Text Mining for the Social Sciences
Lecture 7: Using Topic Models in Social Science

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Introduction

Last time we discussed inference in the LDA graphical model.

Formally topics are distributions over words, and documents are distributions over topics.

In many applications, researchers treat these distributions as inherently meaningful, and then use them to evaluate social science models.

Important to realize that neither objective is intrinsic to LDA, which is simply a clustering model.

Outline

1. Topic meaning
   1.1 Human interpretation
   1.2 External validity
2. Case study on transparency and career concerns

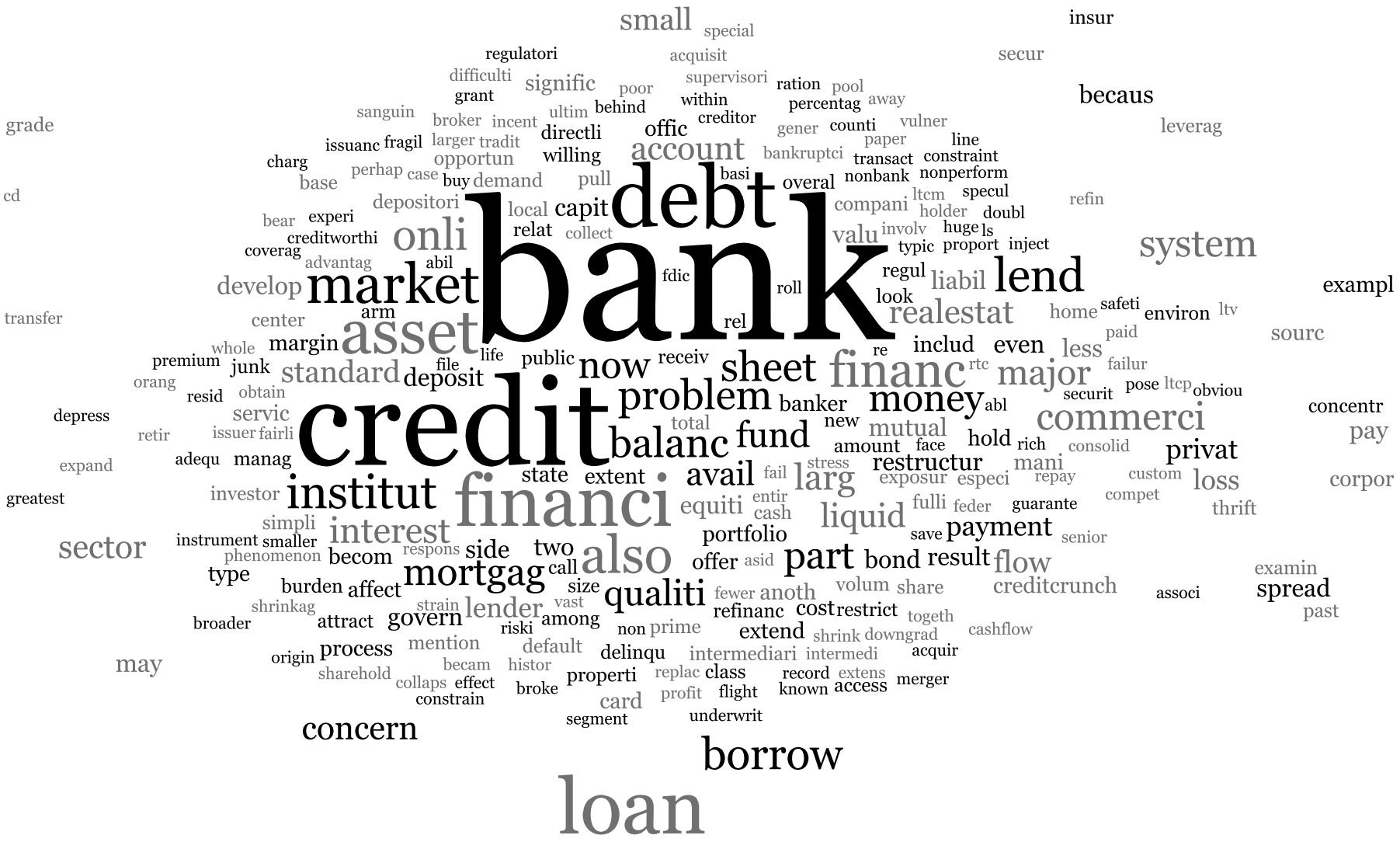
Topics and Meaning

Recall that the LSA representation of a document was useful for information retrieval, but not so much for interpreting content.

On the other hand, LDA consistently produces topics that seem to "mean" something.

But important to realize that any meaning we put on topics is an ex-post subjective judgment.

Topic 38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Quinn et al (2010)

Table 3 Topic Keywords for 42-Topic Model

Topic (Short Label)	Keys
1. Judicial Nominations	*nomine, confirm, nomin, circuit, hear, court, judg, judici, case, vacanc*
2. Constitutional	*case, court, attornei, supreme, justic, nomin, judg, m, decis, constitut*
3. Campaign Finance	*campaign, candid, elect, monei, contribut, polit, soft, ad, parti, limit*
4. Abortion	*procedur, abort, babi, thi, life, doctor, human, ban, decis, or*
5. Crime 1 [Violent]	*enforc, act, crime, gun, law, victim, violenc, abus, prevent, juvenil*
6. Child Protection	*gun, tobacco, smoke, kid, show, firearm, crime, kill, law, school*
7. Health 1 [Medical]	*diseas, cancer, research, health, prevent, patient, treatment, devic, food*
8. Social Welfare	*care, health, act, home, hospit, support, children, educ, student, nurs*
9. Education	*school, teacher, educ, student, children, test, local, learn, district, class*
10. Military 1 [Manpower]	*veteran, va, forc, militari, care, reserv, serv, men, guard, member*
11. Military 2 [Infrastructure]	*appropri, defens, forc, report, request, confer, guard, depart, fund, project*
12. Intelligence	*intellig, homeland, commiss, depart, agenc, director, secur, base, defens*

Formalizing Interpretablility

Chang et. al. (2009) propose an objective way of determining whether topics are indeed interpretable.

