Interconnectedness in the Corporate Bond Market

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Introduction

Does interconnectedness improve market quality?

- Academic literature does not provide definitive answers
  - Allen and Gale (2000): complete networks help mitigate effects of shocks
  - Acemoglu et al. (2015): large shocks problematic for highly interconnected networks

Our Approach

- Introduce a new financial network construct: the assets network
- Build the corporate bond network
  - Large and important market
  - High institutional ownership
- Study linkages between interconnectedness and market quality

YES $\Rightarrow$ Interconnectedness improves market quality

Our Approach

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  - Large and important market
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YES ⇒ Interconnectedness improves market quality

Contributions

1. We develop a novel measure of *asset-based* IC at bond issuer level, using granular insitutional holdings data

2. We establish stylized facts about cross-sectional and time series evolution of IC in the corporate bond market

3. We contribute to the understanding of the role of IC on corporate bond market functioning and its impact on financial stability

4. We show the importance of IC for corporate bond pricing

Related Literature

- Network literature
  - Anton and Polk (2014), Diebold and Yilmaz (2014), Greenwood et al. (2015), Brunetti et al. (2019), etc.
- Growing literature in intermediary asset pricing
  - He et al. (2017), Ben-David et al. (2021), Haddad & Muir (2021), Bretscher et al. (2022), Li & Yu (2022a, 2022b), etc.
- Literature on the role of interconnectedness
  - Allen & Gale (2000), Elliot et al. (2014, 2021), Acemoglu et al. (2015), Duarte & Eisenbach (2021), etc.

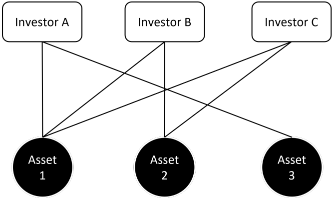
Building Financial Networks

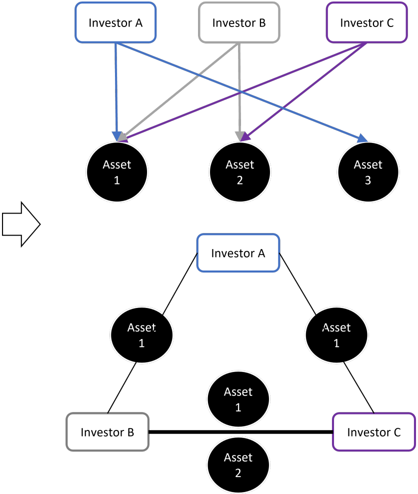
Three ways of building networks in finance

1. Correlation: Billio et al. 2012; Diebold and Yilmaz 2014
2. Physical: Brunetti et al. 2019
3. Overlapping portfolios: Caccioli et al. 2015

Conventional Approach on Defining IC

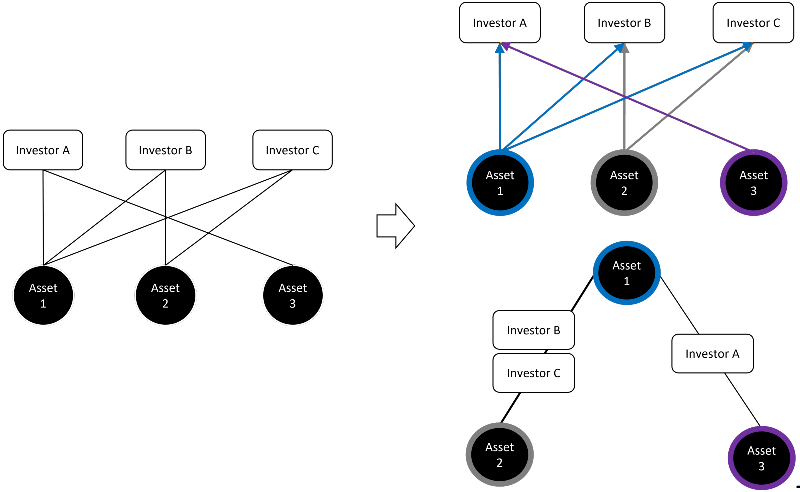
Literature has focused on **investors**, hence the network of investors based on "overlapping portfolios"





