Do Expert Panelists Herd?
Evidence from FDA Committees

Melissa Newham[1] Rune Midjord[2]

[1]DIW Berlin & KU Leuven

[2]Copenhagen Business School

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Outline

1. Motivation
2. Overview
3. FDA Advisory Committees
4. Data and descriptive analysis
5. Model
6. Results

Motivation

- **Expert committees** and advisory boards are commonly used to help with making difficult and important decisions
- A roll-call or **sequential vote** is often used to gauge the collective information held by the individual members
- However if members engage in **herd behavior** (i.e. swayed by observing preceding votes) information contained in vote may be compromised

This paper:

- *To what extent are expert panelists influenced by previous votes? Consequences for information aggregation?*

Overview

- We consider **FDA Advisory Committees** which vote on yes/no questions related to new drug applications
- Empirically, **herding is difficult to measure**; decisions may be clustered for other reasons
- Applying a dataset of $\geq 10,000$ votes cast by experts in FDA Committees, we estimate a **structural model** of voting that allows us to **disentangle herding** from other factors and **quantify herd votes**
- We make use of a **change in procedure** in 2007 for FDA committees: sequential voting $\rightarrow$ simultaneous
- FDA decisions **affect millions of users**; if bad drugs are approved the consequences can be fatal

Research questions

1. Do expert panelists engage in herd behavior? If yes, what proportion of votes are herd votes?
2. Are certain types of experts more likely to herd?
3. Which voting procedure leads to better information aggregation?

Preview

1. Do expert panelists engage in herd behavior? If yes, what proportion of votes are "herd votes"?

   Yes - approx. 9% of all sequential votes are herd votes

2. Are certain types of experts more likely to herd?

   There is heterogeneity in herd behavior - temporary members are more prone to herding than regular members

3. Which voting procedure leads to better information aggregation?

   Simultaneous voting. Sequential voting performs particularly badly when information is imprecise and when belief updating is "naive".

Contribution to literature

- Formal analysis of herd behavior started with Banerjee (1992), Bikhchandani et al. (1992), and Welch (1992)
- Large experimental literature on social learning
- This paper contributes to the **empirical** literature on herd behavior
- Other empirical papers have studied herding in different settings
  - E.g. presidential primaries (Knight and Schiff, 2010), restaurant dining (Cai et al., 2009), investment recommendations (Graham, 1999), stock market trading (Cipriani and Guarino, 2014), and movie reviews (Camara and Dupuis, 2014)
- We are first to estimate **herd-voting in committees**
- Our empirical estimation strategy, making use of a **natural experiment**, is unique

FDA Advisory Committees

- In the US, producers of new drugs are required to win approval from the Food and Drug Administration (FDA) in order to market their products
- As part of review process, the FDA can refer a matter of drug approval to one of its advisory committees
- Intention is to provide the FDA with independent opinions from outside experts
- Recommendations are **non-binding** and the FDA makes the final decision

FDA Advisory Committees

"Should omapatrilat be approved for the treatment of hypertension?"

FDA Advisory Committees

- Change in procedure in 2007: sequential voting → simultaneous
- Under sequential voting, order follows seating plan which is jointly decided by committee's executive secretary and the chair
  - Voting order may be reversed from question to question
  - Across different meetings, an individual committee member typically does not always sit in the same seat
  - We find order is unrelated to observable voter characteristics such as educational background or being a regular member
- Under simultaneous voting, members place their votes with electronic voting devices and after the votes have been locked in they go on the record and state what they voted (in the order they are seated)

FDA Advisory Committees

CHAIRMAN ABRAMSON: What I'd like to do is now go to question number 4 and take a vote as to whether the committee concurs that there is adequate evidence to approve rofecoxib as an analgesic. . . . Let's go around this way. Dr. Katona.

DR. KATONA: I was hoping I wouldn't be the first one for this difficult question.

