The Network of Firms Implied by the News

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What we know

- Firms are connected to each other through business links

  - Costumer-supplier, competitors, strategic partnerships, subsidiaries, banking, credit, etc.

- Business links spread risks across firms through contagion, affecting asset prices

  - Bai et al. (2015), Barrot and Sauvagnat (2016), Cohen and Frazzini (2008), Jorion and Zhang (2009), and others

- Firm network architecture is key driver of aggregate risks

  - Acemoglu et al. (2012, 2017), Eisenberg and Noe (2001), Gabaix (2011), Herskovic (2018)

$\rightarrow$ Accurate risk measurement requires an understanding of the network of firm links in the economy

The problem

- Data on business connections between firms are incomplete, sparse, and lagged

    - Interbank links: Proprietary, only big banks

    - Compustat segments: Only costumer-supplier

    - BEA input-output: Inter-sectoral, infrequently updated

    - Variance decomposition: Mostly asset price correlations

    - 10-K similarity: Mostly peers

    - Internet co-searches: Mostly peers

$\rightarrow$ The unavailability of extensive and timely firm network data hinders the precise measurement of risks

Our solution

- Scherbina and Schlusche (2015) identify firm links by considering firms co-mentioned in news articles

- Inspired by this approach, we use news data to identify firm links

We show:

1. Incentives drive the news to report about *distressed* firm links (suggesting that the news reporting is biased)

2. News-implied firm networks contain signals that are highly *predictive* of firm-level and aggregate risks (unlike other data)

What we do

- We develop a machine learning methodology to identify firm links from text data

    – 106,521 full-text articles published between 2006 and 2013 from Reuters financial news

    – We identify a link between two firms whenever they are mentioned in the same sentence of an article

News-implied network

- The news-implied networks exhibit core-periphery architecture
  - Babus and Hu (2017), Bernanke et al. (1999), Carvalho and Gabaix (2013), and others
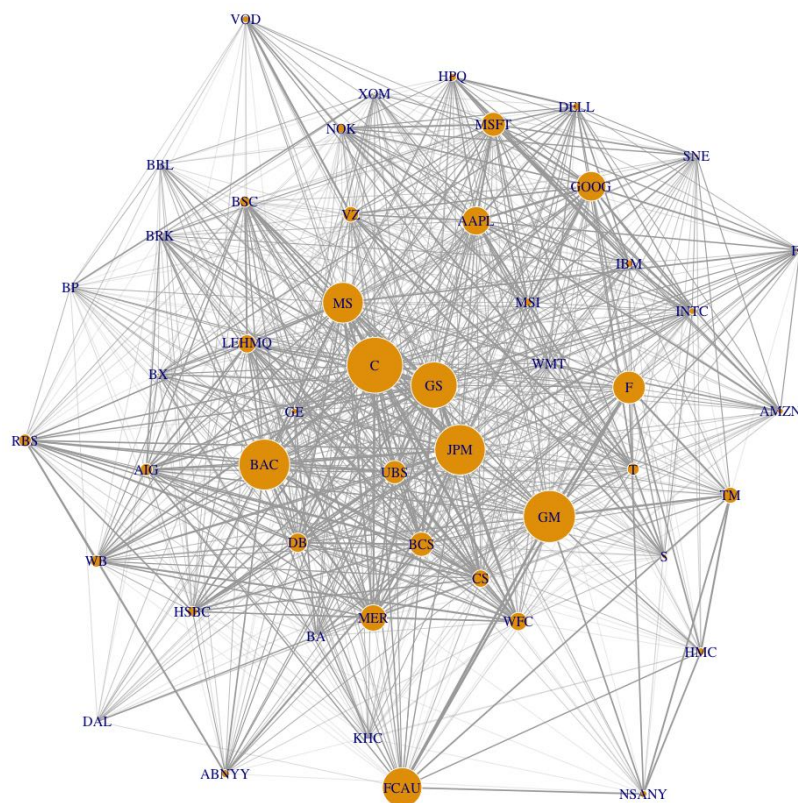
Result 1: Distressed firm links in news

|		
(Return)$_+$ of Firm 1	0.079	0.091
(Return)$_-$ of Firm 1	* -0.218	-0.173
Volatility of Firm 1	*** 1.382	*** 1.353
Upgrade dummy of Firm 1	-0.055	0.106
Downgrade dummy of Firm 1	*** 0.219	. 0.179
Revisions up of Firm 1		0.004
Revisions down of Firm 1		*** 0.013
Earnings surprise of Firm 1		0.017
(Net income)$_+$ of Firm 1	-16.497	21.525
(Net income)$_-$ of Firm 1	*** -20.542	** -32.026
(Return)$_+$ of Firm 2	0.010	-0.013
(Return)$_-$ of Firm 2	. -0.181	-0.003
Volatility of Firm 2	*** 1.244	*** 1.336
Upgrade dummy of Firm 2	0.070	0.169
Downgrade dummy of Firm 2	** 0.198	0.143
Revisions up of Firm 2		0.004
Revisions down of Firm 2		*** 0.011
Earnings surprise of Firm 2		0.012
(Net income)$_+$ of Firm 2	-0.454	9.358
(Net income)$_-$ of Firm 2	*** -18.691	*** -42.598
Link-month obs.	81416	48479
Positive obs.	13734	8133
Unique links	1927	1156
Unique firms	525	361

Mechanism

- Our results suggest that news outlets choose to report about links between firms that experience financial distress

- This is consistent with a reader demand consideration mechanism posited by Mullainathan and Shleifer (2005)
  - Fine-tune content to match readers' interests and lock them in
  - García (2018) and Niessner and So (2018) show that the news reports more frequently and severely about negative shocks

- If demand consideration drive our results, we should expect to more frequently see links that impact the health of popular firms
  - Links between a less popular distressed firm and a more popular firm it may contaminate

Less popular firm drives link likelihood

	Popularity proxy			
	Market capitalization		Number of 13-F investors	
(Return)$_+$ of Firm 1	0.206	0.052	0.239	0.264
(Return)$_-$ of Firm 1	0.005	0.055	−0.024	0.098
Upgrade dummy of Firm 1	−0.024	0.109	−0.141	−0.026
Downgrade dummy of Firm 1	0.003	−0.042	0.056	0.054
Revisions up of Firm 1		0.004		0.002
Revisions down of Firm 1		· 0.006		0.005
(Return)$_+$ of Firm 2	−0.011	0.106	−0.026	−0.082
(Return)$_-$ of Firm 2	*** −0.408	· −0.272	* −0.320	· −0.295
Upgrade dummy of Firm 2	0.053	0.181	* 0.226	* 0.265
Downgrade dummy of Firm 2	*** 0.353	*** 0.297	*** 0.300	** 0.236
Revisions up of Firm 2		0.006		0.007
Revisions down of Firm 2		*** 0.019		*** 0.020
Link-month obs.	81416	48479	59465	48185
Positive obs.	13734	8133	9682	8086
Unique links	1927	1156	1415	1149
Unique firms	525	361	411	356