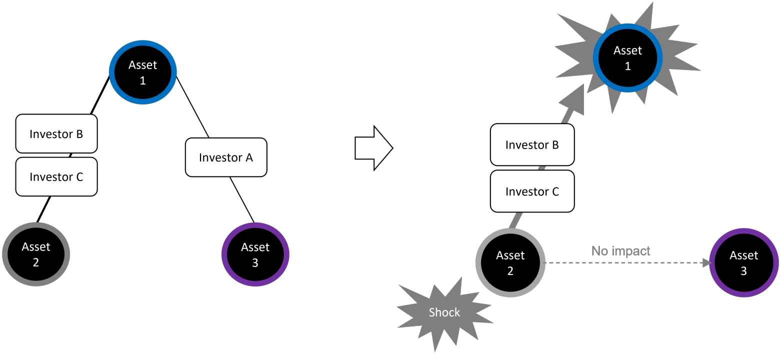
Our New Network of Assets

Our focus is on **assets**, hence the network based on "overlapping investors"



Our New Network of Assets (Cont'd)

Assets networks allows to learn about shock propagation among assets



Measuring Asset-level IC

$$E = \begin{array}{c|cccc|c} & I_1 & I_2 & \cdots & I_N & \\ \hline A_1 & E_{11} & E_{12} & \cdots & E_{1N} & V_1^A \\ A_2 & E_{21} & E_{22} & \cdots & E_{2N} & V_2^A \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ A_S & E_{S1} & E_{S2} & \cdots & E_{SN} & V_S^A \\ \hline & V_1^I & V_2^I & \cdots & V_N^I & \end{array} . \tag{1}$$

- $A = A_1, A_2, ..., A_S$ financial assets, $I = I_1, I_2, ..., I_N$ financial institutions, E_{ki} \$ amount invested by I_k in A_i
- Summing across columns = total amount of asset i held by system:

$$Network\ strength \equiv V_i^A = \sum_{k=1}^{N} E_{ik} \tag{2}$$

Measuring Asset-level IC (Cont'd)

$$\mathring{E} = \begin{array}{c|cccc|c} & I_1 & I_2 & \cdots & I_N & \\ \hline A_1 & \mathring{E}_{11} & \mathring{E}_{12} & \cdots & \mathring{E}_{1N} & D_1^A \\ A_2 & \mathring{E}_{21} & \mathring{E}_{22} & \cdots & \mathring{E}_{2N} & D_2^A \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ A_S & \mathring{E}_{S1} & \mathring{E}_{S2} & \cdots & \mathring{E}_{SN} & D_S^A \\ \hline & D_1^I & D_2^I & \cdots & D_N^I & \end{array}, \tag{3}$$

- $\mathring{E}$ is the *corresponding adjacency matrix*, where $\mathring{E}_{ik} = 1$ if $E_{ik} > d$ and zero otherwise.
- Summing across the columns = number of firms holding asset i:

$$\textit{Degree of asset } i \equiv D_i^A = \sum_{k=1}^{N} \mathring{E}_{ik} \tag{4}$$

Measuring Asset-level IC (Cont'd)

We define the network of financial assets as $O^A = (A, \mathrm{P}^A)$

$$A = \{A_1, A_2, ..., A_S\} \tag{5}$$

$$P^A_{i,j} = \frac{\sum_{k=1}^{N} \overset{\circ}{E}_{i,k} \overset{\circ}{E}_{j,k}}{\left\| \overset{\circ}{E}_{i\cdot} \right\| \left\| \overset{\circ}{E}_{j\cdot} \right\|}, \tag{6}$$

where $\left\| \overset{\circ}{E}_i \right\|$ is the norm of the vector of investors holding asset i and $P^A_{i,j}$, the cosine similarity $\Rightarrow$ the distance between two non-zero vectors of an inner-product space

$$IC^A_i = \frac{1}{N(S-1)} \sum_{j \in \{1,...,S\}: j \neq i} P^A_{i,j}. \tag{7}$$