Two tests:

1. *Word intrusion*. Form set of words consisting of top five words from topic k + word with low probability in topic k. Ask subjects to identify inserted word.

2. *Topic intrusion*. Show subjects a snippet of a document + top three topics associated to it + randomly drawn other topic. Ask to identify inserted topic.

Estimate LDA and other topic models on NYT and Wikipedia articles for $K = 50, 100, 150$.

Results

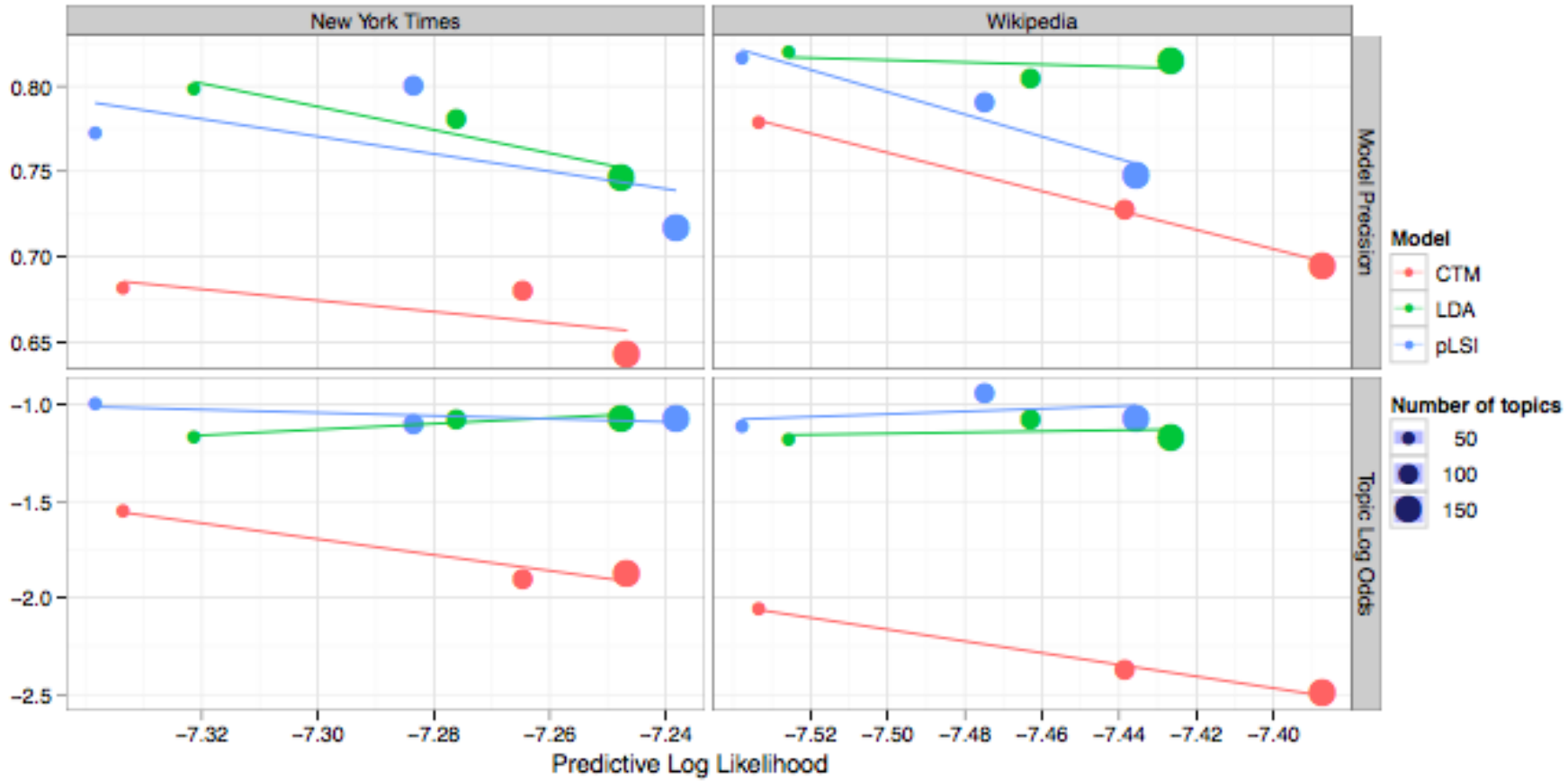


Figure 5: A scatter plot of model precision (top row) and topic log odds (bottom row) vs. predictive log likelihood. Each point is colored by model and sized according to the number of topics used to fit the model. Each model is accompanied by a regression line. Increasing likelihood does not increase the agreement between human subjects and the model for either task (as shown by the downward-sloping regression lines).

Implications

Topics seem objectively interpretable, at least in this context.

Tradeoff between goodness-of-fit and interpretablility, which is generally more important in social science.