- Extract from FDA Advisory Committee meeting on new drug application Vioxx (rofecoxib), 20 March 1999

Data

- Data source: full set of **meeting transcripts** downloaded via www.fda.gov from 1996 (start of public records) to Aug. 2014
- **10,466 yes/no votes with full voting profiles** concerning 813 voting questions; 375 under sequential and 438 under simultaneous
- "Yes" vote is always associated with a favourable assessment of the treatment
- **Voter characteristics:**
  - Regular or temporary member, consumer or patient representative, educational background, gender, conflict of interest waiver
- **Vote question characteristics:**
  - FDA reviewer score (-1,0,1), priority review, question type (e.g. efficacy, risk vs. benefit), product category (drug or biologic), application type, and committee (e.g. Oncologic)

Descriptive analysis

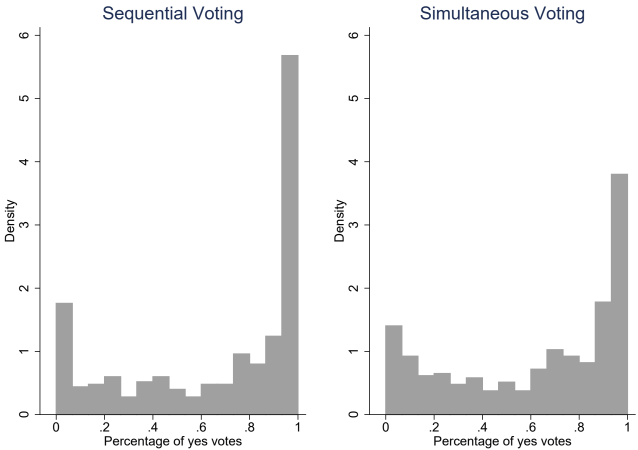


Figure 1: Agreement of Votes for FDA Advisory Committees

Descriptive analysis

	Mean by Voting Rule		
Variable	Sequential	Simultaneous	Difference
Unamimous	0.48	0.29	0.19***
Majority size	0.87	0.84	0.03***
Percent yes	0.66	0.61	0.05*

Notes: $***p < 0.01, **p < 0.05, *p < 0.1$.

Table 1: Descriptive statistics for vote outcomes

- Significantly more unanimous vote outcomes under sequential voting: **48%** vs. **29%** under simultaneous voting

Descriptive analysis

We run several regressions at the individual vote level (v_i^j), controlling for question-level and individual-level covariates X_{ij}:

$$Pr[I_{ij} = 1] = \gamma_0 + \gamma_1 Sequential_j + X_{ij}\delta + \epsilon_{ij}$$

Three binary dependent variables I_{ij}

- $I(v_i^j = v_{i-1}^j) = 1$ if a member i's vote matches the preceding vote
- $I(WithMajority) = 1$ if a member votes in line with the majority up until that point
- $I(v_i^j = yes) = 1$ if a member votes "yes"

Descriptive analysis

	Dependent variable					
	(1)	(2)	(3)	(4)	(5)	(6)
	$I(v_i^j = v_{i-1}^j)$	$I(v_i^j = v_{i-1}^j)$	$I(WithMajority)$	$I(WithMajority)$	$I(v_i^j = yes)$	$I(v_i^j = yes)$
Sequential	0.0633***	0.0492*	0.0451***	0.0652**	0.0572***	0.0459
Size/10	0.00657	0.00436	0.00198	-0.000915	-0.00444	-0.00330
FDA Reviewer Score = -1	-0.0971***	-0.0976***	-0.0649***	-0.0671***	-0.144***	-0.144***
FDA Reviewer Score = 1	0.0710***	0.0711***	0.0717***	0.0718***	0.183***	0.183***
Priority	-0.00421	-0.00534	-0.00926	-0.0109	0.119***	0.121***
Share COI	0.0302	0.0318	0.0564*	0.0535*	0.0633	0.0655
Supplementary	0.0144	0.0138	0.0144	0.0152	-0.00811	-0.00929
Biologic	0.0192	0.0186	0.0188	0.0179	0.0432***	0.0434***
Seat	-0.000200	-0.00146	0.000738	-0.000155	-0.000447	0.000198
Regular	-0.00792	-0.00158	0.00651	0.0305***	-0.0251**	-0.0267**
Patient Rep.	-0.0572***	-0.0487*	-0.0312	-0.0113	0.0547**	0.0476*
Consumer Rep.	-0.0333*	-0.0481*	-0.0489***	-0.0506**	-0.0859***	-0.129***
PhD	-0.00736	-0.0156	-0.0129	-0.0193	-0.0146	-0.0232*
Male	0.00266	0.0108	-0.0107	-0.00795	-0.00286	-0.00802
COI Waiver	0.0220	0.0293	0.0128	0.0166	0.00230	0.0849*
Seat X Seq.		0.00367*		0.00285		-0.00200
Regular X Seq.		-0.0160		-0.0675***		0.0105
Patient Rep. X Seq.		-0.0328		-0.0763*		0.0222
Consumer Rep. X Seq.		0.0314		-0.0106		0.115***
PhD X Seq.		0.0220		0.0186		0.0175
Male X Seq.		-0.0195		-0.00704		0.0137
COI X Seq		-0.00590		-0.00007		-0.0920*
Question Type	yes	yes	yes	yes	yes	yes
Topical Committee	yes	yes	yes	yes	yes	yes
Constant	0.634***	0.642***	0.713***	0.713***	0.341***	0.346***
Observations	9,653	9,653	9,231	9,231	10,466	10,466
R-squared	0.032	0.032	0.026	0.028	0.082	0.083

