Recent trends in analytical accounting research

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Outline

Today's agenda

- Two recent trends:
  - Investigating properties of accounting information besides precision
  - investigating how "rationally inattentive" investors responds to firms' disclosure and how firms strategically disclose in the presence of such "rationally inattentive" investors.

Outline

Going beyond precision

- An important question in accounting: how to design accounting standards to produce information that will improve the efficiency with which capital is allocated.
- Common wisdom is that more information can never be worse.
- Previous literature find that in strategic settings, more information may be worse (Dye 2001, Verrecchia 2001, Kanodia 2006, Beyer et al. 2010, Stocken 2013, Kanodia and Sapra 2016).
- The focus is on the quantity, or precision, of information to be disclosed.

Going beyond precision- Continued

- While precision is important, many actual accounting standards cannot be readily classified as providing more or less precise information.
- Analysis on other properties can shed light on how optimal information properties map into actual accounting standards.
- We focus on bias.

How to think about modelling bias

- What is an example of a biased earnings report?
- Suppose the earnings report always subtracts the true value by 5 cents, how would a rational decision maker respond when observing the earnings report?
- So, would subtracting true value by 5 cents a good way of modelling bias?

How to think about modelling bias, continued

- Think about conservative bias, adopting a higher verification for good news versus bad news.
- What is the implication of higher verification for good news versus bad news?

Modelling bias (from Gigler et al. 2009)

- Implication is that bad earnings occurs more frequently but is less informative; good earnings occurs less more frequently but is more informative. Overall the informativeness of earnings does not vary with bias, that is, the precision does not vary with bias.
- In statistics, a measure of informativeness is the likelihood ratio.
- Denote y as reported earnings, $x \in \{x_H, x_L\}$ as true earnings (e.g., cash flow in a static model) and δ as reporting bias with higher δ representing more conservative bias.
- Then $\frac{f(y|x_H)}{f(y|x_L)}$ is the likelihood ratio.

Modelling bias (from Gigler et al. 2009), continued

- Therefore more conservative bias (i.e., higher δ) results in more informative good earnings and less informative bad earnings translates into higher $\frac{f(y|x_H)}{f(y|x_L)}$ (as for high y, $\frac{f(y|x_H)}{f(y|x_L)}$ moves away from 1 and for low y, $\frac{f(y|x_H)}{f(y|x_L)}$ moves towards 1).

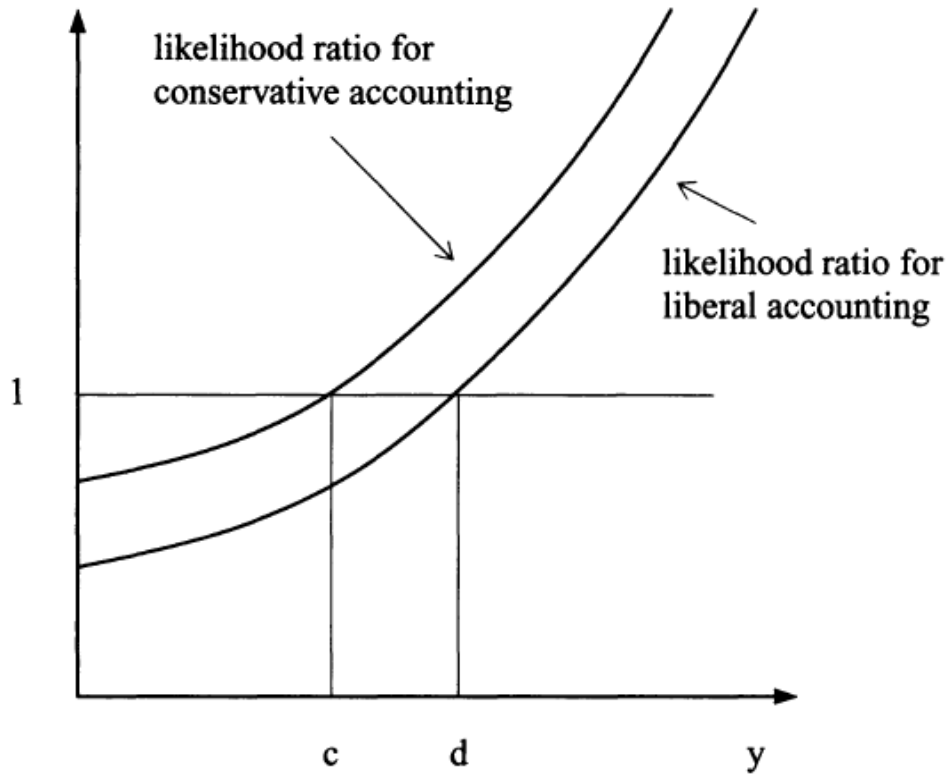

FIG. 1.—Informational implications of accounting conservatism.