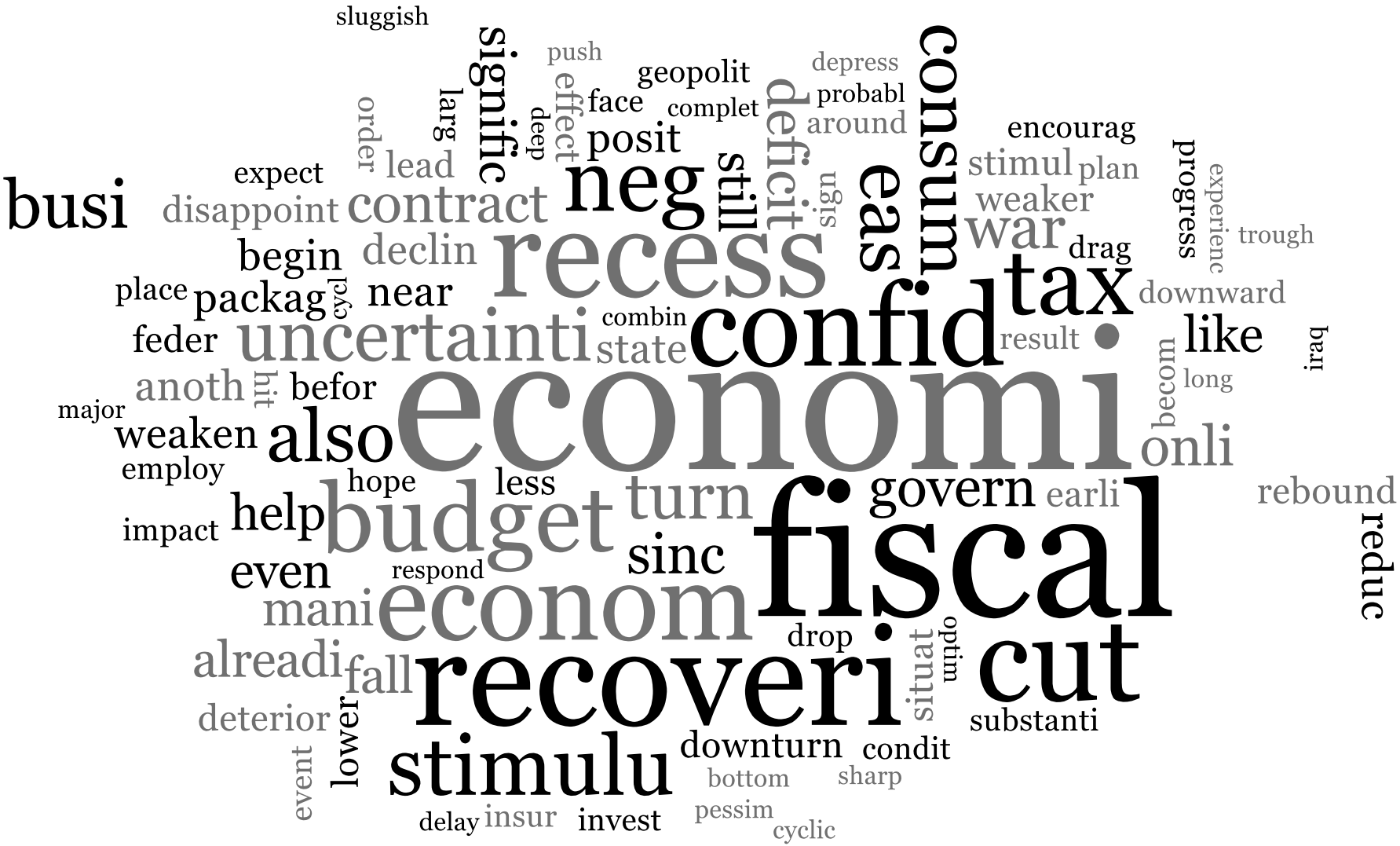
Potential development of statistical models in future to explicitly maximize interpretablility.

External Validity

One common way of validating the subjective labels placed on topics is to see whether they relate to objective measures in ways we expect.

In FOMC context, can compare how attention changes with market conditions and external events.

Topic 45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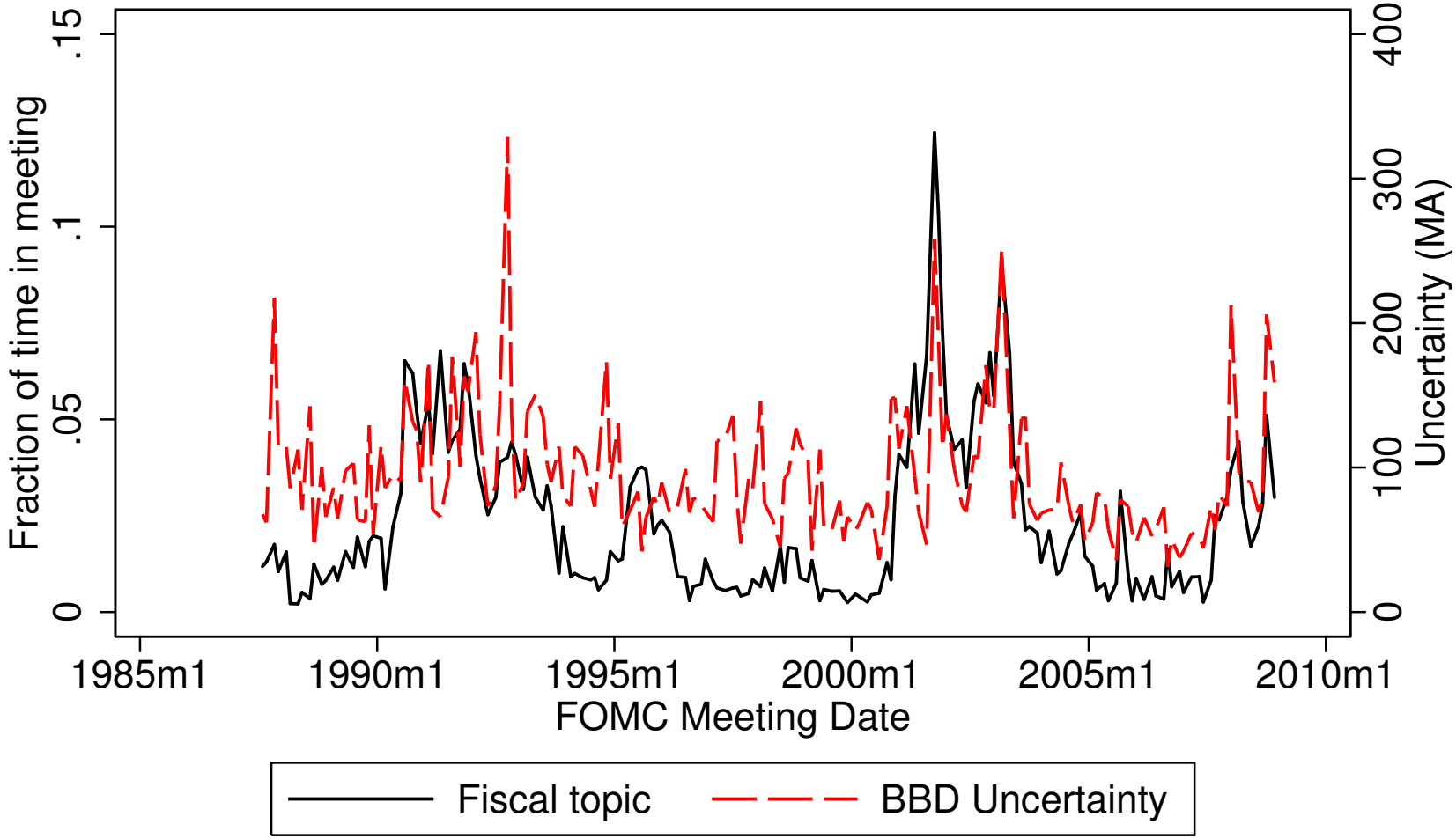
FOMC and Market Attention to "Recession/Fiscal"



