Overview
○

Introduction
○○○

Research Design
○○○○○○

Results
○○○○○○

Future Research Direction
○

Context-Based Interpretation of Financial Information
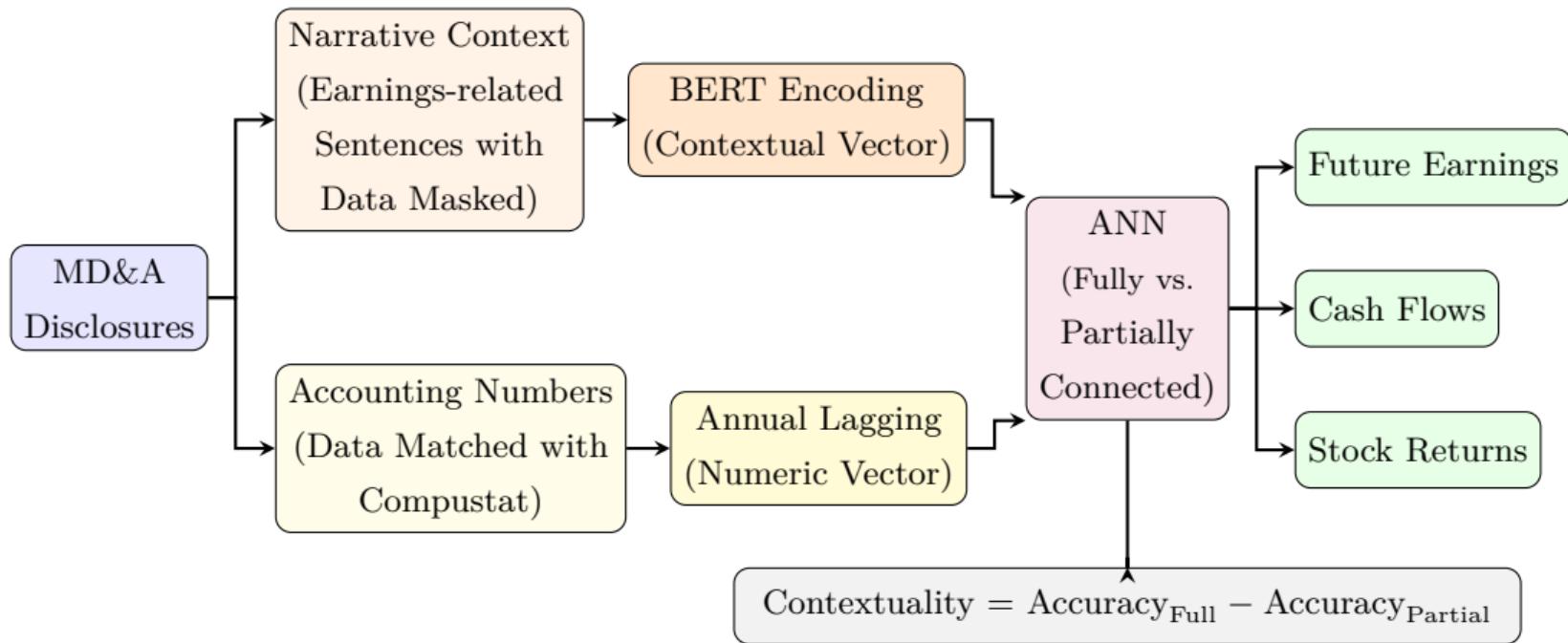
Alex G. Kim & Valeri V. Nikolaev (2024, *JAR*)

解读人：李子明

武汉大学金融系

2025.11.02

Overview

Research Question

- How **accounting numbers** and **their surrounding narrative context** interact with each other?
    - To what extent narrative disclosures alter informativeness of accounting numbers?
    - How economically important this complementarity shaping investors' belief?
    - When does textual context matter most?

Motivation

- Interaction between numeric and narrative disclosures remain to be understood.
  - When use accounting data to assess cash flows, narrative disclosures can:
  - (1) Provide incremental information beyond numbers (**direct informational value**).
  - (2) Contextualize and interpret numbers (**interactive informational value**).

- Contradiction between theoretical notion and existing empirical evidence.
  - Accounting regulators (SEC, IASB) concern about **lack of informative commentary** on reported performance and consider to **enhance contextual disclosures**.
  - Existing evidence show textual information (MD&A) **contain incremental value** but **economically improvements is insignificant**.
  - Prior methods not allow nonlinear and deep interactions of numbers and text, contextual information cannot be captured.

Contribution

- Contribute to literature on textual analysis of corporate communications.
  - Prior mainly explore **unidimensional feature**: sentiment, complexity, similarity.
  - Bochkay et al.(2023) advocate deep learning when **multidimensional features unknown** and **complex nonlinearity essential**.
  - This paper introduce new DL to measure contextuality which not reachable previously.
- Contribute to literature study interaction between numeric and narrative disclosures.
  - MD&A is incrementally informative to numeric data (Bochkay and Levine, 2019).
  - Textual attributes interact with accounting numbers (Li, 2008).
  - Explanatory power derived from interactions is limited (Lundholm and Minnis, 2013).
  - This paper show interaction between two modes is economically large and collective value of interaction exceed direct informationa value.

How to Quantify Role of Context in Interpretation of Numbers?