The gist of Gigler et al. (2009)

- Gigler et al. (2009) went on to show that more conservative bias results in less efficient debt contract.
- Setting: a firm needs investment I in a project, which can generate a terminal cash flow x. The investment is financed by debt with a face value D and a covenant based on accounting earnings y, denoted as y^C, where y is a noisy signal about $\widetilde{x} \in \{x_H, x_L\}$.
- Continuation/liquidation decisions are chosen upon observing y, with liquidation generating a liquidation payoff of M. Assume that $E[\widetilde{x}] > M$ so that the project is of positive NPV.
- Timeline of the model
  - Date 0: debt contract $\{D, y^C\}$ is signed
  - Date 1: y is observed, liquidation occurs if $y < y^C$ and continuation occurs otherwise.
  - Date 2: $\widetilde{x} \in \{x_H, x_L\}$ realized if the project is continued.

The gist of Gigler et al. (2009), continued

- Debt contract efficiency is measured as the (inverse) of the sum of decision errors due to y being noisy about x.
- Intuition: more conservative bias results in good earnings being more informative and bad earnings less informative. Since firms will continue the project when earnings is good and terminate the project when earnings is bad, more conservative bias results in more false alarm error (terminating good projects) and less undue optimism error (continuing bad projects).
- Project positive NPV implies that false alarm error is more costly.
- Consistent with empirical findings in Dyreng et al. (2017).

Application of the Gigler et al. (2009) way of modelling bias

- When $y \in \{y_H, y_L\}$ (i.e., in a binary framework), a specification that fits the Gigler et al. (2009) way of modelling bias is

$$\Pr(y_H|x_H) = \lambda - \delta;\ \Pr(y_L|x_L) = \lambda + \delta.$$

- $\lambda \in (0, 1)$ measures the informativeness of the signal and $\delta \in (0, \min(1 - \lambda, \lambda))$ measures the bias of the signal with higher δ implying more conservative bias.
- This specification, first proposed by Gigler and Hemmer (2001), has been used extensively in the accounting literature to study the optimal bias in various settings (Li 2013 introduces renegotiation; Chen et al. 2007 and Bertomeu et al. 2017 introduces moral hazard and earnings manipulation; Friedman et al. 2016 introduces product market competition; Caskey and Laux 2017 introduces private benefit and earnings manipulation).

Application of the Gigler et al. (2009) way of modelling bias: Jiang (2016)

- Jiang (2016) introduces non-accounting information and explores the optimal bias of accounting information in the presence of non-accounting information, which may have its own bias. (WP version shows the result for a more general specification).
- Setup similar to Gigler et al. (2009) with the addition of (potentially) biased non-accounting information.

Jiang (2016), continued

- The general insight is that when non-accounting information has aggressive bias, the accounting information should also be aggressively biased, that is, the biases are complements.
- Intuition: aggressive bias means bad signals more informative and good news less informative. Therefore, non-accounting information system generates more decision errors when good news is present. This requires accounting information system to generate informative bad news, resulting in aggressive bias being optimal.
- This result is in contrast with coventional wisdom that accounting needs to be conservative to compensate for the optimal bias of other information.

Going beyond explicitly modelling bias

- Can bias arise endogenously as part of a solution of the optimal accounting rules?
- This requires modelling accounting signals not simply as true cash flow plus normally distributed noise (for an exception, see Armstrong et al. 2016).
- If we assume the optimal accounting rules are designed ex-ante (i.e, a commitment to a set of rules), then we can apply the insights of Bayesian persuasion literature (Kamenica and Gentzkow 2011) into specific accounting settings. This literature does not impose any particular a priori structure on the specification of noise structure.
- There is a growing literature in accounting on this topic: Gox and Wagenhofer (2009), Bertomeu and Cheynel (2015), Huang (2016), Jiang and Yang (2017, 2021), Michaeli (2017), Friedman et al. (2020, 2021), Bertomeu et al. (forthcoming).

What is a persuasion game?