Data

- Thomson Reuters eMAXX: Comprehensive data on corporate bond holdings and characteristics
  - Individual institutional investor-bond-year-quarter
  - 1998:Q3–2021:Q3
  - U.S. domiciled institutional investors
- TRACE: Intraday trading data
- Other sources including
  - Total bond outstanding amuonts from Mergent FISD (Fixed Income Securities Database)
  - Supplementary ratings data from S&P Global
  - Firm-level COVID exposure measures made available by Hassan et al. (2023)

Sample Construction

- Subset list of institutional investors to those whose corporate bond AUM is above median in the AUM distribution each quarter
  - Obtain 112 banks, 543 investment managers, 473 insurance companies, and 114 other types
  - This subset holds $\sim$ 80% of total par amount of corporate bonds held on eMAXX
- Subset to bonds held by at least 10 institutional investors on average over panel
- Further aggregate bonds at the issuer-level

Sample Coverage

Summary Statistics

- About $200,000$ bonds
- Average outstanding amount: \$2 billion
- Average remaining maturity: 8 years
- Average coupon rate: 6 percent
- Average rating: BBB
- Standard deviation: high for all variables

Summary Statistics on Issuer-level Bonds TRACE Variables

Network of Corporate Bonds

(a) Full network

(b) 20 largest amount outstanding

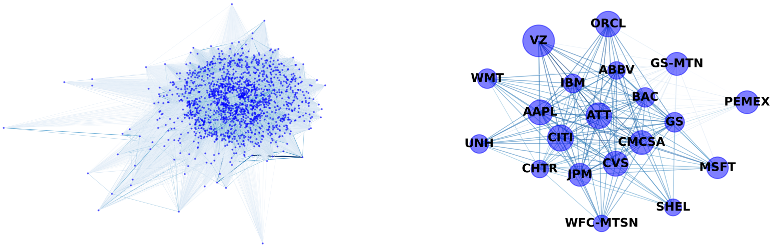


Figure: A snapshot of the network in 2021:Q3

Cross-Sectional Observations

Average IC in corporate bonds is low but with great heterogeneity

Panel A: Cross-section of Corporate Bonds						
Variables	*N*	*Mean*	*Med*	*Std.Dev.*	*Min*	*Max*
Cos. Sim.	7,350	0.034	0.033	0.015	0.0019	0.067
Degree	7,350	44.37	32.78	40.46	1	294
Strength	7,350	369,524	178,285	625,914	512	6,458,448
Quarters	7,350	18.98	11	18.89	2	77

The network changes over time with: IC increased after the GFC

OLS Regressions

$$Spread_{it} = \alpha + \beta IC_{it} + \gamma X_{it} + FE_i + FE_t + \epsilon_{it} \tag{8}$$

$$Illiquidity_{it} = \alpha + \beta IC_{it} + \gamma X_{it} + FE_i + FE_t + \epsilon_{it} \tag{9}$$

$$Volatility_{it} = \alpha + \beta IC_{it} + \gamma X_{it} + FE_i + FE_t + \epsilon_{it} \tag{10}$$

- X_{it} matrix of time-varying bond characteristics (trading volume, outstanding issuance size, coupon rate, credit rating, and time to maturity)
- FE_i issuer fixed effects
- FE_t time fixed effects (current year-quarter)

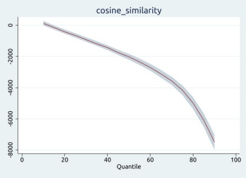
OLS Regressions Results

	(1) Spread	(2) Amihud illiquidity	(3) IQR of traded prices	(4) Realized volatility
IC	-0.449***	-0.152***	-0.114***	-0.066***
	(0.062)	(0.018)	(0.015)	(0.016)
Rating	-2.431***	-0.205***	-0.317***	-0.373***
	(0.143)	(0.021)	(0.022)	(0.031)
Coupon	0.376***	-0.132***	-0.107***	-0.078***
	(0.054)	(0.016)	(0.013)	(0.015)
Time to mat.	-0.021**	0.016***	0.019**	0.018***
	(0.010)	(0.005)	(0.008)	(0.005)
Amount	0.295***	0.325***	0.222***	0.020
	(0.056)	(0.023)	(0.019)	(0.013)
Volume	-0.264***	-0.464***	-0.281***	
	(0.025)	(0.019)	(0.016)	
FE	Issuer, time	Issuer, time	Issuer, time	Issuer, time
Observations	182,607	182,607	182,607	182,607
R-squared	0.702	0.468	0.439	0.464