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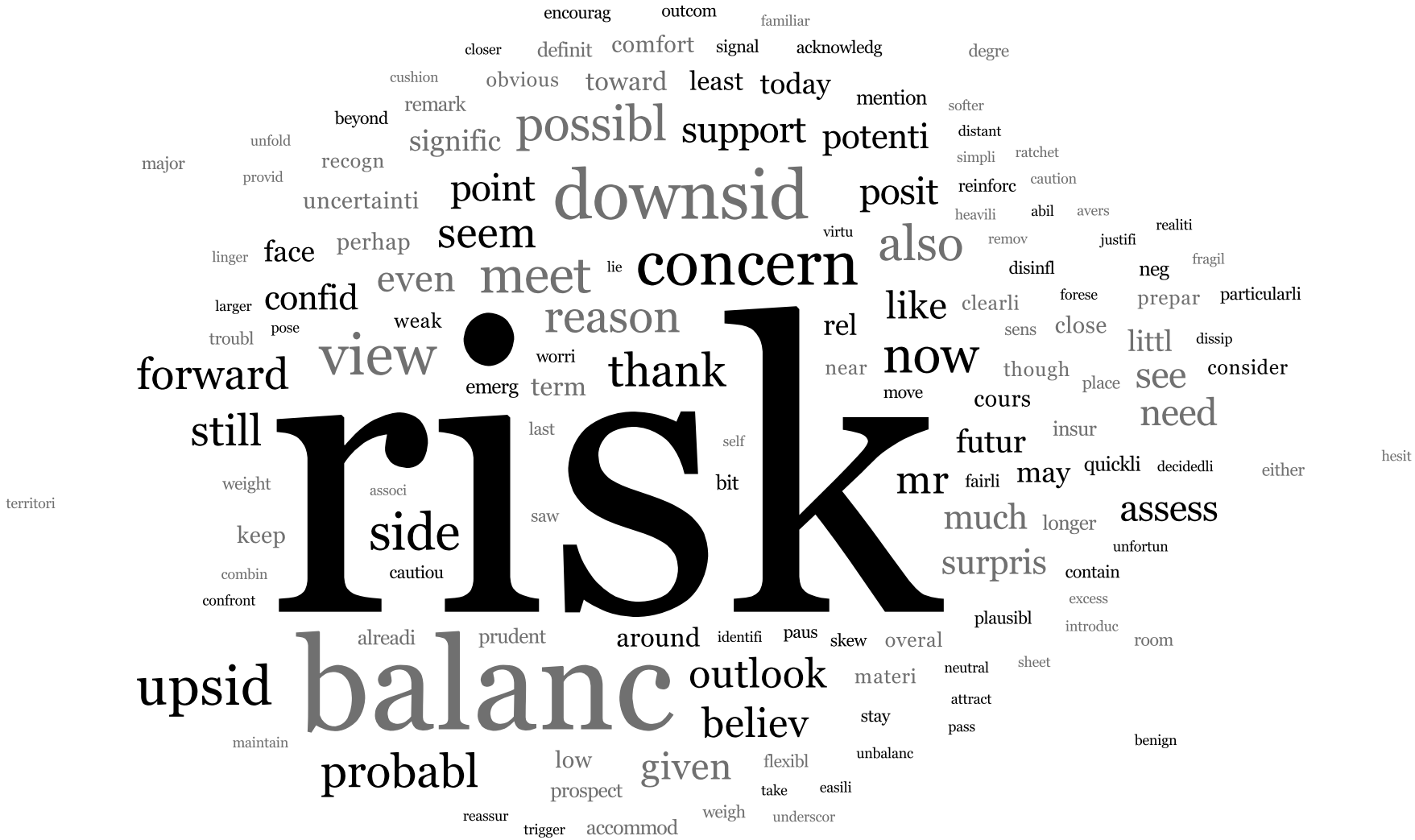
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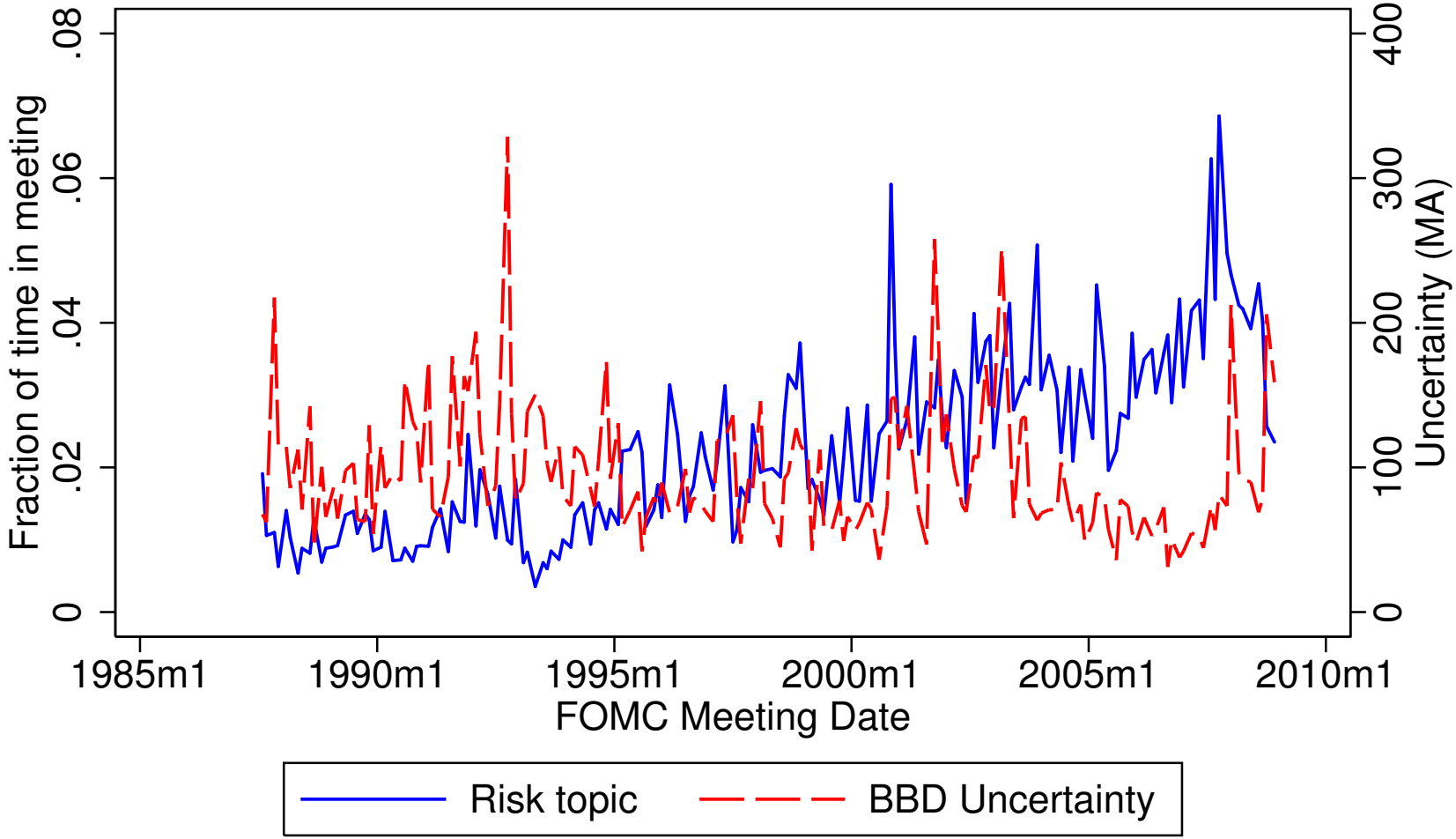
FOMC and Market Attention to "Risk"



