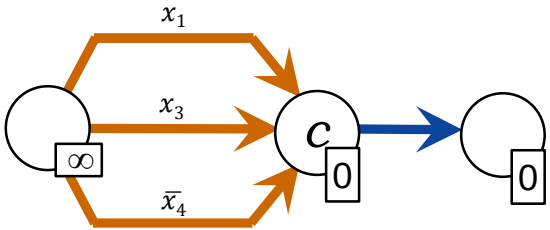
Depends on order of updates → best order? → NP-hard

Reduction from MAXSAT

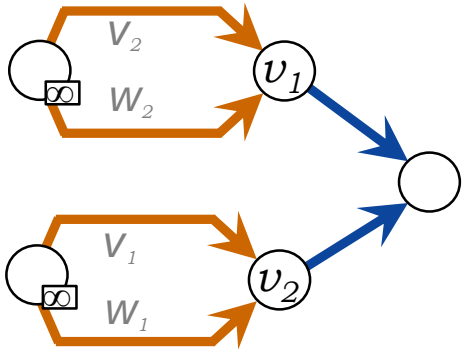
variables

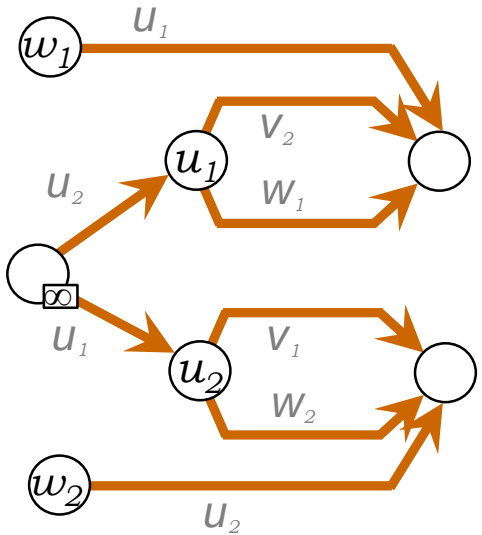


clauses

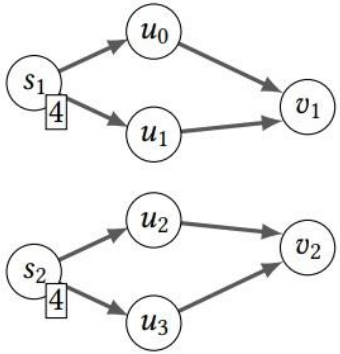


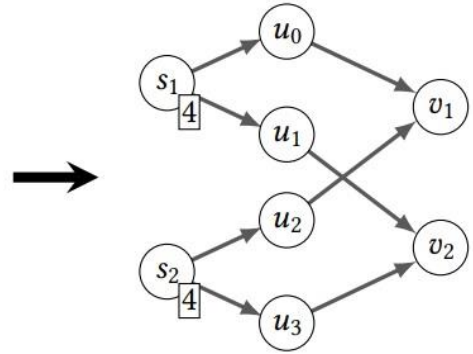
Best Order from Specific Point of View?

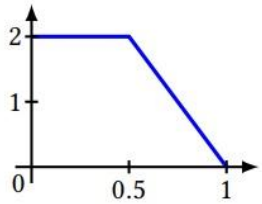




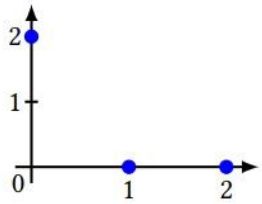
Reducing Risk



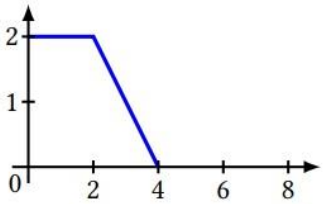




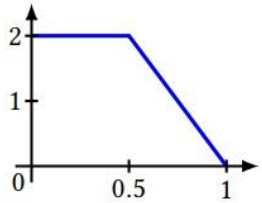
proportional



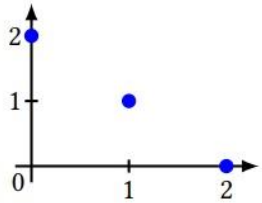
worst-set



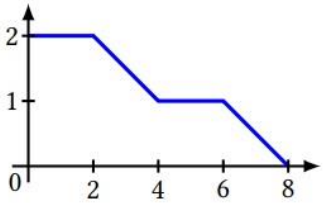
worst-sum



proportional



worst-set



worst-sum


Hard → Easy?

Solution space		
	no default costs	default costs
long positions only	1 maximal solution Easy to find	1 maximal solution Easy to find
+ covered shorts	1 maximal solution Easy to find	1 maximal solution Easy to find
+ any shorts	Many Pareto-optimal solutions Any/best one hard to find *with money or cycle restrictions:* best one still hard to find *with money+cycle restrictions:* unique solution, easy to find	Many Pareto-optimal solutions Any/best one hard to find Possibly no solution *with money restrictions:* possibly no solution *with cycle restrictions:* a solution always exists *with money+cycle restrictions:* best one still hard to find

In Short, What Regulators Should Do

No Uncovered Short Positions

Thank You!

Questions & Comments?

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