Notes: OLS regression. Standard errors in parentheses are robust. $***p < 0.01, **p < 0.05, *p < 0.1$.

Table 2: Reduced-form results

Descriptive analysis: Takeaways

- Results are **consistent with herding** but not conclusive, more definitive statements require a structural model
- Differences in voting behavior across committee members motivates allowing for **heterogeneity** in the model
  - Regular members and also patient rep.'s are less likely to vote with present majority under sequential voting
  - Members display different preferences: patient rep.'s are more likely to vote yes whereas consumer rep.'s are more likely to vote no

Model

- Members vote on yes/no questions
- Voting procedure: $\xi \in \{simultaneous, sequential\}$
- If voting is sequential, panelists vote sequentially and openly in an exogenously given order
- For each question there is an **unobserved state** $\theta \in \{0, 1\}$
- $\boldsymbol{\mu}_0 = Pr(\theta = 1) \in (0, 1)$ is **common prior** belief that the correct answer is 1 or "yes"
- Each member i receives a **private signal** s_i which depends on the state and **precision of information** $\boldsymbol{\tau}$ (following Cipriani and Guarino, 2014)

$$f^1(s_i|\theta = 1) = 1 + \tau(2s_i - 1)$$
$$f^0(s_i|\theta = 0) = 1 - \tau(2s_i - 1)$$

Model

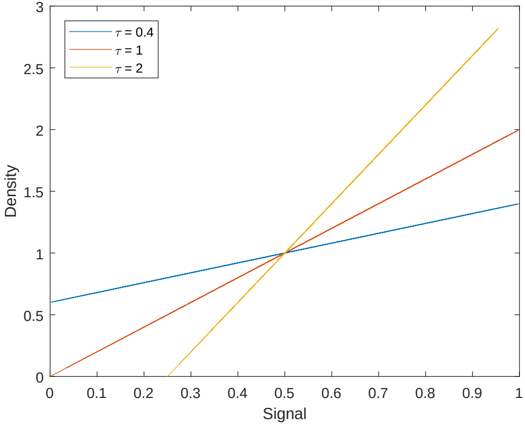


Figure 2: Probability Density Function of Private Signals $|\theta = 1$

Model

- **Types**: Expressive ($t = E$) or herd type ($t = H$)
- Types are private information
- Expressive type relies only on his/her own signal, herd type additionally uses **vote-history** h_i to guide his/her vote
- With probability $\boldsymbol{\lambda}$ a committee member is the herd type under sequential voting
- Two variants: 1) Herd types are fully Bayesian, 2) Herd types are "naïve"

Model

- Experts want their vote to match the true state and can be more or less **cautious** $\boldsymbol{\pi} \in (0,1)$
- The voting rule can be characterized as a **cut-off strategy** where $\bar{s}_i$ is the cut-off signal s.t. $P(\theta = 1|\bar{s}_i) = \pi$
- Expressive types will vote yes if $s_i > \bar{s}_{i,t=E}(\mu_0, \tau, \pi)$
- Herd types will vote yes if $s_i > \bar{s}_{i,t=H}(\mu_0, \tau, \pi, \lambda, h_i)$