- Belongs to a game of communication: a sender of an information signal tries to persuade a receiver of the information signal to take certain actions.
- The payoff of both the sender and the receiver depends on the action the receiver takes and an underlying state (representing uncertainty).
- The sender's and the receiver's interest may not be perfectly aligned (i.e. there is a conflict-of-interest).
- The informational signal is a (potentially noisy) signal about the state.
- Persuasion game requires commitment: the sender can remain silent. If the sender communicates, the sender has to communicate truthfully the realization of the signal (i.e. there is no ex-post manipulation).
- Examples: Grossman (1981), Milgrom (1981), Verreccia (1983), Dye (1985), Jung and Kwon (1988), Shin (1994) (sender: manager; receiver: market)

What is a Bayesian persuasion game?

- Common persuasion games assume the sender chooses whether or not to disclose after observing the ex-post realization of the signal but take the information structure of the signal as given.
- Bayesian persuasion games assume that the sender can choose the information structure of the signal ex-ante but has to report whatever realization of the signal ex-post.
- This makes it quite suitable to study mandatory accounting issues, by modelling the optimal information structure as optimal mandatory reporting rules with again manager as the sender and the market as receiver. Conflict-of-interest can be modelled as various agency problems.

General insight (Kamenica and Genzkow 2011)

- Suppose the action is binary, $a \in \{0, 1\}$, the state is binary $\theta \in \{H, L\}$, the sender has a preferred action $a = 1$ and the receiver prefers to match action with the state (i.e. $a = 1$ when $\theta = H$ and $a = 0$ when $\theta = L$).
- Then it is without loss of generality to assume a binary signal structure, i.e. $s \in \{h, l\}$. Suppose the receiver chooses $a = 1$ when observing $s = h$ and $a = 0$ when observing $s = l$.
- The optimal signal structure from the sender's perspective is such that: when the receiver takes $a = 0$ (i.e. the sender's least preferred action), $s = l$ is perfectly informative that $\theta = L$ and when the receiver takes $a = 1$ (i.e. the sender's preferred action), $s = h$ is very uninformative in the sense that the receiver is indifferent between choosing $a = 1$ and $a = 0$ (generalization of the insight of Gox and Wagenhofer 2009).

General insight (Kamenica and Genzkow 2011) continued

- This implies that bad news is more informative than good news, i.e. aggressive accounting if interpreting s as accounting signals.
- Intuition: the sender wants to maximize the chance of getting $s = h$ and therefore has to make $s = h$ as uninformative as possible, subject to the receiver still choosing $a = 1$ when observing $s = h$ (i.e. indifferent between choosing $a = 1$ and $a = 0$).

Accounting applications: Jiang and Yang (2021)

- Sender: manager; receiver: investors; $a \in \{0, 1\}$ where $a = 0(1)$ denotes liquidating (continuation).
- Conflict of interest: manager has a private benefit $B \geq 0$ if the project is continued.
- Social planner designs the information system to maximize investment efficiency. The manager and the investors design security (as well as covenant) based on the properties of the information system.
- A combination of ex-ante information system design (by a social planner) and ex-ante security design by the sender and the receiver.
- Higher B results in lower investment efficiency and less conservative accounting (intuition: higher B results in bad news having to be more informative to deter the manager from continuation $\longrightarrow$ less conservative accounting).

Outline

Motivation of the rational inattention literature

- The workhorse model used in macroeconomics is the so-called real business cycle models based on rational expectations framework, pioneered by Pigou (1929) and Lucas (1975).
- The underlying assumption of the rational expectations is that people form expectations conditional on *all* the information available to them and take into account that others will do so as well *at the instant* when making decisions.
- Intuitively, such model will predict decisions variables (e.g., prices and wages) to fluctuate *instantaneously* and *completely* to new information. Such predictions, however, are inconsistent with empirical data.
- Examples in accounting include PEAD (Bernard and Thomas 1989, 1990) and the accrual anomaly (Sloan 1996).

What is rational inattention

- Pioneered by Sims (1998, 2003), rational inattention relaxes the assumption that people can process *all* the information available to them and form expectations on them.
- Technically, it adds an information flow constraint in the optimization problem. Intuitively, even if the signal may be a perfectly informative signal about the fundamental, people perceive this informative signal as some noisy signal about the fundamental, as paying full attention is prohibitively costly.
- It generates sluggish response to new information, i.e., underreaction to new information, which better fits the observed empirical data.

Why is rational inattention particularly relevant now

In an information-rich world, the wealth of information means a dearth of something else: a scarcity of whatever it is that information consumes. What information consumes is rather obvious: it consumes the attention of its recipients. Hence a wealth of information creates a poverty of attention and a need to allocate that attention efficiently among the overabundance of information sources that might consume it.