Highly robust to alternative specifications
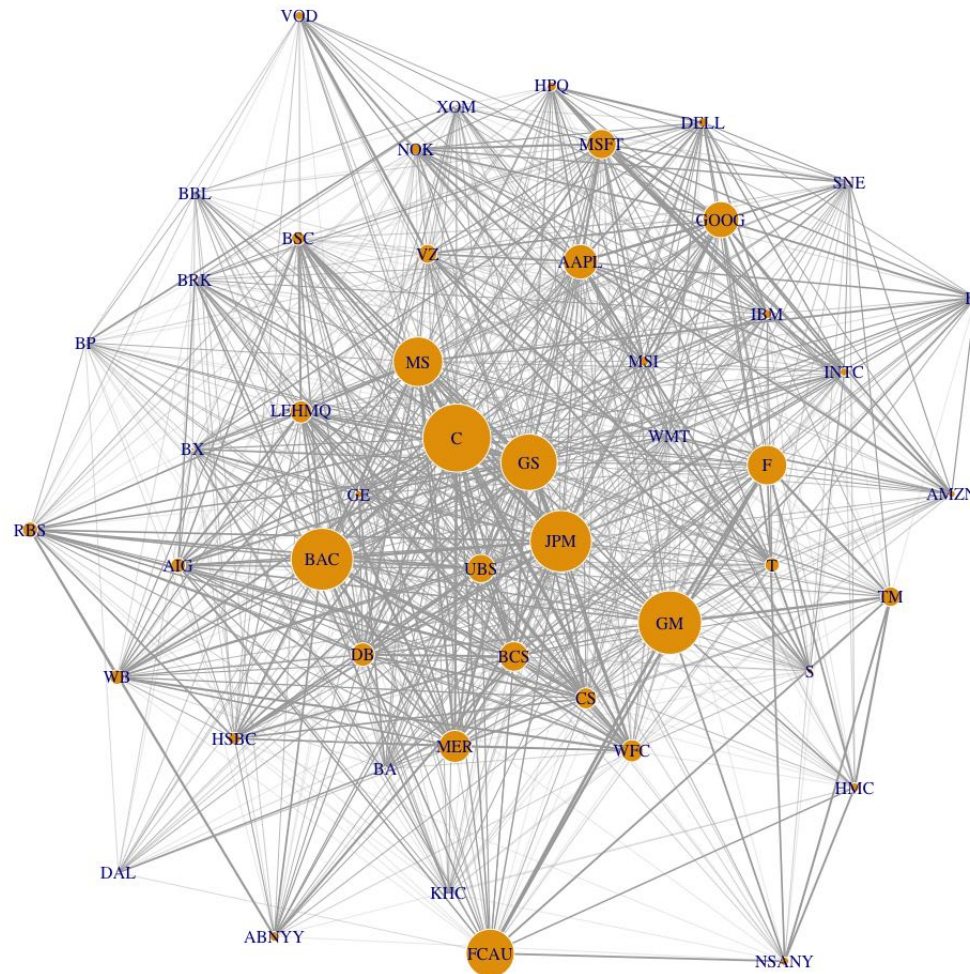
Temporary contamination
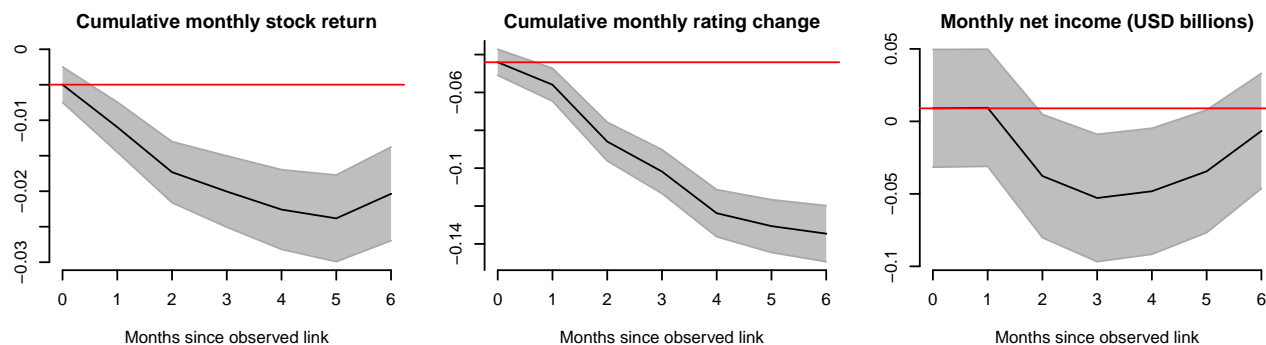
(a) Post-link performance of smaller firm.
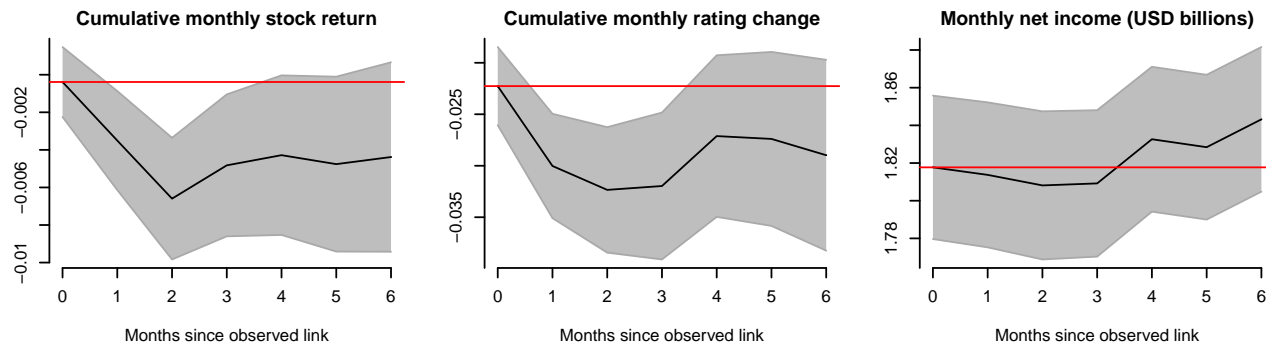
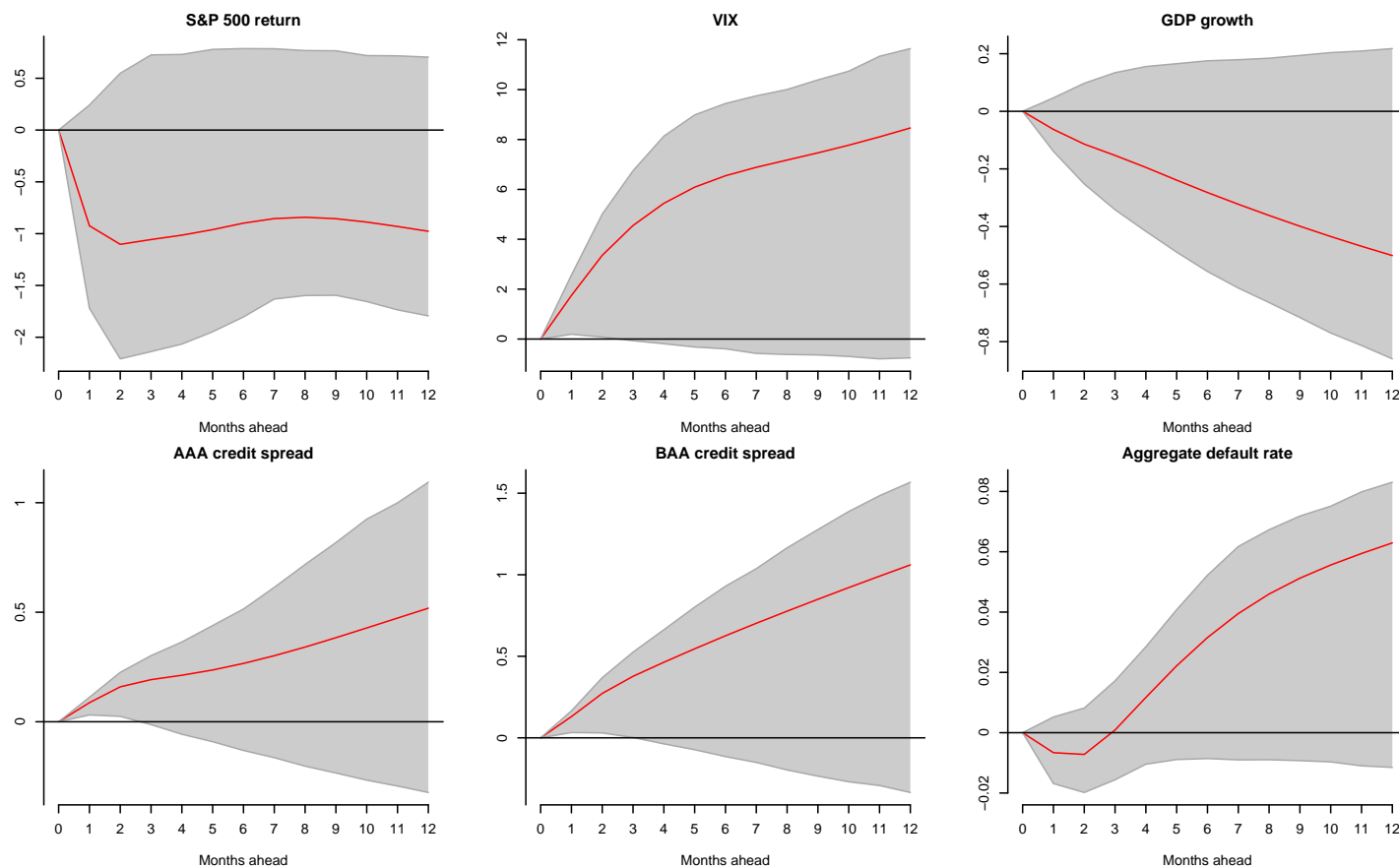(b) Post-link performance of larger firm.

News-implied contagion flows from smaller to larger firm
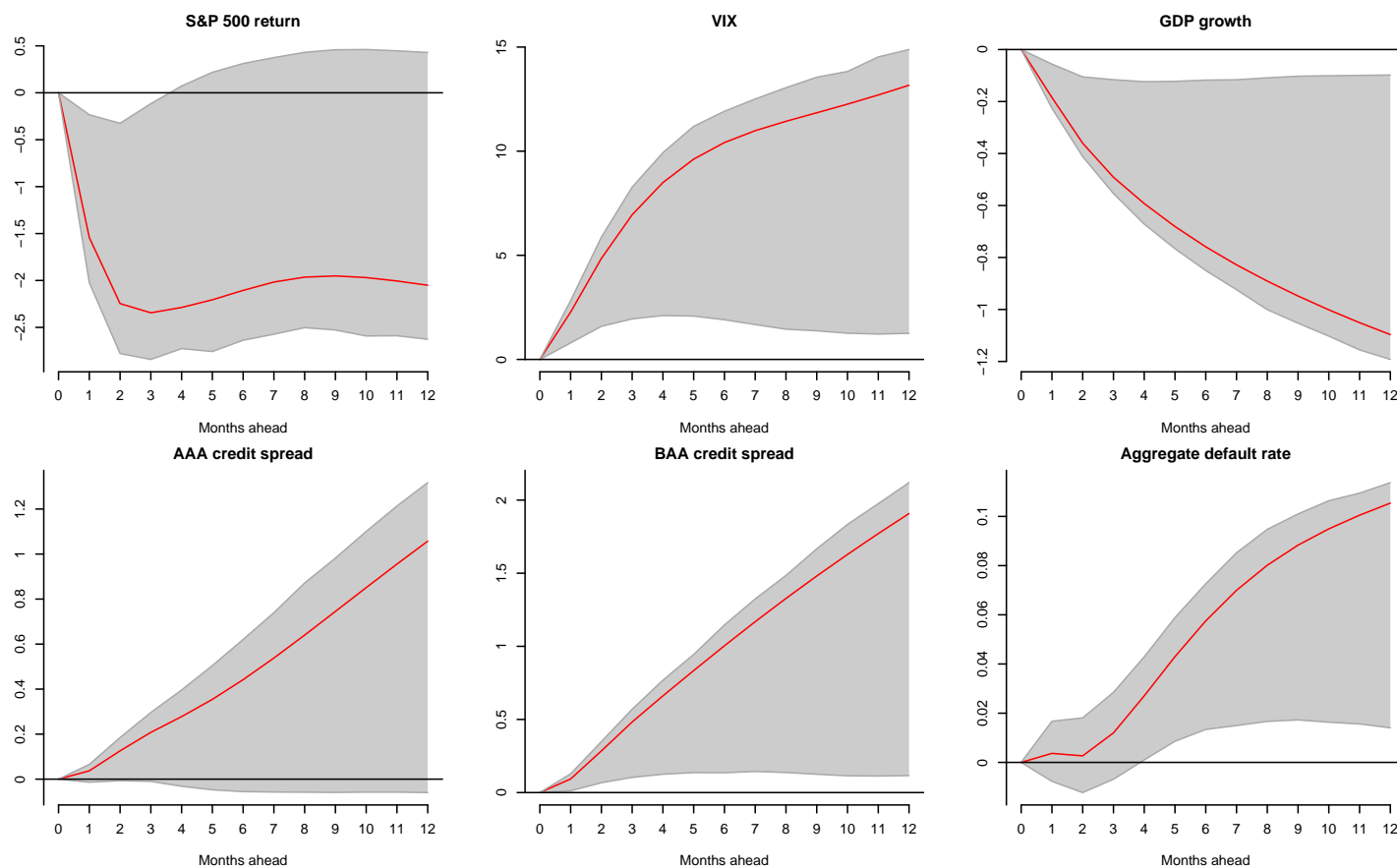
Result 2: News networks predict distress