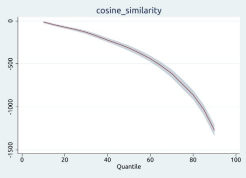
Quantile Regressions

- Regression curve gives summary for *averages* of distributions corresponding to x's
- But measures of conditional central tendency do not always adequately characterize a statistical relationship among variables
- We are interested in estimating the conditional quantiles of a spread/illiquidity/volatility whose conditional distribution depends on IC and a vector of covariates

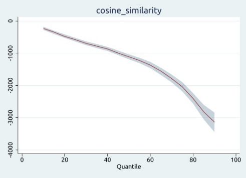
Results from Quantile Regressions



(a) Spread



(b) Illiquidity



(c) Realized volatility

Corporate Bond Characteristics by Interconnectedness Decile

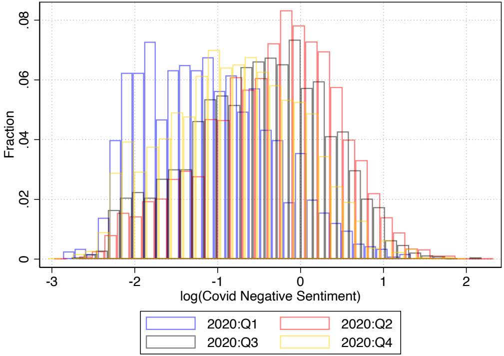
IC decile	Rating	Coupon rate	Time-to-maturity	Amount ($bil)	Volume ($bil)
1	10.92	7.24	109.54	0.27	81.53
2	10.41	7.45	149.16	0.31	95.76
3	10.74	7.22	82.83	0.45	105.99
4	10.97	6.81	188.91	0.51	109.07
5	10.75	6.75	124.82	0.65	106.14
6	11.13	6.36	91.24	0.80	104.63
7	11.39	6.02	173.37	1.16	105.69
8	11.93	5.70	106.88	2.21	109.49
9	11.96	5.41	41.75	3.26	136.11
10	11.41	4.93	41.85	3.97	162.64

Credit rating, the most important determinant of bond investment, does not entirely predict bond's placement in the structure

Studying the Mechanism: Using COVID Shock

- COVID-19 shock $\Rightarrow$ exogenous bifurcation of firms (Hassad et al. 2023): distinguish between COVID-exposed and COVID-unexposed firms
- Textual analysis of earnings call transcripts used to determine COVID-exposed and COVID-unexposed firms
- Was the effect of COVID on COVID-exposed bonds mitigated by the IC to unexposed bonds?

Event Study: COVID Shock



Covid-Exposed Bonds

$$Spread_{i,t}^{exposed} = \alpha + \beta_1 IC_{i,t-1}^{unexposed} + \gamma' X_{i,t} + FE_i + FE_t + \epsilon_{i,t}$$

$$Illiquidity_{i,t}^{exposed} = \alpha + \beta_1 IC_{i,t-1}^{unexposed} + \gamma' X_{i,t} + FE_i + FE_t + \epsilon_{i<t}$$

$$Volatility_{i,t}^{exposed} = \alpha + \beta IC_{i,t-1}^{unexposed} + \gamma' X_{i,t} + FE_i + FE_t + \epsilon_{i,t},$$

Covid-Exposed Bonds

t = 2020:Q1, t-1 = 2019:Q4	*Spread$_t$*	*Amihud illiquidity$_t$*	*IQR of traded prices$_t$*	*Realized volatility$_t$*
$IC_{e \to \mathcal{U}, t-1}$	-0.754***	-0.394***	-0.293***	0.00565
	(0.213)	(0.0804)	(0.0731)	(0.0907)
Rating$_{t-1}$	-1.743***	-0.350***	-0.340***	-0.305***
	(0.154)	(0.0580)	(0.0527)	(0.0628)
Coupon rate$_{t-1}$	0.285*	-0.158***	-0.0223	0.159**
	(0.159)	(0.0598)	(0.0544)	(0.0670)
Time to maturity$_{t-1}$	0.285**	0.150***	0.192***	0.338***
	(0.132)	(0.0498)	(0.0452)	(0.0551)
Size$_{t-1}$	0.508**	0.643***	0.428***	0.0532
	(0.249)	(0.0941)	(0.0855)	(0.0884)
Trade volume$_{t-1}$	-0.0528	-0.784***	-0.300***	
	(0.186)	(0.0704)	(0.0640)	
FE	Issuer, time	Issuer, time	Issuer, time	Issuer, time
Obs.	278	278	278	278
R^2	0.451	0.385	0.204	0.207