From Simon (1969), pp. 40-41

How is rational inattention different from costly information acquisition?

- The literature on costly information acquisition is similar in the sense that it assumes that investors incur a cost to acquire information, with higher cost for acquiring a more informative signal.
- The difference between rational inattention and the costly information acquisition framework lies in: 1) investors choosing allocation of attention among various signals (e.g., signals recognized in the financial statements versus signals disclosed in the footnotes); 2) investors having flexibility in choosing how to understand the signals (i.e., choosing the underlying information structure rather than choosing the precision of a normally distributed noise), subject to an information capacity constraint. Those two differences can potentially generate richer and more general implications.
- The second point, denoted as flexibility, is often ignored in the literature.

A simple framework of rational inattention

- Suppose an investor makes trading decisions, denoted as y, based on their understanding of an earnings report x. The report x has a prior distribution $g(x)$.
- The investor chooses how much attention to pay to x, resulting in a noisy signal s of x. The more attention paid, the less noise in s. The investor then makes decision y based on s, or, equivalently, based on the posterior distribution of x, denoted as $I(x|s)$. However, no particular form on $I(x|s)$ is imposed (i.e., $I(x|s)$ can be any form).
- Paying attention is costly and Sims (2003) introduced a cost function based on entropy and mutual information from information theory to capture the cost of paying attention.

Entropy and mutual information

- The purpose of information is to reduce uncertainty. Therefore, a measure of informativeness is a measure of reduction of uncertainty, which requires a measure of uncertainty to start with.
- For x, without any information s, the prior uncertainty is measured by the entropy of the prior distribution g, defined as

$$H(x) = -E[\log g(x)] = -\int \log g(x) \times g(x) dx.$$

  $H(g)$ is larger the less informative g is. For example, if x is known to be equal to a for sure, then $g(x) = \delta_{\{x=a\}}$ and $H(g) = 0$.
- When s is learned, the posterior uncertainty is measured by the entropy of I, defined as

$$\begin{aligned} H(x|s) &= -E[\log I(x|s)] \\ &= -\int\int \log I(x|s) \times I(x|s) dx m(s) ds, \end{aligned}$$

  where $m(s)$ is the prior distribution of s.

Entropy and mutual information- Continued

- Again $H(x|s)$ is larger the less informative s is. It can be shown that $H(x|s) \leq H(x)$, i.e., I is at least as informative as g (as s is at most useless).
- The difference, $I(x;s) \equiv H(x) - H(x|s)$, is defined as the mutual information between x and $x|s$. The larger $I(x;s)$ is, the more informative s is about x.
- The rational inattention literature usually assumes that processing cost $C = \lambda I(x;s)$ for some $\lambda > 0$ and impose the constraint that $C \leq k$ where k is interpreted as a cognitive processing capacity.

Why not use variance to measure uncertainty

- Entropy is equivalent to variance for the normal distribution case, but this only works for this special case.
- Consider the following example (Jiang and Yang 2017). Suppose there are $N > 2$ states indexed by $i \in \{1, 2, ..., N\}$ and consider two scenarios. In scenario A, uncertainty is represented by both state 1 and state N occuring with $\frac{1}{2}$ probability, and the rest $N - 2$ states occuring with 0 probability. In scenario B, uncertainty is represented by $\frac{1}{N}$ probability for each state $i \in \{1, 2, ..., N\}$.
- When $N > 2$, $var(A) = \frac{(N-1)^2}{4} > var(B) = \frac{(N-1)(N+1)}{12}$. Thus, based on the variance measure, A exhibits more uncertainty than scenario B. But this is counterintuitive, as in scenario A there are only two possible outcomes but in scenario B there are N possible outcomes. This requirement rules out variance as the measure for uncertainty.

General insights from the rational inattention framework

- Flexibility not an issue if g is normal and optimal decision y is unbounded and linear in x (e.g., quadratic or mean-variance preferences) as in this case optimal attention allocation always results in I being a normal signal.
- More attention paid when prior uncertainty is larger.
- More attention paid when the signal is more important (e.g., if y depends on x_1 and x_2, then more attention will be paid to signals of x_1 if y varies more with x_1).
- Attention paid to limited number of signals (e.g., if y depends on x_1,x_2, ..., x_m, then attention may only be paid to the $n < m$ most important signals).