Inspired by Acemoglu et al. (2012) and Herskovic (2018)

Impulse responses to average degree shocks

Impulse responses to second-order IC shocks

Predictive power & alternative networks

		S&P 500		VIX		GDP growth	
		(1)	(2)	(1)	(2)	(1)	(2)
News	Lagged average degree		-0.187		$*\,0.327$		-0.010
	Lagged 1st-order IC		-0.167		-0.635		0.080
	Lagged 2nd-order IC		$**\,-82.610$		$***\,113.676$		$***\,-11.546$
Segments	Lagged average degree	0.001	-0.001	0.001	0.000	0.000	0.000
	Lagged 1st-order IC	1.880	-2.479	2.183	2.846	-0.102	-0.132
	Lagged 2nd-order IC	-4.293	2.132	-23.009	-25.632	2.912	0.875
V-D	Lagged average degree	-0.014	0.005	0.022	0.007	-0.003	-0.001
	Lagged 1st-order IC	0.032	0.013	-0.032	-0.040	-0.011	-0.012
	Lagged 2nd-order IC	-2.175	-2.279	1.233	1.618	-0.072	-0.098
H-P	Lagged average degree	-0.228	-0.408	-1.890	-2.015	0.129	0.121
	Lagged 1st-order IC	7.812	7.648	-10.673	$\cdot\,-12.966$	1.092	$*\,1.321$
	Lagged 2nd-order IC	102.288	87.301	-120.211	$\cdot\,-142.381$	8.638	9.632
Controls		Intercept, autoregression, predictive factors					
Number of observations		83	83	83	83	83	83
Out-of-sample R^2		0.155	0.341	0.770	0.853	0.703	0.799
F-statistic			$**\,6.105$		$***\,12.468$		$***\,10.759$

Alternative data sources are not as predictive

Conclusion

- We show that the news reports about distressed firm links that drive firm-level and aggregate risks

- News-implied contagion flows from a less popular to a more popular firm and yields predictable returns and credit downgrades

- News-implied firm networks contain information about financial uncertainty and contagion effects that drive aggregate outcomes

- News-implied connectivity is a better predictor of aggregate risks than measures derived from alternative networks

- To obtain our results, we develop a machine learning methodology that extracts a network of firm links from text data

Thank you!

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Methodology

- We develop a natural language processing methodology to identify unique firm names in text data

  1. Stanford coreNLP to identify named organizations

  2. Machine learning to pick out firms among set of recognized organizations

  3. Match with CRSP / Compustat

Methodology

```
-- GM-UAW contract seen hard to match fully by rivals
-- By  David Bailey
-- Tue Oct 2, 2007 3:47pm EDT
-- http://www.reuters.com/article/2007/10/02/us-gm-uaw-idUSN0242907020071002


 DETROIT  (Reuters) - Several aspects of the tentative contract between General Motors Corp ( GM.N ) and the United Auto Workers union will be hard for Ford Motor Co.
( F.N ) and Chrysler LLC to match in labor talks expected to heat up in coming days, people familiar with the negotiations said.

 The adoption of second-tier wages for new hires at GM represents an attractive concession for Ford and Chrysler, but the structure of a retiree health-care trust
could prove difficult to transfer, sources familiar with the matters said on Tuesday. The establishment of a Voluntary Employees Beneficiary Association trust, or
VEBA, was a centerpiece of the UAW's agreement with GM, allowing the automaker to take some $50 billion of liabilities off its books. Privately held Chrysler has been
focused on cash flow since Cerberus acquired the automaker over the summer, to the point that it has been taking daily cash flow reports. The GM-UAW health-care trust
would not provide savings until 2010, when the new trust is expected to take over some $3 billion in annual retiree health care payments from the top U.S. automaker.
Ford and Chrysler would be hard-pressed to match the bump-up in pension payments to their retirees that GM has agreed to give to its UAW retirees under the tentative
contract, people familiar with the talks said. UAW President Ron Gettelfinger said on Friday he expected to assess the state of talks with both Ford and privately held
Chrysler after local UAW leaders unanimously recommended that workers approve the GM contract. Gettelfinger wants the agreement with GM to serve as a basic pattern for
talks with Ford and Chrysler in keeping with a long-held tradition that has kept all three Detroit-based automakers on a similar labor-cost footing. The union's deal
with GM includes a second-tier wage for new hires outside the production line, a health-care trust for retirees and some job security. UAW VOTES ON GM CONTRACT
CONTINUE The UAW may not resume full negotiations with Ford or Chrysler until it completes the ratification, or has enough of a favorable indication from the voting at
GM locals first, one person close to the talks said. Subcommittees for the UAW and Chrysler had been meeting this week, but there was no indication when full talks
would resume, said the person, who asked not to be named because of the private nature of the talks. In the meantime, negotiators at Ford and Chrysler have been poring
over the details in the UAW contract with GM. The UAW and GM reached a tentative four-year contract last week to end a two-day national strike -- the first full-scale
walkout by the UAW against GM since 1970. The union wants to wrap up the ratification voting by October 10. A majority of the UAW members at GM must approve of the
contract for the agreement to be ratified. The more than 73,000 GM hourly workers represented by dozens of UAW locals across the United States have begun voting on the
contract. Members of UAW Local 174 near Detroit voted Monday in favor of the contract after a heavy turnout among the 250 to 300 members in one of the first tests of
the new contract. A local in Lansing, Michigan, was voting on Tuesday, while other major locals had scheduled informational meetings and votes for later in the week
and running into next week. Local 174 members said job security promises, the hiring of temporary workers as permanent employees and a better understanding of the
impact of the health-care trust on retirees may have tipped the scale toward ratification. GM gave the UAW job guarantees, made 3,000 temporary workers permanent and
promised to insource some jobs done by contractors in addition to the health-care trust. The automaker gave binding commitments to its 16 U.S. assembly plants through
the four-year contract, but three do not have binding commitments beyond that and GM expressly excluded two powertrain plants and a service parts operation from a
moratorium on plant closings and sales. A local representing workers at an assembly plant in Orion, Michigan, that has no GM commitments beyond 2013 is scheduled to
vote on Wednesday on the contract. (Additional reporting by  Kevin Krolicki  and  Poornima Gupta )
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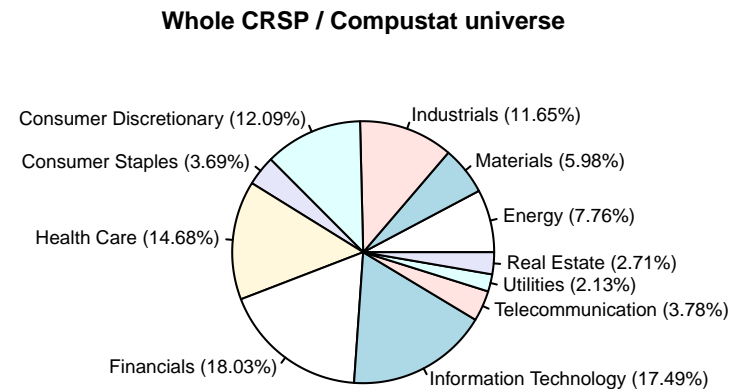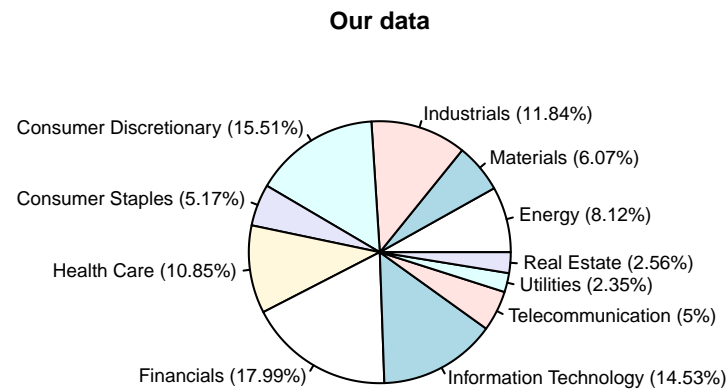
(c) Sample article.

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# A tibble: 4 x 7
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   <chr> <int>  <int>   <int> <chr>         <chr>     <chr>
1 doc1       1     10      10 ORGANIZATION GM         ""
2 doc1       1     16      16 ORGANIZATION Ford       ""
3 doc1       1     18      18 ORGANIZATION Chrysler   ""
4 doc1       1     41      41 DATE         Tuesday    XXXX-WXX-2
```

(d) Output of Stanford NER.