Model

- Using Bayes' rule, the **cutoff signals** for each types are:

$$\bar{s}^j_{i,t=E} = \frac{\mu_0 - \pi}{2\tau(2\mu_0\pi - \pi - \mu_0)} + \frac{1}{2} \tag{1}$$

$$\bar{s}^j_{i,t=H} = \frac{\mu_i - \pi}{2\tau(2\mu_i\pi - \pi - \mu_i)} + \frac{1}{2} \tag{2}$$

- $\mu_i \equiv P(\theta = 1|h_i)$ indicates member i's beliefs about the state after observing the preceding votes and updating their beliefs
  - **Bayesian model**: herd types are fully Bayesian and take into account the probability that voters before them are herd types
  - **Naïve model**: herd types believe everyone before them is an expressive type (following Eyster and Rabin, 2010)
- μ_i can be computed recursively for $i \geq 2$, and setting $\mu^j_1 = \mu^j_0$

Herding

(Local) **herd voting** occurs whenever a herd type is swayed by the history of votes i.e. when the herd type votes yes (no), whereas ignoring the vote-history, he/she would have voted no (yes)

DEFINITION (herd-voting):
(i) Committee member $i_{t=H}$ engages in herd-yes-voting if for a specific voting question

$$\bar{s}_{i,t=E} > s_i > \bar{s}_{i,t=H}$$

(ii) Committee member $i_{t=H}$ engages in herd-no-voting if for a specific voting question

$$\bar{s}_{i,t=E} < s_i < \bar{s}_{i,t=H}$$

Estimation

- The likelihood of a sequence of votes over the set of voting questions J can be written as

$$P(\{v^j\}_{j=1}^J|\Phi) = \prod_{j=1}^J P(v^j|\Phi) \tag{3}$$

where Φ is the vector of parameters $\{\mu, \tau, \lambda, \xi, \pi\}$ More details

- To incorporate heterogeneity, we specify λ, π and τ as functions of observable voter characteristics
- Common prior μ_0^j depends on observable characteristics X^j of the voting question via a logit formulation
- Maximize the likelihood function directly using the full dataset of votes

Identification: Intuition

- Common prior μ_0: **proportion of yes to no** votes at the question level
- Precision of private information, τ_i: overall **agreement** in votes + individual who more often **votes in line with majority** (esp. under simultaneous) will be estimated to have a higher precision of information
- Members' standard of proof π_i: **variation in a member's votes across different questions**; if a member is cautious there will be less variation in their votes and they will vote no more often
- Probability to be herd type λ_i: **exact sequence of votes** under sequential voting
- Importantly, **access to simultaneous data** helps us to get a grip on the key parameters of the model when there are no herd effects at play

Results: Baseline model

- On average **around half** of committee members take the vote history into consideration
- Committee members are sightly cautious
- Precision of information is quite high $\tau = 1.26$ (1.28 in naïve model)
  - $\rightarrow$ the probability that a member gets an incorrect signal (i.e. a signal < 0.5 when the state is 1, or a signal > 0.5 when the state is 0) is 20%

	Bayesian		Naïve	
Parameter	Estimate	SD	Estimate	SD
λ	0.48	0.04	0.52	0.04
π	0.58	0.02	0.59	0.03
τ	1.26	0.03	1.28	0.03

Table 3: Estimates for main parameters of interest

Results: Heterogeneity in herd behavior

- Temporary members are more prone to herding than regular members: 55% vs. 38% in Bayesian model
  - Frequent attendance of meetings may make members less influenceable, supporting this we find first time members are more likely to vote with the present majority under sequential voting
- Patient rep.'s are the least likely to be influenced by previous votes
- Educational background and gender have little effect

	Bayesian		Naïve	
Parameter	Estimate	SD	Estimate	SD
$\gamma_{reg.}$	0.38	0.06	0.46	0.06
$\gamma_{temp.}$	0.55	0.07	0.67	0.07
$\gamma_{cons.}$	0.45	0.1	0.51	0.09
$\gamma_{pat.}$	0.32	0.15	0.35	0.14
γ_{phd}	0.06	0.06	-0.01	0.06
γ_{COI}	0.16	0.06	0.11	0.06
γ_{male}	0.0	0.06	-0.04	0.05