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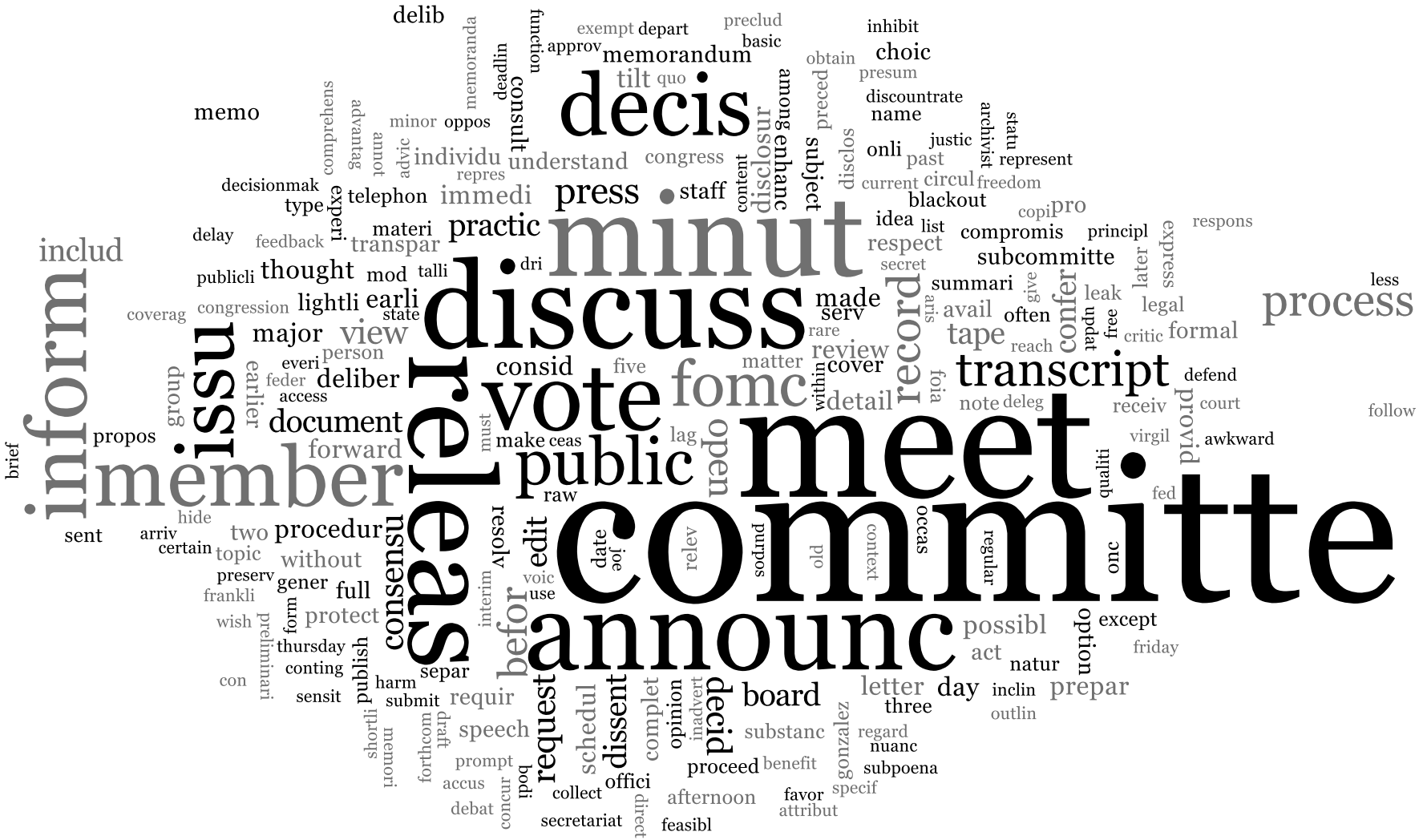
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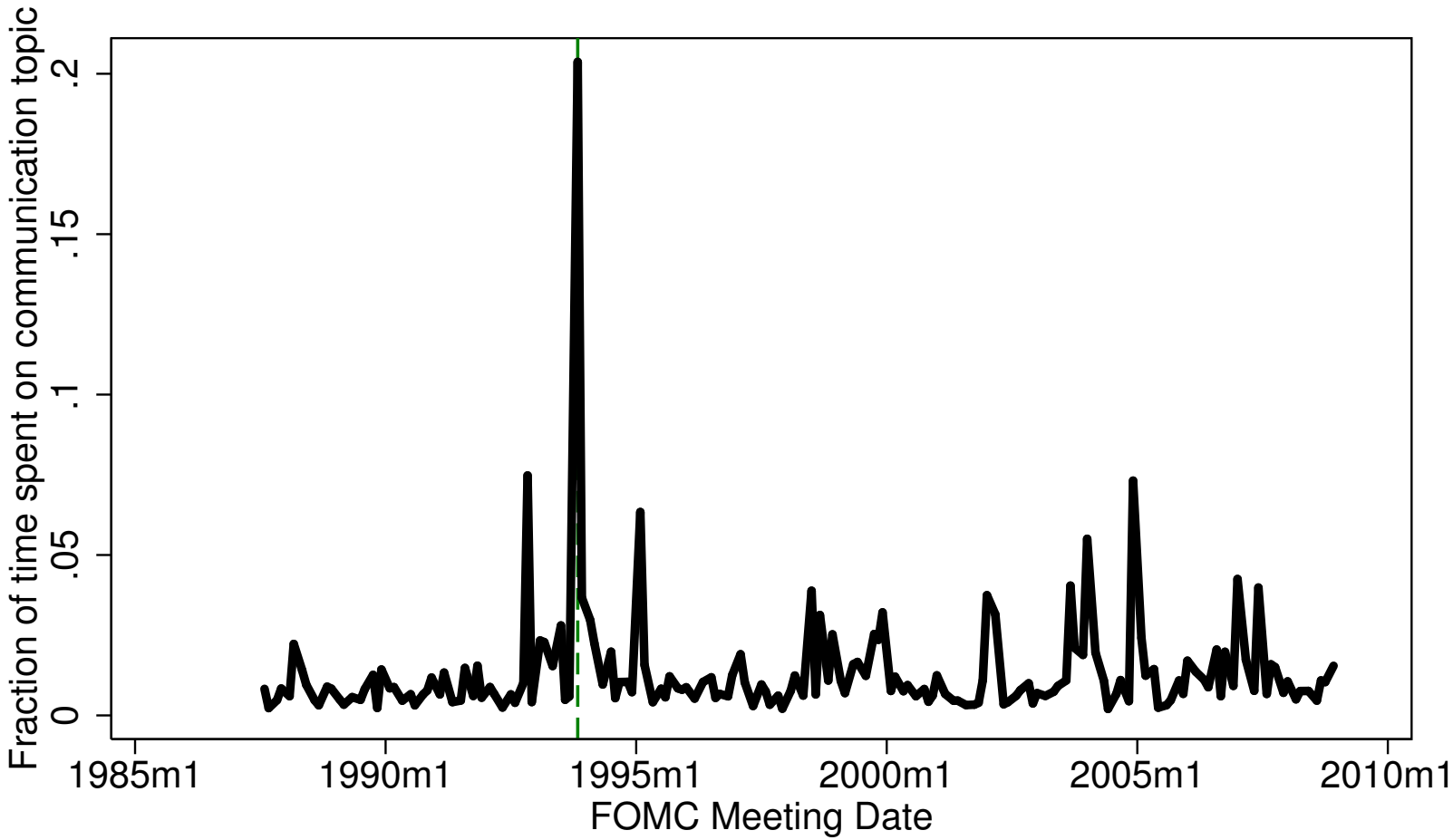
Surprised by Transparency?