Output

Our data

Industrials (11.84%)
Materials (6.07%)
Consumer Discretionary (15.51%)
Energy (8.12%)
Consumer Staples (5.17%)
Real Estate (2.56%)
Utilities (2.35%)
Health Care (10.85%)
Telecommunication (5%)
Financials (17.99%)
Information Technology (14.53%)

Whole CRSP / Compustat universe

Industrials (11.65%)
Consumer Discretionary (12.09%)
Consumer Staples (3.69%)
Materials (5.98%)
Energy (7.76%)
Health Care (14.68%)
Real Estate (2.71%)
Utilities (2.13%)
Telecommunication (3.78%)
Financials (18.03%)
Information Technology (17.49%)

$\rightarrow$ Representative sample of cross section of U.S. economy

News-implied network

- News-implied networks are extensive and timely
  - 20,504 unique links between 2,406 firms

  - We cover a similar cross section of firms as CRSP / Compustat

  - We capture competitive relations, strategic partnerships, credit relations, parent-subsidiaries, and costumer-supplier links, among others

  - Available in arbitrary frequencies (we consider monthly)

Time series
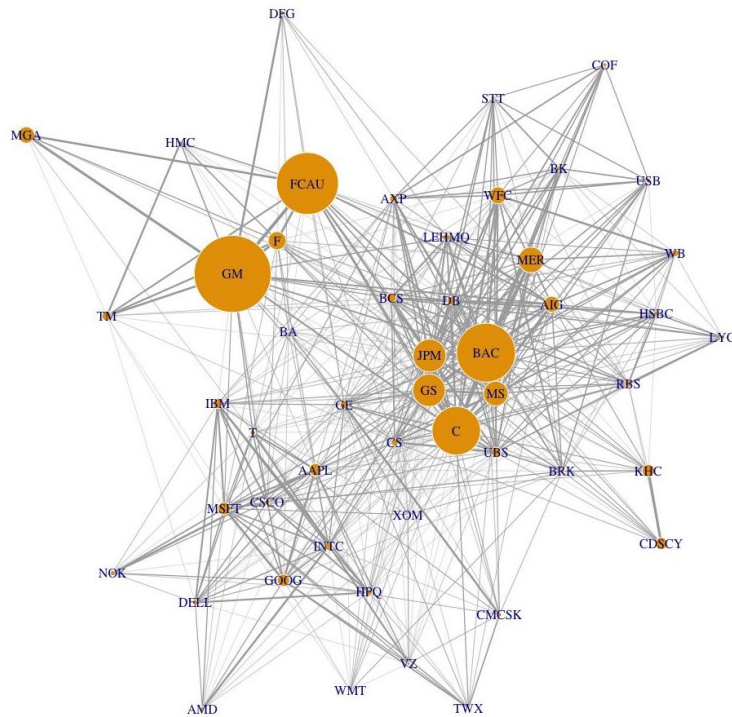
(e) 2009.
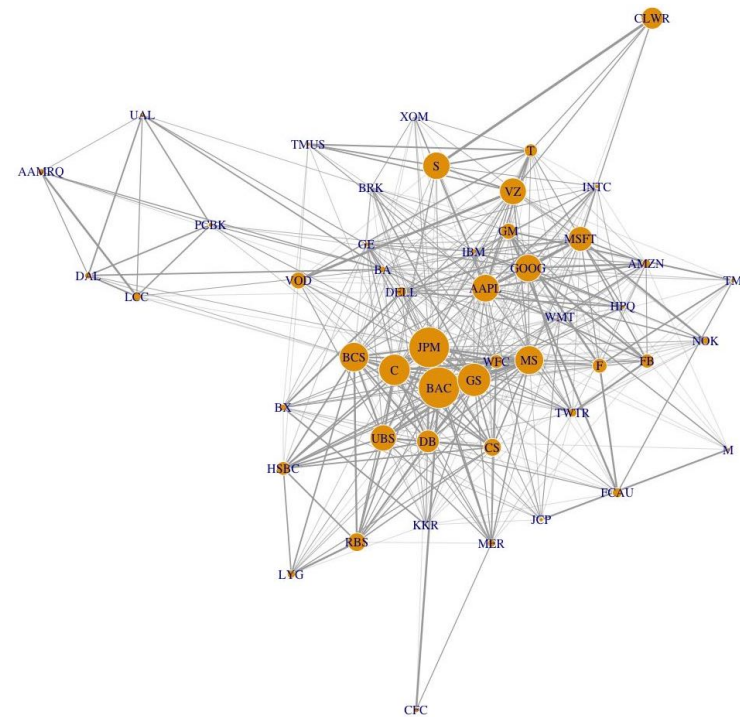
(f) 2013.

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Validation

- Our approach is highly accurate, correctly identifying and matching 73% of all firm mentions

  - Close to 90% of mistakes are due to non-match with CRSP / Compustat or non-identification by Stanford coreNLP

  - Only in 3% of all firm mentions do we mismatch firms

- Compared to an approach based on Reuters Instrument Codes, we capture a wider cross section of firms

  - Many more small and private firms

- Methodology particularly useful for text data in which firms are not clearly labelled (e.g., New York Times)

Link identification

- We establish a link between two firms if they are mentioned in the same sentence of a news article

  - 177,300 links in whole sample

  - 20,504 unique links between 2,406 firms (not all firms are connected)

- Linked firms tend to be large, with many links across sectors (about 60% inter-sectoral)

Sample sentences

Link	Representative sentence	Interpretation
(Apple, Google)	*"Chief Executive Eric Schmidt signaled that Google, the world's dominant Web search provider, is working more closely with Apple Inc., the pace setter in the consumer electronics world."*	Competitive (strategic)
(Toyota, GM)	*"GM argued that it needed to cut the nearly $5 billion per year it spends on health care to compete against Japanese rivals led by Toyota Motor Corp."*	Competitive (destructive)
(C, MS)	*"Citigroup, Credit Suisse, Deutsche Bank, Goldman Sachs, Merrill Lynch, Morgan Stanley and UBS said in a statement they will form a new company with an independent management team to develop the trading platform."*	Interbank
(BofA, Merrill Lynch)	*"Bank of America Corp on Sunday is in advanced talks to acquire Merrill Lynch & Co Inc, a deal that would give the bank the world's largest brokerage and a sizable investment bank."*	M&A
(Vodafone, Verizon)	*"Verizon Wireless, a 55 percent owned joint venture with Vodafone Group Plc, added 2.3 million net customers in the fourth quarter."*	Parent subsidiary
(Daimler, Chrysler)	*"The German company Daimler AG will contribute another 650 million euros to cover long-term liabilities at Chrysler."*	Credit
(Boeing, UPS)	*"U.S. aircraft maker Boeing Co. confirmed an order for 27 Boeing 767-300 Freighters from package delivery company United Parcel Service Inc."*	Costumer-supplier

Counterfactual
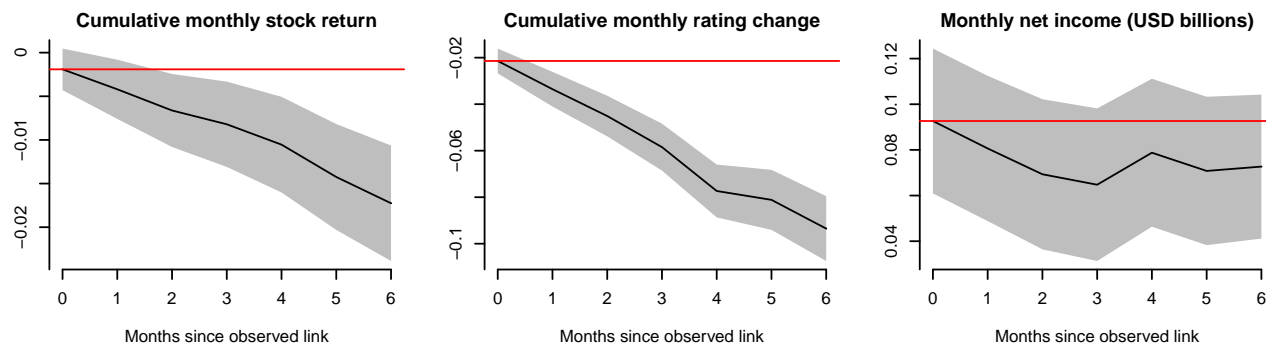
(g) Post-link performance of smaller firm.
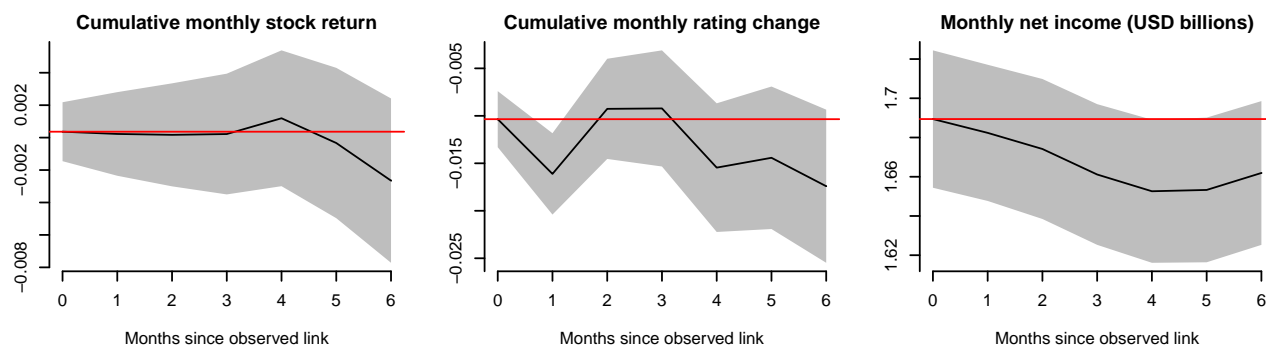
(h) Post-link performance of larger firm.