Applications in finance

- Natural applications in financial markets as there are multiple assets and multiple sources of information.
- Van Nieuweiburgh and Veldkamp (2010) explains the under-diversification puzzle. Key intuition: the more investor learns about an asset, the more investor holds of the asset, making it even more valuable to learn the asset.
- Van Nieuweiburgh and Veldkamp (2009) explains the home bias. Key intuition: home investors have a more precise prior about home assets to begin with, which makes it even more valuable to learn the home assets and hold the home assets.
- Peng and Xiong (2006) explains investors' category learning behavior, where category learning is defined as reacting more to market and industry information than firm-specific information. Key Intuition: learning market and industry information helps understanding the value of more than one firm.

Peng and Xiong in more detail

- A representative investor holds a portfolio of mn firms, with n firms in each of the m industries.
- Firm j in industry i pays dividend $d_{ij} = h + f_i + g_{ij}$, where h, f_i and g_{ij} are macro component, industry component and firm-specific components, respectively, with means zero and prior variances σ_h^2, σ_f^2 and σ_g^2 respectively.
- Investor chooses attention allocation to h, f_i and g_{ij}, denoted as $\lambda_h, \lambda_{f,i}$ and $\lambda_{g,i,j}$ to minimize $var(\sum_{i=1}^{m}\sum_{j=1}^{n} d_{i,j}|I)$ subject to the attention constraint $\lambda_h \geq 0$, $\lambda_{f,i} \geq 0$, $\lambda_{g,i,j} \geq 0$ and $\lambda_h + \sum_{i=1}^{m} \lambda_{f,i} + \sum_{i=1}^{m}\sum_{j=1}^{n} \lambda_{g,i,j} \leq 1$.
- The attention paid affect the investor's information set. More attention paid to a particular component results in a more informative signal of that component, where mutual information is used to measure informativeness.

Peng and Xiong in more detail, continued

- Mutual information
  $I = \frac{1}{2} \log \frac{\text{prior variance of the component}}{\text{posterior variance of the component}} = \frac{1}{2}\theta\kappa\lambda$ where $\kappa\lambda$ represents the amount of attention paid to the component. Higher $\kappa\lambda$ is, the lower the posterior variance.
- Proposition 1 shows that if $m^2\sigma_h^2 > \sigma_f^2$ and $n^2\sigma_f^2 > \sigma_g^2$, then the investor allocates the highest attention to the macro component, followed by the sector component, and lowest attention to the firm-specific component.
- When κ is sufficiently small, no attention is paid to firm-specific components.

Peng and Xiong in more detail, continued

- Intuition:

$$
\begin{aligned}
& var\left(\sum_{i=1}^{m}\sum_{j=1}^{n} d_{i,j} | I\right) \\
= \quad & m^2 n^2 \sigma_h^2 e^{-\theta\kappa\lambda_h} + \sum_{i=1}^{m} n^2 \sigma_f^2 e^{-\theta\kappa\lambda_{f,i}} + \sum_{i=1}^{m}\sum_{j=1}^{n} \sigma_g^2 e^{-\theta\kappa\lambda_{g,i,j}}.
\end{aligned}
$$

- Therefore, paying attention to macro factor has the highest marginal benefit of reducing variance when $m^2\sigma_h^2 > \sigma_f^2$ and $n^2\sigma_f^2 > \sigma_g^2$.

The potential in accounting reseach- theory

- So far, very few studies in accounting.
- Rational inattention models have the potential to explain those anomalies such as PEAD and accrual anomaly in a rational framework.
- Another potential direction: how managers choose to disclose their information in the presence of attention-constrained investors (Hirshleifer and Teoh 2003, Jiang and Yang 2017, Lu 2019, Bertomeu et al. 2020, Chen et al. 2020).

The potential in accounting reseach- empirical

- There are some but still few studies in accounting.
- Blankespoor et al. (2020) provides a nice summary of empirical studies.
- However, their framework of awareness cost, acquisition cost and integration cost is not exactly consistent with the rational inattention framework (they are more of providing a general framework of information processing costs).

The potential in accounting reseach- empirical continued

- Two examples: Ferracuti and Lind (2021) find that on days when more firms are announcing earnings, the idiosyncratic uncertainty of announcing firm increases while aggregate uncertainty declines, with more Google searches for macro-related terms on those days; Dyer (2021) finds that local investors pay more attention to public information of local firms and make more profitable trading decisions.
- New technologies make measurement of attention possible (e.g., EDGAR downloads, Google searches).

Thank you!

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