Topics and Model Testing

Once we have estimated topics, what can we do with them?

One option is to simply describe and index text.

Another goal is to test behavioral models by using topics as dependent variables in regressions motivated by theory.

Example is Hansen, McMahon, and Prat (2015).

The Environment

Recall discussion of benefits and costs of transparency and natural experiment at FOMC.

How does economic theory predict FOMC members should react to increase in transparency?

Career Concerns

Dynamic models in which only short-term contracts are possible.

Agent's type is unknown, and observed behavior/performance today determines future principals' beliefs.

Agents today maximizes future principals' beliefs (which may be different from today's productivity).

Payoff to good reputation can be:

1. Higher wages
2. Non-monetary perks
3. Psychological benefit

Career Concerns and Transparency

What are the predicted effect of transparency?

Career Concerns and Transparency

What are the predicted effect of transparency?

Positive
Discipline: Holmström (1999).

Career Concerns and Transparency

What are the predicted effect of transparency?

Positive
Discipline: Holmström (1999).

Negative
Conformity: Scharfstein and Stein (1990), Prat (2005)
Non-conformity: Ottaviani and Sørensen (2000), Levy (2007)

Career Concerns and Transparency

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Discipline: Holmström (1999).

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Conformity: Scharfstein and Stein (1990), Prat (2005)
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These effects predicted to decline with experience.

FOMC Background

The Federal Open Market Committee meets eight times per year.

19 members: seven Governors, and twelve regional Fed Presidents.

Meeting Structure:

1. **Economic Situation Discussion (FOMC 1)**
   - 1.1 Board staff present the economic situation (including forecast).
   - 1.2 FOMC members present their views of the economic outlook.
2. **Policy Strategy Debate (FOMC 2)**
   - 2.1 Staff presents a variety of monetary policy alternatives (without a recommendation).
   - 2.2 First the Chairman, and then other FOMC members discuss their policy preferences.