Our results are inconsistent with firms being linked at random when they are distressed (Niessner and So (2018))

Implications – link-level results

- Our results suggest that the news reports about distressed firm links to attract concerned investors of popular firms as readers

- News-implied links enable contagion from small to large firms
  - Affects asset prices and credit risk
  - In contrast to lead-lag relationships in equity markets that generally flow from large to small firms (Cohen and Frazzini (2008), Lo and MacKinlay (1990), Hou (2007))

- Extending Scherbina and Schlusche (2015), we show that the news is not an unbiased source of data on firm links
  - Selective news reporting, as highlighted by Nimark and Pitschner (2019)

Vector auto-regression

- We consider a monthly one-lag VAR model of several aggregate risk measures and the orthogonalized connectivity measures

  - GDP growth is most exogenous variables

  - Connectivity measures are most endogenous variables

- Identification based on Cholesky decomposition of residual variance covariance matrix

Average degree & financial uncertainty

	VIX	VXO	Financial uncertainty (Jurado et al. (2015))	Financial uncertainty (Carriero et al. (2018))	EMV index (Baker et al. (2019))
Intercept	. −3.313	* −3.984	−0.001	−0.056	−0.777
	(−1.930)	(−2.268)	(−0.037)	(−0.747)	(−0.296)
Lagged value	*** 0.725	*** 0.712	*** 0.952	*** 0.776	*** 0.384
	(11.349)	(11.040)	(37.384)	(12.725)	(4.115)
Average degree	*** 0.504	*** 0.552	** 0.003	*** 0.016	*** 0.764
	(5.637)	(5.693)	(2.997)	(3.706)	(5.578)
First-order IC	0.744	0.872	−0.010	0.024	0.024
	(0.714)	(0.791)	(−1.196)	(0.547)	(0.018)
Second-order IC	−33.447	−33.780	0.062	* −2.036	54.368
	(−1.471)	(−1.405)	(0.315)	(−1.992)	(1.504)
# obs.	84	84	84	84	84
Adjusted R^2	0.8198	0.823	0.970	0.827	0.502

Financial uncertainty is high when many firms face distress, which is precisely in periods in which the news-implied network is dense

Second-order IC & credit risk contagion
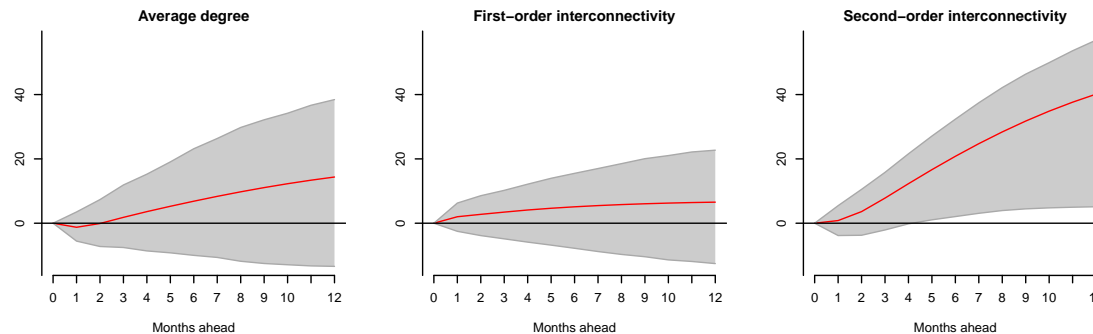
(i) Aggregate default rate.
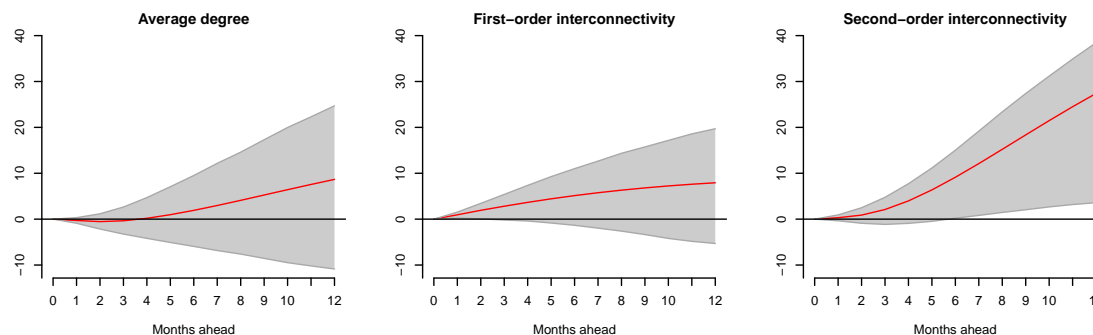
(j) Credit risk contagion factor of Azizpour et al. (2018).

Second-order IC gives a measure of the length of the contagion chain, capturing the potential for credit risk contagion in the economy

Implications – aggregate-level results

- News-implied networks contain information about contagion and uncertainty effects that drive aggregate outcomes

- New results show that news reporting on its own can trigger large aggregate fluctuations
  - About a third of the effects due to transitory changes in news-implied network
  - Consistent with recent findings by Chahrour et al. (2019)

- All in one, the information contained in the news is predictive of aggregate risks (beyond sentiment and beyond truthful reporting)
  - In alignment with Manela and Moreira (2017) and Liu and Matthies (2018)

Article co-mentions
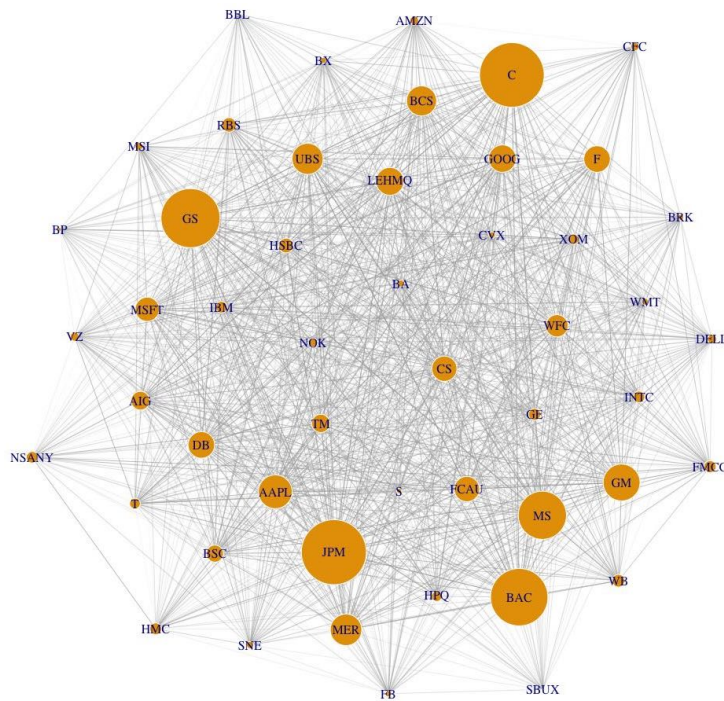
(k) Co-mentions in same article.
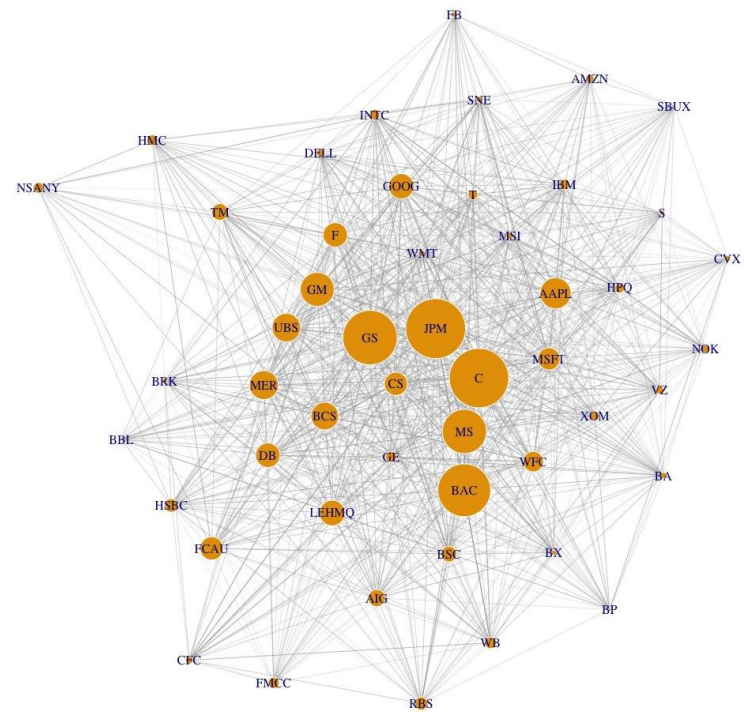
(l) Co-mentions in same sentence.