Table 4: Estimation Results for λ_i

Other findings

- Results are qualitatively similar across the naïve and Bayesian model
- Heterogeneity in members' abilities: regular members have highest ability on average, consumer and patient rep.'s have less precise information Estimates
- Consumer reps are particularly cautious, their standard of proof π is 0.67, whereas π for patient reps is 0.49 in the Bayesian model Estimates
- Estimated common priors range from 0.44 to 0.84

Quantifying herd votes

- Using our model and estimated parameters we **simulate voting** under sequential and simultaneous rule
- By comparing an individual's simulated vote under sequential and simultaneous voting we can directly observe herd votes
- We find that approximately **9%** of all sequential votes are "herd votes"
- This level of herding generates patterns in line with what we see in the real data; share of unanimous vote outcomes increases markedly under sequential voting

Quantifying herd votes

	μ_0=0.5		μ_0=0.8	
	Seq.	Sim.	Seq.	Sim
Herd vote share	8.9%	NA	8.4%	NA
Unanimous outcome share	25%	9%	42.6%	28.5%
Average majority size	0.88	0.8	0.88	0.82

Notes: $\tau = 1.26$, $\pi = 0.58$, $\lambda = 0.48$

Table 5: Simulated outcomes with Bayesian updating

	μ_0=0.5		μ_0=0.8	
	Seq.	Sim.	Seq.	Sim
Herd vote share	9.8%	NA	6.7%	NA
Unanimous outcome share	27.5%	10.6%	54.6%	37.4%
Average majority size	0.88	0.8	0.91	0.87

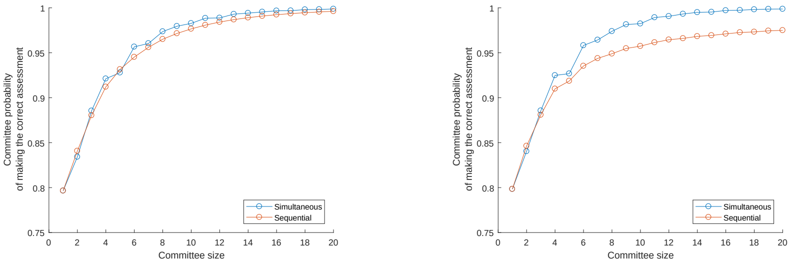
Notes: $\tau = 1.28$, $\pi = 0.59$, $\lambda = 0.52$

Table 6: Simulated outcomes with naïve updating

Information aggregation

- **Our approach**: what is the probability that the committee makes the correct assessment about a drug under each voting procedure?
- The committee's overall assessment $A^j \in \{0, 1\}$ is defined as being favorable when the updated belief about the state being "yes" after everyone has voted is greater than one half
- We consider both Bayesian and naïve updating
- The probability of making the correct assessment can be computed by calculating the number of instances where $A^j = \theta^j$ across all possible voting profiles and weighting appropriately by the probability of the state and the voting profile conditional on the state Formula

Information aggregation: Results

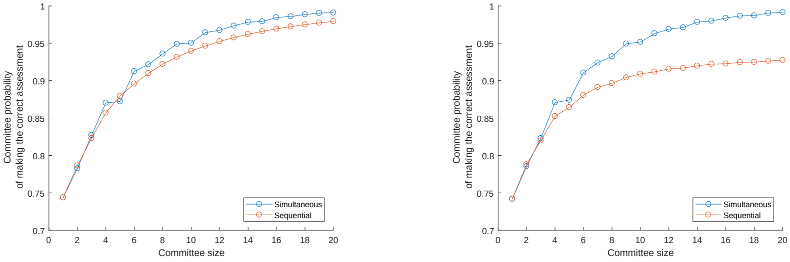


(a) Bayesian updating   (b) Naïve updating

Figure 3: Committee probability of making the correct assessment

- DMR to increasing committee size
- Informational inefficiencies under sequential voting are more prominent if belief updating is naive

Information aggregation: Results



(a) Bayesian updating (b) Naïve updating

Figure 4: Information aggregation with a lower precision of information

- Sequential voting performs particularly badly relative to simultaneous voting when information is imprecise.

Concluding remarks

- Applying a structural model, we find that expert panelists are suseptible to herd behavior under sequential voting, with negative consequences for information aggregation

Policy implication:

- Follow the example of the FDA and substitute sequential voting with simultaneous (electronic) voting