FOMC takes Government in Sunshine Act seriously.

Testing through Differences

One option is to run

$$y_{ts} = \alpha + \beta D(\mathit{Trans}) + \lambda X_t + \varepsilon_t \qquad \text{(DIFF)}$$

Main issue is that other changes may have coincided with increase in transparency.

With high frequency data, for example tick-level equity prices, one can conduct event study.

FOMC only meets eight times per year, so event study not feasible.

Difference in Differences

Difference-in-differences controls for (common) time trends by comparing how one group's reaction to transparency differs from another's.

In a pure RCT, there would be a treatment and control group.

Instead, HMP use experience in Fed system to proxy for strength of career concerns, which should correlate with behavioral response to transparency:

$$FedExp_{it} = \text{years in Fed system prior to FOMC} + \text{years on the FOMC}$$

$$y_{its} = \alpha_i + \delta_t + \beta D(Trans) + \eta FedExp_{it} + \phi D(Trans) \times FedExp_{it} + \epsilon_{it} \quad \text{(DinD)}$$

Test ϕ coefficient on interaction term.

Dependent Variables

Counts

1. How much someone speaks—words
2. How many statements they make
3. How many questions they ask
4. How many numbers they refer to

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Functions of Topic Content

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3. How many questions they ask
4. How many numbers they refer to

Functions of Topic Content

Influence

Counts—Diff Regression

Main Regressors	(1) Total Words	(2) Statements	(3) Questions	(4) Numbers	(5) Total Words	(6) Statements	(7) Questions	(8) Numbers
D(Trans)	52.3*	-0.36	-0.00093	3.56***	35.3	-1.98**	-0.67***	1.60***
	[0.081]	[0.324]	[0.990]	[0.004]	[0.137]	[0.011]	[0.006]	[0.001]
D(Short)	-71.9***	-0.30**	-0.11	-1.74**	-178***	-1.18***	-0.40***	-1.83***
	[0.000]	[0.014]	[0.327]	[0.049]	[0.000]	[0.000]	[0.000]	[0.000]
D(NBER)	14.4	-0.38	-0.075	-1.00	-30.6	0.46	-0.068	-0.64
	[0.571]	[0.208]	[0.665]	[0.197]	[0.259]	[0.482]	[0.752]	[0.175]
BBD uncertainty	0.22	-0.0032	0.00021	0.0033	-0.042	-0.0093**	-0.0042***	0.00018
	[0.252]	[0.506]	[0.870]	[0.527]	[0.872]	[0.035]	[0.000]	[0.969]
D(2 day)	34.5	1.39**	0.57**	1.44**	59.5	-0.13	0.071	1.08*
	[0.115]	[0.048]	[0.020]	[0.044]	[0.219]	[0.841]	[0.733]	[0.079]
Constant	655***	4.59***	1.13***	7.93***	329***	6.31***	1.69***	2.20***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.004]
Unique Members	36	36	36	36	36	36	36	36
Member FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	No	No	No	No	No	No	No	No
Within Meeting	FOMC1	FOMC1	FOMC1	FOMC1	FOMC2	FOMC2	FOMC2	FOMC2
Sample	89:11-97:09	89:11-97:09	89:11-97:09	89:11-97:09	89:11-97:09	89:11-97:09	89:11-97:09	89:11-97:09
Obs	1148	1148	1148	1148	1138	1138	1138	1138
Transparency effect	7	-	-	14	-	-49	-49	14

Counts—DiD Regression

Main Regressors	(1) Total Words	(2) Statements	(3) Questions	(4) Numbers	(5) Total Words	(6) Statements	(7) Questions	(8) Numbers
D(Trans)	-486***	-5.85**	-2.72	-8.43***	-2,940	82.3	38.9	-20.2
	[0.000]	[0.010]	[0.139]	[0.002]	[0.268]	[0.293]	[0.117]	[0.706]
Fed Experience	973***	6.38	5.04	21.6***	232	-5.49	-2.62	1.83
	[0.000]	[0.142]	[0.163]	[0.001]	[0.200]	[0.305]	[0.124]	[0.618]
D(Trans) x Fed Experience	0.42	0.026	0.0047	-0.21***	-0.68	0.11***	0.037***	-0.078***
	[0.798]	[0.298]	[0.667]	[0.004]	[0.738]	[0.010]	[0.007]	[0.005]
Constant	-10,240***	-66.7	-55.7	-234***	0	0	0	0
	[0.000]	[0.175]	[0.172]	[0.002]	[.]	[.]	[.]	[.]
Unique Members	36	36	36	36	36	36	36	36
Member FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Within Meeting	FOMC1	FOMC1	FOMC1	FOMC1	FOMC2	FOMC2	FOMC2	FOMC2
Sample	89:11-97:09	89:11-97:09	89:11-97:09	89:11-97:09	89:11-97:09	89:11-97:09	89:11-97:09	89:11-97:09
Obs	1148	1148	1148	1148	1138	1138	1138	1138
Rookie effect	-	-	-	14	-	-49	-49	14

Dependent Variables: Topics

Statement $\xrightarrow{LDA}$ K-dimensional probability vector $\xrightarrow{Function}$ dependent variable.

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   Define conditional topic distribution $\boldsymbol{\chi}_{i,t,s}$
2. Herfindahl concentration index (breadth of discussion).
3. Percentage of time on quantitative topics (information acquisition).
4. Proximity to Chairman in FOMC2:
   - 4.1 *Dot product similarity*: $DP_{it} = \sum_k \chi^k_{G,t}\chi^k_{i,t}$.
   - 4.2 *Bhattacharyya coefficient*: $BH_{it} = \sum_k \sqrt{\chi^k_{G,t}\chi^k_{i,t}}$.
   - 4.3 *Kullback-Leibler divergence*: $KL_{it} = \sum_k \chi^k_{G,t} \ln\left(\frac{\chi^k_{G,t}}{\chi^k_{i,t}}\right)$.