Information in same-sentence links

	Average degree (article co-mention)	First-order IC (article co-mention)	Second-order IC (article co-mention)
Intercept	* 5.479	*** 1.108	** 0.025
	(2.427)	(6.567)	(3.058)
Average degree (sentence co-mention)	*** 2.129 (18.803)		
First-order IC (sentence co-mention)		*** 0.447 (9.355)	
Second-order IC (sentence co-mention)			*** 0.920 (12.258)
Number of observations	85	85	85
Adjusted R^2	0.808	0.507	0.640

Information in cross-sentence links

	VIX	VXO	Financial uncertainty (Jurado et al. (2015))	Financial uncertainty (Carriero et al. (2018))	EMV index (Baker et al. (2019))
Intercept	* -3.657	* -4.276	0.008	-0.062	-0.604
	(-2.167)	(-2.452)	(0.411)	(-0.815)	(-0.234)
Lagged value	*** 0.760	*** 0.751	*** 0.937	*** 0.796	*** 0.367
	(14.992)	(14.690)	(42.794)	(14.803)	(4.359)
Average degree	*** 0.480	*** 0.521	*** 0.003	*** 0.015	*** 0.775
(sentence co-mention)	(5.560)	(5.620)	(3.492)	(3.584)	(5.813)
Average degree residual	0.004	0.011	0.000	0.000	0.190
(Article co-mention)	(0.053)	(0.132)	(0.572)	(0.104)	(1.608)
Number of observations	84	84	84	84	84
Adjusted R^2	0.816	0.820	0.970	0.820	0.510

Economically relevant information about financial uncertainty is contained in same-sentence links

Information in cross-sentence links
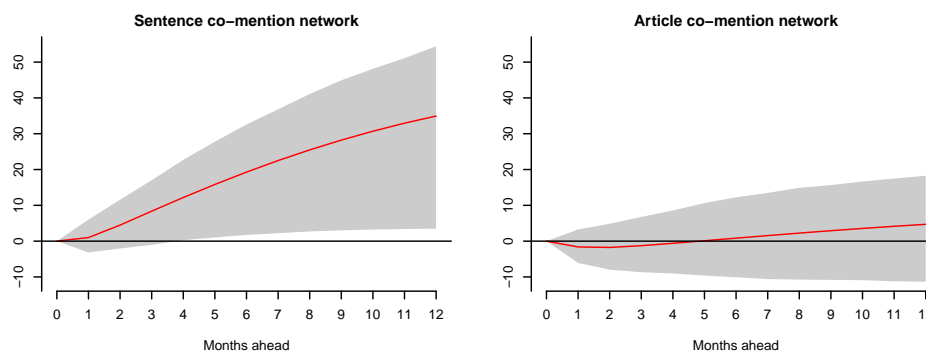
(m) Aggregate default rate.
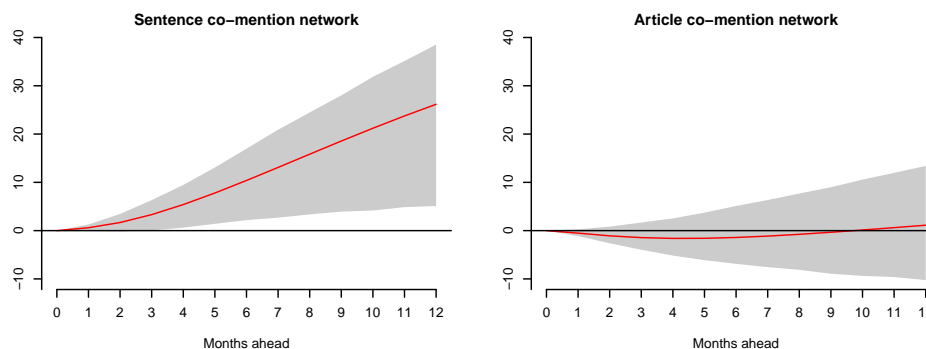
(n) Contagion factor of Azizpour et al. (2018).

Economically relevant information about contagion is also contained in same-sentence links