Covid-Unexposed Bonds

$$Spread_{i,t}^{unexposed} = \alpha + \beta_1 IC_{i,t-1}^{exposed} + \gamma X_{i,t} + FE_i + FE_t + \epsilon_{i,t}$$

$$Illiquidity_{i,t}^{unexposed} = \alpha + \beta_1 IC_{i,t-1}^{exposed} + \gamma X_{i,t} + FE_i + FE_t + \epsilon_{i,t}$$

$$Volatility_{i,t}^{unexposed} = \alpha + \beta IC_{i,t-1}^{exposed} + \gamma X_{i,t} + FE_i + FE_t + \epsilon_{i,t}$$

Covid-Unexposed Bonds

t = 2020:Q1, t-1 = 2019:Q4	$Spread_t$	Amihud $illiquidity_t$	IQR of traded $prices_t$	Realized $volatility_t$
$IC_{u \to \mathcal{E}, t-1}$	-0.140	-0.119	-0.0517	0.243***
	(0.105)	(0.0829)	(0.0694)	(0.0869)
$Rating_{t-1}$	-0.890***	-0.289***	-0.192***	-0.240***
	(0.0781)	(0.0618)	(0.0518)	(0.0641)
Coupon $rate_{t-1}$	0.608***	-0.0217	0.0241	0.266***
	(0.0822)	(0.0651)	(0.0545)	(0.0686)
Time to $maturity_{t-1}$	0.0840	0.0382	0.0192	0.138***
	(0.0563)	(0.0446)	(0.0373)	(0.0468)
$Size_{t-1}$	0.137	0.535***	0.105	0.0198
	(0.102)	(0.0809)	(0.0677)	(0.0754)
Trade $volume_{t-1}$	0.00130	-0.713***	-0.187***	
	(0.0778)	(0.0616)	(0.0516)	
FE	Issuer, time	Issuer, time	Issuer, time	Issuer, time
Obs.	322	322	322	322
R^2	0.594	0.336	0.115	0.196

Fallen Angels

- Fallen angels: From BBB to high-yield
  - spreads widen, liquidity drops and volatility increases
  - higher capital requirements
- Consider all BBB bonds
- Assumption: fallen angel downgrades plausibly exogenous within a narrow window
- Are the effects of "fallen angels" mitigated by the IC to "un-fallen angels"?

Fallen Angels: Results

	(1) Spread	(2) Amihud illiquidity	(3) IQR of traded prices	(4) Realized volatility
IC	-0.619***	-0.343***	-0.289***	-0.148
	(0.214)	(0.084)	(0.099)	(0.097)
Rating	-2.313***	-0.469***	-0.290*	-0.314*
	(0.363)	(0.142)	(0.167)	(0.165)
Coupon	0.518***	-0.103	0.082	-0.040
	(0.192)	(0.075)	(0.088)	(0.087)
Maturity	-0.086	-0.028	-0.028	0.0006
	(0.083)	(0.033)	(0.038)	(0.038)
Amount	0.390**	0.714***	0.590***	0.225***
	(0.177)	(0.069)	(0.081)	(0.076)
Volume	0.052	-0.770***	-0.558***	
	(0.121)	(0.048)	(0.056)	
FE	Time	Time	Time	Time
Observations	580	580	580	580
R-squared	0.643	0.515	0.447	0.454

Conclusion

- We are developing a theory model, based on Merton (1987), to study what happens when
  - number of assets increases
  - number of investors increases
  - shape of the network changes
- Updating data until end of 2024