Topic 0

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Topic 7—Data Topic

Transparency and Deliberation

Main Regressors	(1) Economics	(2) Economics	(3) Herfindahl	(4) Herfindahl
D(Trans)	0.16***	0.064	-0.0038	0.34*
	[0.002]	[0.933]	[0.674]	[0.055]
Fed Experience	-0.28***	0.036	-0.0035	-0.018
	[0.008]	[0.484]	[0.852]	[0.134]
D(Trans) x Fed Experience	0.00019	-0.0014**	0.00061*	-0.00028***
	[0.655]	[0.018]	[0.060]	[0.003]
Constant	3.70***	0	0.15	0
	[0.002]	[.]	[0.483]	[.]
Unique Members	36	36	36	36
Member FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Within Meeting	FOMC1	FOMC2	FOMC1	FOMC2
Sample	89:11-97:09	89:11-97:09	89:11-97:09	89:11-97:09
Obs	1148	1138	1148	1138
Rookie effect	-	21	-20	12

Transparency and Quantitative Discussion

Main Regressors	(1) Numbers	(2) Numbers	(3) Data Topics (7&11)	(4) Data Topics (7&11)
D(Trans)	-8.43***	-20.2	-0.032**	-0.10
	[0.002]	[0.706]	[0.019]	[0.631]
Fed Experience	21.6***	1.83	0.066**	0.010
	[0.001]	[0.618]	[0.032]	[0.485]
D(Trans) x Fed Experience	-0.21***	-0.078***	-0.00071***	-0.00027**
	[0.004]	[0.005]	[0.003]	[0.035]
Constant	-234***	0	-0.69**	0
	[0.002]	[.]	[0.045]	[.]
Unique Members	36	36	36	36
Member FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Within Meeting	FOMC1	FOMC1	FOMC1	FOMC2
Sample	89:11-97:09	89:11-97:09	89:11-97:09	89:11-97:09
Obs	1148	1138	1148	1138
Rookie effect	14	14	17	16

Proximity and Preferences

Main Regressors	(1) D(Voice Dissent)	(2) D(Voice Dissent)	(3) D(Voice Dissent)
D(Non-Voter)	0.0060	0.0072	0.0083
	[0.802]	[0.764]	[0.727]
DP	-1.03*		
	[0.059]		
BH		-0.46***	
		[0.005]	
KL			0.11***
			[0.003]
Constant	0.49***	0.81***	0.34***
	[0.000]	[0.000]	[0.000]
R-squared	0.226	0.229	0.229
Unique Members	35	35	35
Member FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
Obs	1194	1194	1194
Type of measure	Similarity	Similarity	Distance

Transparency and Proximity

Main Regressors	(1) DP	(2) BH	(3) KL
D(Trans)	0.013***	0.78	1.70
	[0.000]	[0.253]	[0.576]
Fed Experience	-0.011	0.0035	-0.065
	[0.453]	[0.940]	[0.754]
D(Trans) x Fed Experience	-0.00021**	-0.00058**	0.0023*
	[0.037]	[0.033]	[0.055]
Constant	0.17	0	0
	[0.307]	[.]	[.]
Unique Members	35	36	36
Member FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
Within Meeting	FOMC2	FOMC2	FOMC2
Sample	89:11-97:09	89:11-97:09	89:11-97:09
Obs	1074	1138	1138
Type of measure	Similarity	Similarity	Distance
Rookie effect	12	11	-9

Summary

Table: Evidence for career concerns

Discipline	**Conformity**
↑ use of numbers in FOMC1	↓ statements in FOMC2
↑ topic breadth in FOMC1	↓ questions in FOMC2
↑ references to data topics in FOMC1	↓ distance from Greenspan in FOMC2
	↓ topic breadth in FOMC2
↑ economics topic percentage in FOMC2	

Influence as a Measure of Informativeness

Discipline tends to increase informativeness, conformity to decrease it. Which effect dominates?

If member's statement more informative, it should drive the debate more.

Influence

When what member i talks about affects what member j talks about, call this influence. Use a PageRank-like algorithm.

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Measure influence:

1. Within meeting
2. Within meeting on Greenspan
3. Across meetings
4. Across meetings on Greenspan

Overall Influence

Main Regressors	(1) W_D	(2) A_D	(3) W_{BH}	(4) A_{BH}
D(Trans)	0.0028***	0.0019**	0.0030***	-0.000057
	[0.000]	[0.036]	[0.000]	[0.810]
Fed Experience	-0.0039	-0.010*	-0.0012	0.00039
	[0.380]	[0.057]	[0.534]	[0.830]
D(Trans) x Fed Experience	-0.000015	-0.00019***	-0.000042**	-0.000012
	[0.732]	[0.009]	[0.041]	[0.439]
Constant	0.096*	0.17***	0.064***	0.051**
	[0.068]	[0.006]	[0.005]	[0.018]
Unique Members	35	32	35	32
Within Meeting	Intra	Inter	Intra	Inter
Obs	1074	1039	1074	1039
Rookie effect	-	17	7	-

Influence on Greenspan

Main Regressors	(1) W_D^G	(2) A_D^G	(3) W_{BH}^G	(4) A_{BH}^G
D(Trans)	0.00031***	0.000032	0.00030***	-0.000012
	[0.009]	[0.814]	[0.000]	[0.711]
Fed Experience	0.00023	-0.0017*	-0.000079	-0.000092
	[0.748]	[0.054]	[0.785]	[0.637]
D(Trans) x Fed Experience	-6.6e-06	-0.000022***	-5.3e-06***	-1.4e-06
	[0.198]	[0.004]	[0.000]	[0.319]
Constant	0.00012	0.022**	0.0034	0.0040*
	[0.988]	[0.030]	[0.309]	[0.080]
Unique Members	35	32	35	32
Within Meeting	Intra	Inter	Intra	Inter
Obs	1074	1039	1074	1039
Rookie effect	-	18	8	-

Conclusion

Topic models are a growth area in social science because they allow us to measure text in an interpretable way, and to quantitatively test behavioral models with qualitative data.

This process has been underway for a few years in political science, but essentially brand new in economics.

In future, scope for developing structural topic models whose latent variables explicitly form part of an economic model's data generating process.