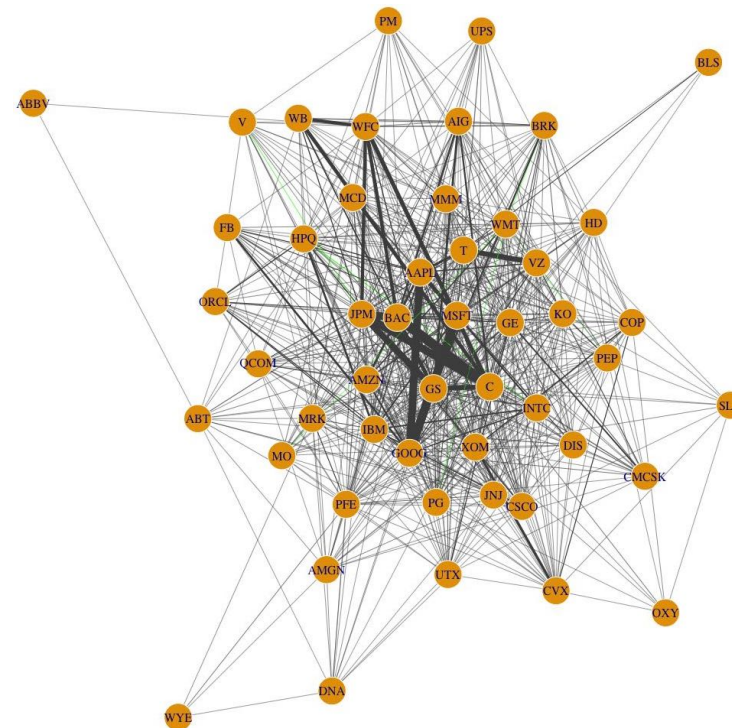# Time series of connectivity measures
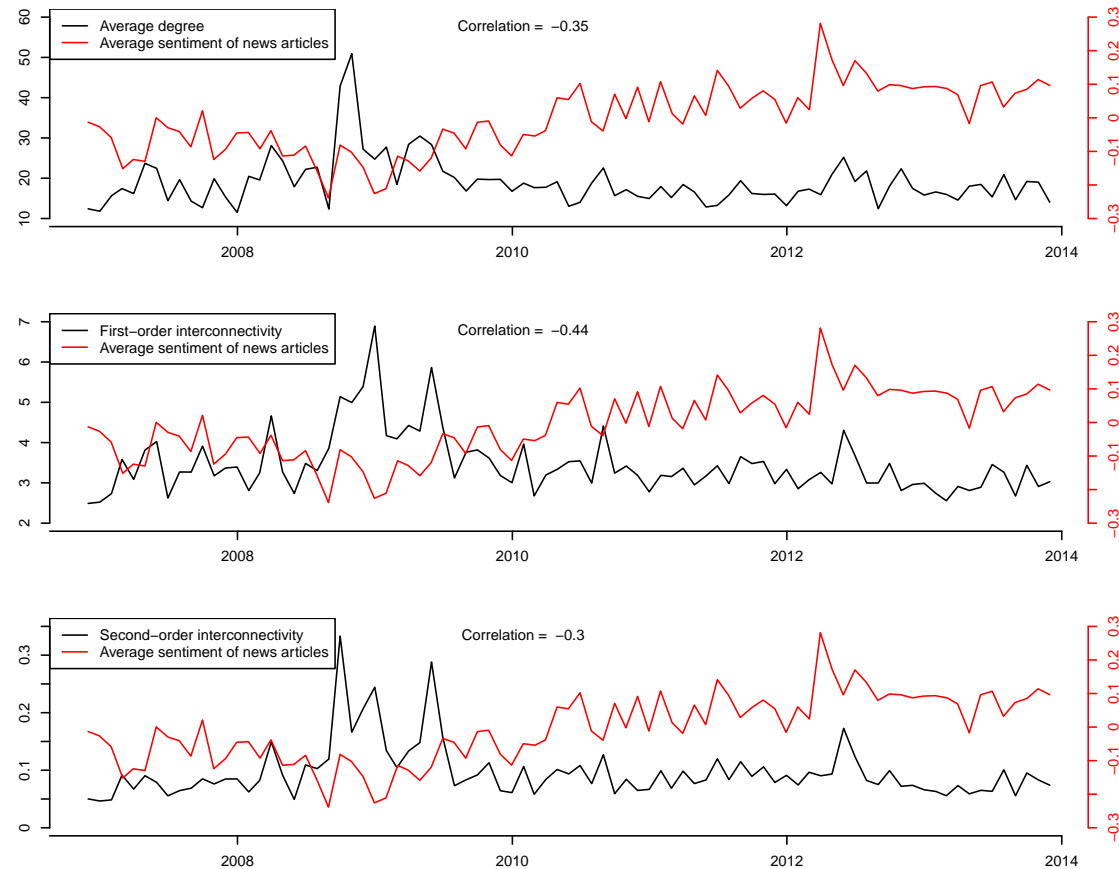
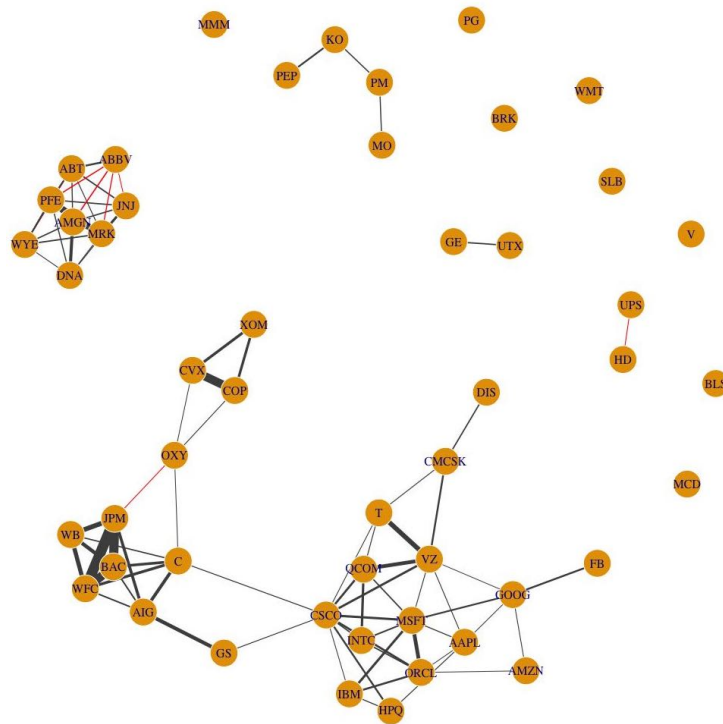# Relationship with other networks
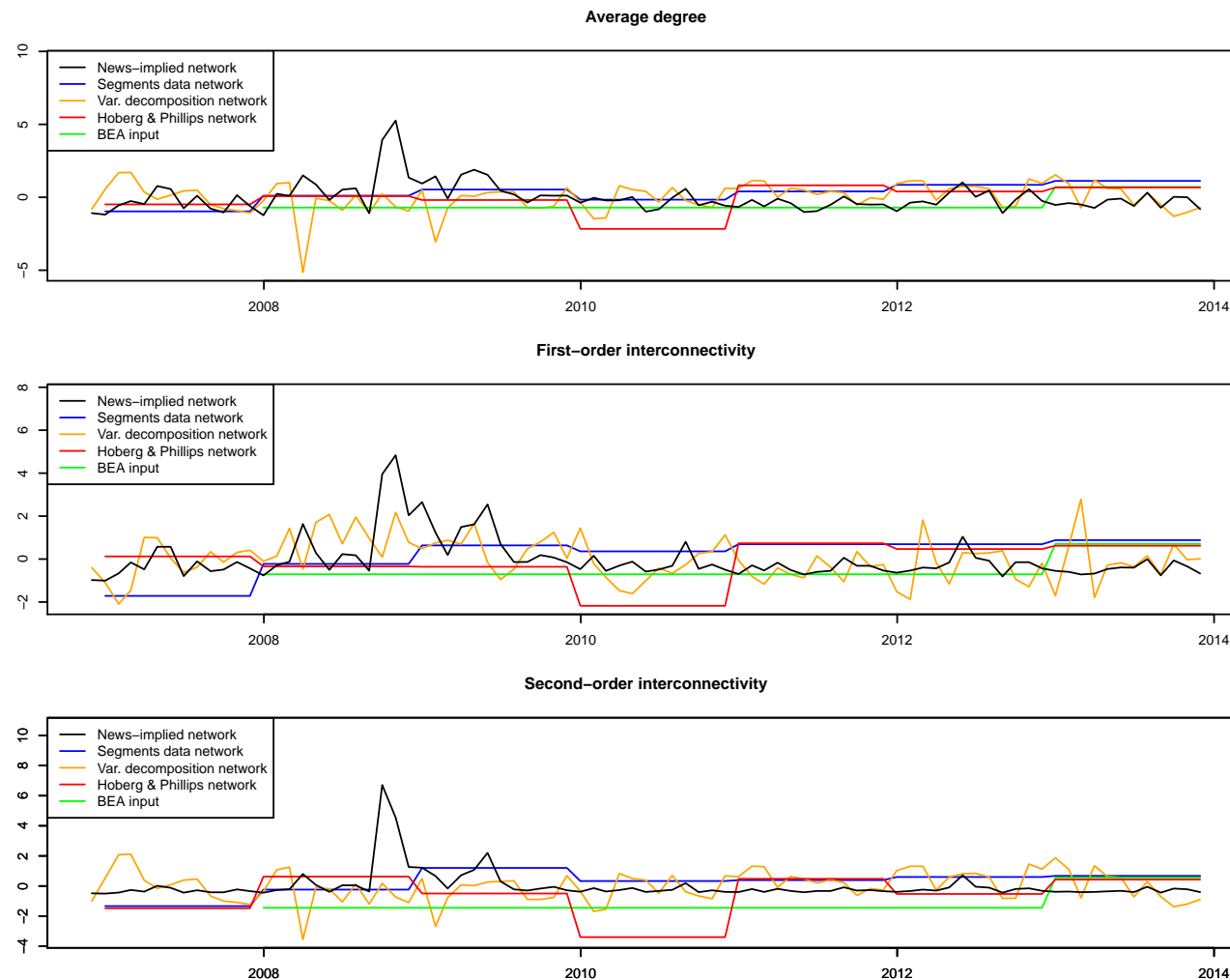
Relation with other networks
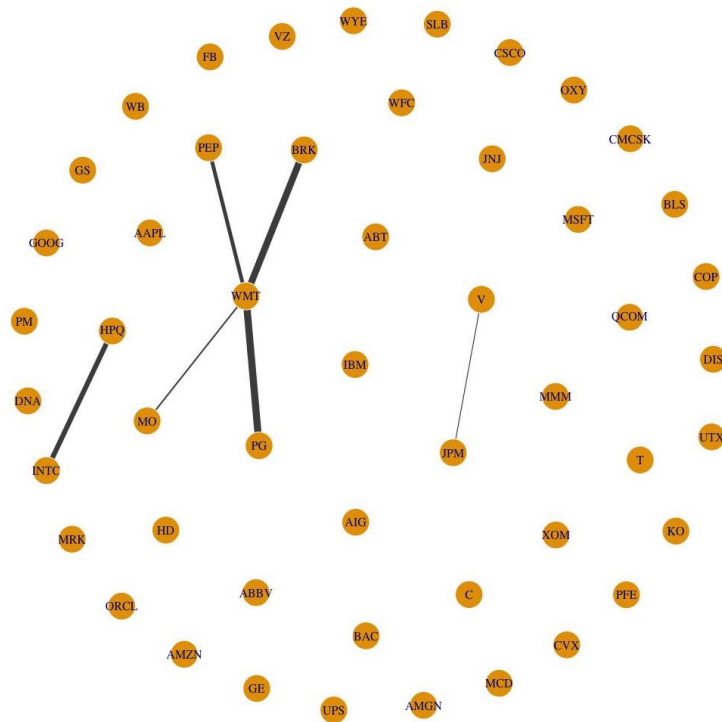
(o) Compustat segments network (100%).
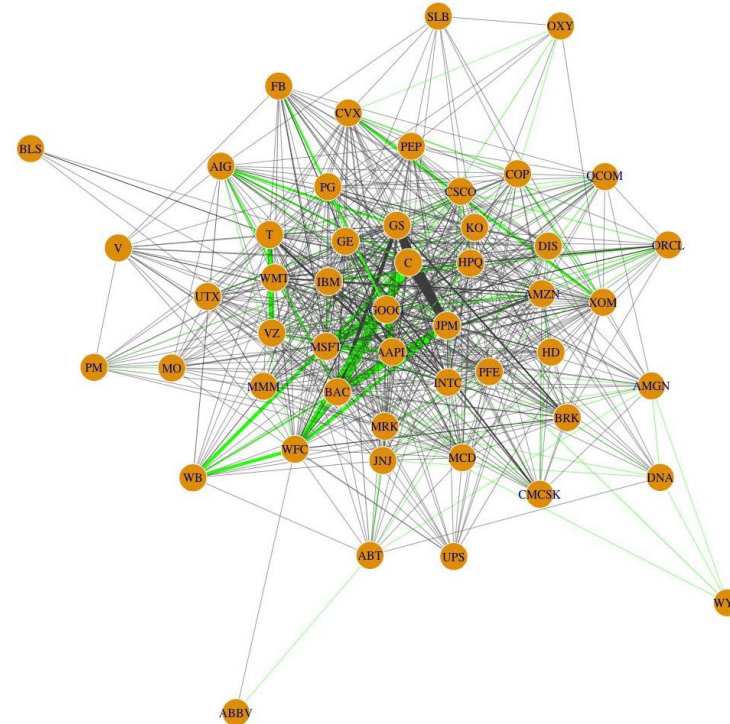
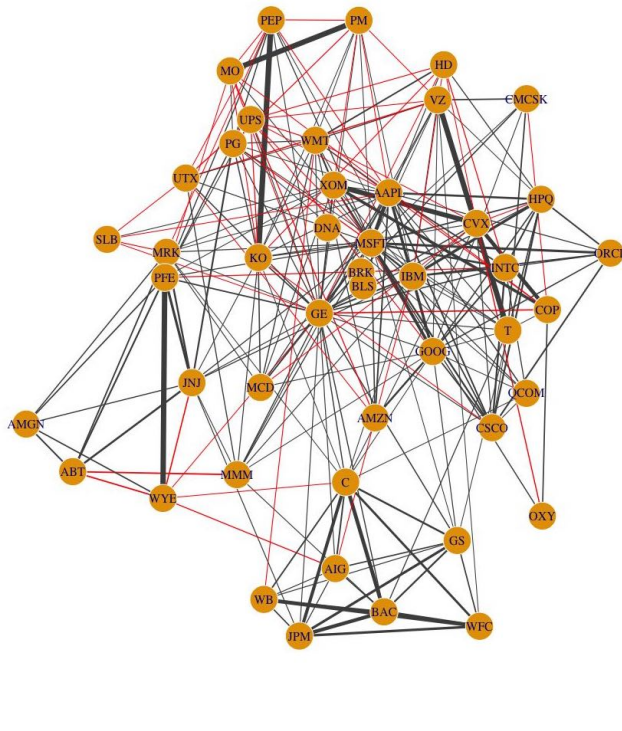(p) News-implied network.