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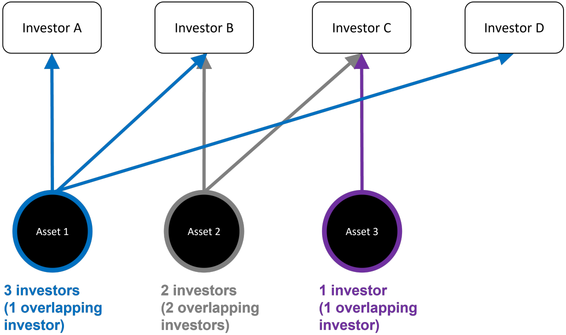
Frame Title

I hope you like the paper

Appendix

Notion of overlapping investors is different from just the number of investors in that bond



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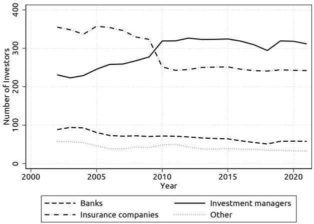
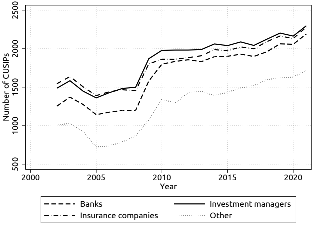
Sample Coverage

(a) Number of Unique Investors



(b) Number of Unique Bonds



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Summary Statistics on Issuer-level Bonds

Variable	Obs	Mean	Std. Dev.	Min	Max
Outstanding issue amount ($bil)	148,109	1.94	5.21	0.10	73.52
Remaining maturity (quarter)	145,407	33.23	25.04	4.00	117.00
Coupon rate	145,882	6.06	2.07	1.86	10.50
Spread (quarterly mean)	146,199	3.21	3.73	(4.79)	37.72
Spread (quarterly median)	146,199	3.03	2.90	0.20	12.97
Spread (last quarterly observation)	146,199	3.01	2.98	0.04	13.47
Rating	141,138	12.22	3.91	5.00	20.67
Trade volume (quarterly mean; $bil)	148,109	125.79	279.31	0.00	7,594.96
Trade volume (quarterly median; $bil)	148,109	39.98	90.35	0.00	2,319.44
Trade volume (last quarterly observation; $bil)	148,109	85.41	222.61	0.00	10,365.76
Price Volatility	148,109	1.67	1.50	0.02	11.13
Illiquidity: Amihud (quarterly mean)	148,109	1.22E-06	3.06E-06	4.75E-13	0.0000435
Illiquidity: Amihud (quarterly median)	148,109	5.84E-07	1.69E-06	2.93E-13	0.0000216
Illiquidity: Amihud (last quarterly observation)	148,109	9.39E-07	2.48E-06	2.20E-12	0.0000132
Illiquidity: IQR (quarterly mean)	148,109	0.56	0.51	0.01	5.03
Illiquidity: IQR (quarterly median)	148,109	0.41	0.44	0.00	4.12
Illiquidity: IQR (last quarterly observation)	148,109	0.60	0.63	0.02	2.85

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Time Series of Spread, Illiquidity, and Realized Volatility

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TRACE

Security-level data on corporate bond spread, liquidity, volatility, and trading volume

- Spread
- Illiquidity measures:
  - $$Amihud_{it} = \frac{1}{D_{it}} \sum_{k=1}^{D_{it}} \frac{r_{ikt}}{Q_{ikt}},$$
    D_{it} total # trades on bond i at day t, r_{ikt} and Q_{ikt} return and traded volume of the kth transaction of bond i on day t
  - IQR = difference between 75th and 25th percentiles of daily prices.
- Realized Volatility = quarterly standard deviation of traded prices of a bond.

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Mapping Financial Networks

- Networks in finance are mapped using three main techniques:
  1. Correlation networks (see, Billio, Getmanski, Lo and Pellizzon, 2012; and Diebold and Yilmaz, 2014)
  2. Physical networks (see, Brunetti, Harris, Mankad and Michailidis, 2019)
  3. Common holdings networks (see, Caccioli, Farmer, Foti and Rockmore, 2015; and Greenwood, 2015)
- New approach of mapping financial networks
  - **Overlapping investors** or **investor similarity network**
  - Mirrors notion of overlapping portfolios

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