Relation with other networks

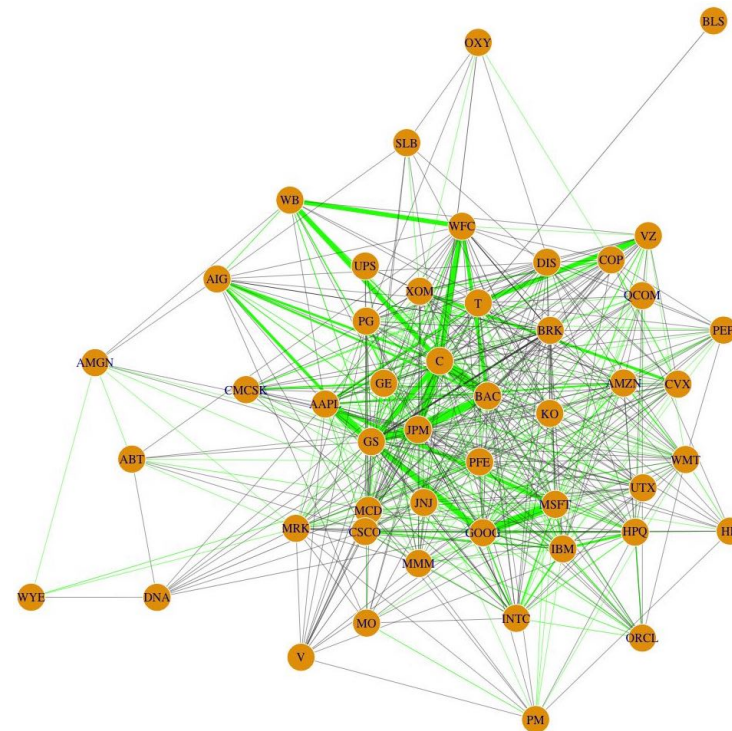(q) Firm similarity network (Hoberg and Phillips (2016), 84%).
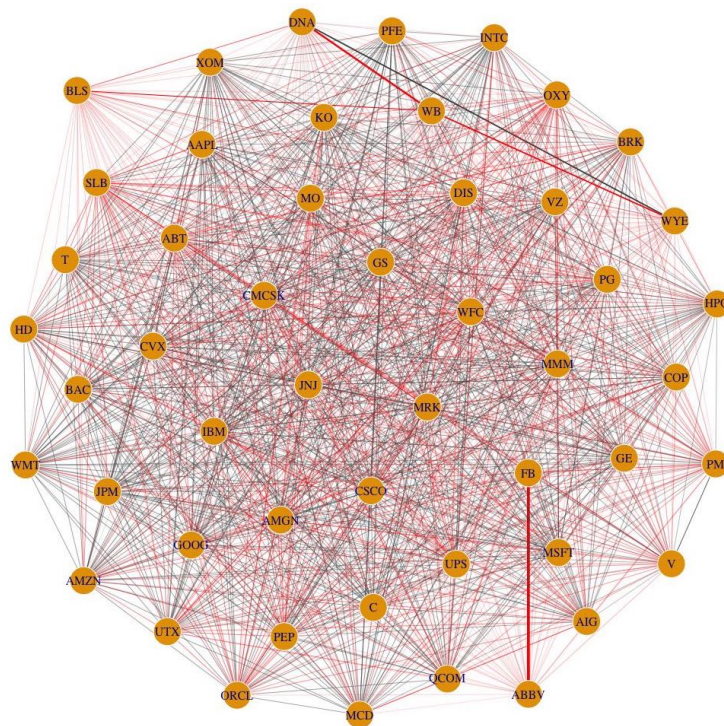
(r) News-implied network.

Relation with other networks

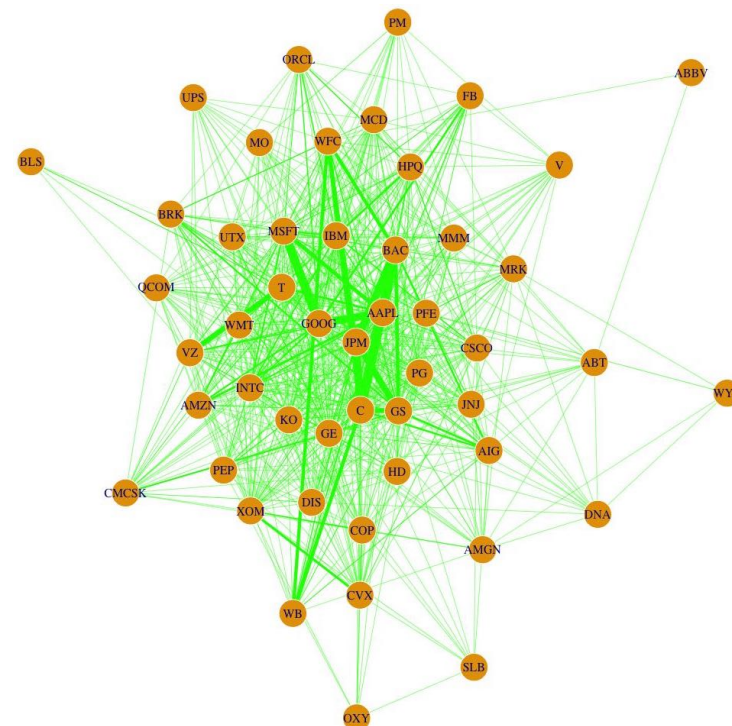(s) EDGAR co-search network (Lee et al. (2015), 78%).

(t) News-implied network.
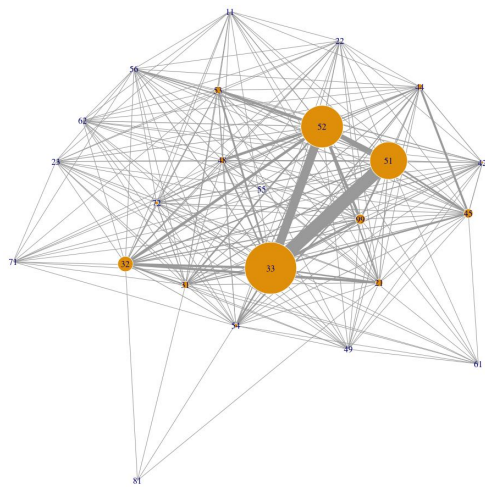
Relation with other networks

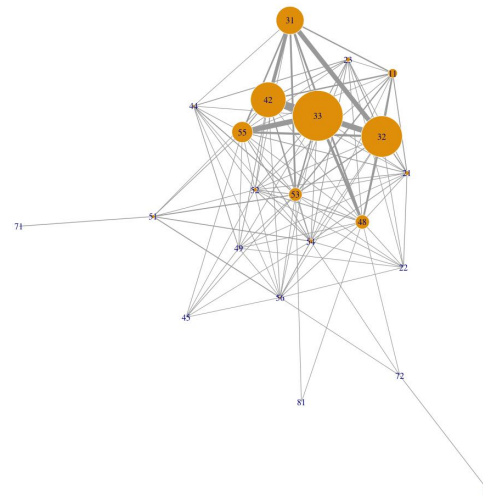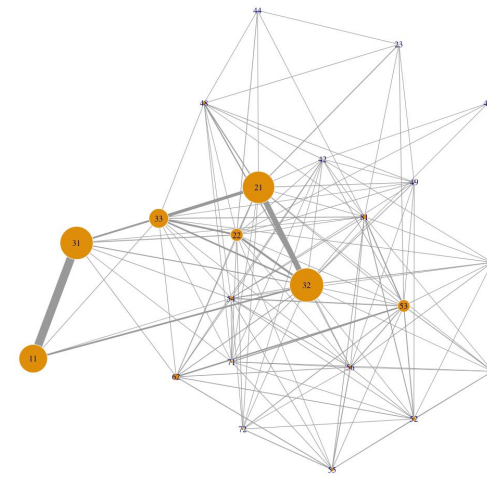(u) Variance decomposition network (Demirer et al. (2018), 56%).

(v) News-implied network.

Relation with other networks

(w) News-implied network.   (x) BEA input network.   (y) BEA output network.

Relationship with other networks

	Average degree	First-order IC	Second-order IC
Intercept	** 84.617	*** 10.218	0.236
	(2.992)	(3.797)	(0.957)
Segments network	−0.001	−0.151	−0.146
	(−0.266)	(−0.492)	(−0.638)
10-K similarity network	* −3.263	** −0.345	* −1070.403
(Hoberg and Phillips (2016))	(−2.316)	(−2.725)	(−2.041)
Variance decomposition network	−0.032	0.004	−2.628
(Demirer et al. (2018))	(−0.996)	(0.257)	(−0.236)
BEA input network	−0.620	−0.293	* −0.028
	(−0.311)	(−1.489)	(−2.241)
Number of observations	71	71	71
Adjusted R^2	0.085	0.164	0.078

$\rightarrow$ News-implied networks complement alternative networks