- Challenge 1: Need to encode semantic features contained in text.
  - Encoder Representations from Transformers (BERT)
  - Capture contextual semantics by dynamic representation based on other words.
  - Encode multidimensional narrative information via last hidden state vector of CLS token which summarize entire text.

- Challenge 2: Require interpret model within which text and numbers can interact.
  - Artificial Neural Network (ANN)
  - Process high-dimensional text vectors and numerical input simultaneously.
  - Model complex relationships between textual and numeric information via multi-layer nonlinear mapping.

Data Processing

- Data collection and sample construction
  - MD&As from 1995 to 2021 of 165,921 filing directories provided by EDGAR.
  - Merge with Compustat: 87,201 with earnings and cash flow, 62,287 with stock return.
- Extraction of earnings-related sentences
  - Identify sentences with earnings-related words using KLS keyword list.
  - Extract one sentence precede and follow identified sentences to capture context.
  - MD&A contain 305 sentences on average, 13.94% (43 sentences) earnings-related.
- Text cleaning
  - Remove tables, figures, special characters, and HTML syntax.
  - Replace all numbers with mask tokens, allowing model to learn position of numbers.
- Encoding with BERT
  - Divide earnings-related sentences into several chunks (512 tokens per chunk).
  - Compute CLS vector for each chunk and average to obtain whole MD&A representation.

Methodology
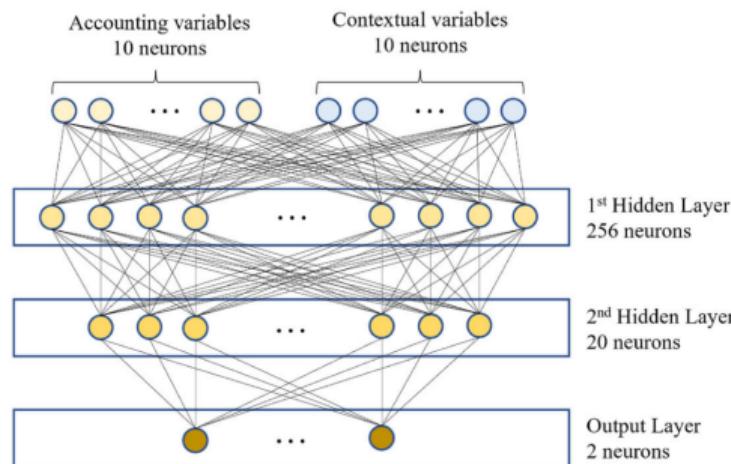
- Interpret information to form belief of future prospects: $\mathbb{E}_t[T_{t+1} \mid A_t, C_t] = \Lambda_t(A_t, C_t)$

- Target variable T_{t+1}: future earnings, cash flows, stock returns

  - (1) Increase or decrease in earnings scaled by total assets
  - (2) Directional changes in cash flow from operations
  - (3) Annual stock buy-and-hold return over fiscal year
  - (4) 60-day cumulated return from 10-K filing date

- Accounting number A_t: current operating cash flows, current earnings, and their four annual lags ($dim(A_t) = 10$)

- Narrative context C_t: averaged CLS vectors from BERT (768-D context vector reduced to 10-D via an additional layer for symmetry with A_t).

- Interpretation model Λ_t: ANN with structure of input layer (numeric and textual input), 256 neuron first hidden layer, 20 neuron second hidden layer, and output layer.

Overview
○

Introduction
○○○

Research Design
○○○●○○

Results
○○○○○○

Future Research Direction
○

Model Design
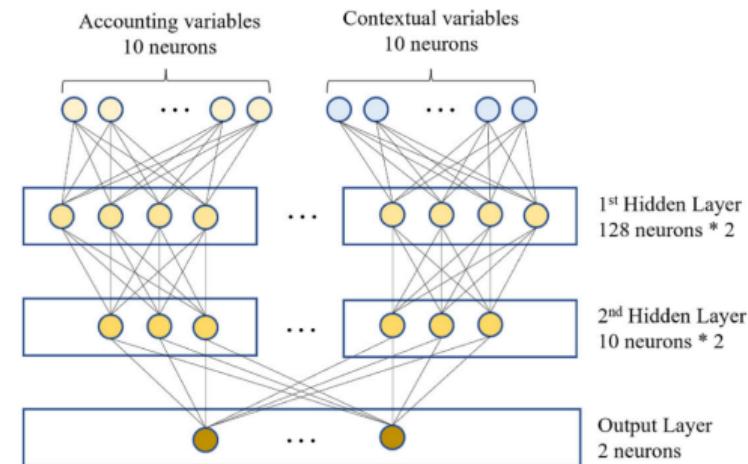
- Numeric input model: only A_t as input

- Textual input model: only C_t as input

- Fully connected model: A_t and C_t interact freely
  - Textual neurons affect activation of numeric neurons and vice versa.
  - Narrative information provide incremental value and shape interpretation of accounting numbers. (**contextualized**)

- Partially connected model: block interaction between A_t and C_t.
  - Restrict communication channels between numeric and textual neurons.
  - Narrative information provide direct information but can not affect interpretation of accounting numbers. (**uncontextualized**)

Models Visualization

(a) Fully Connected Neural Network Model

(b) Partially Connected Neural Network Model

Training and Hyperparameter Selection
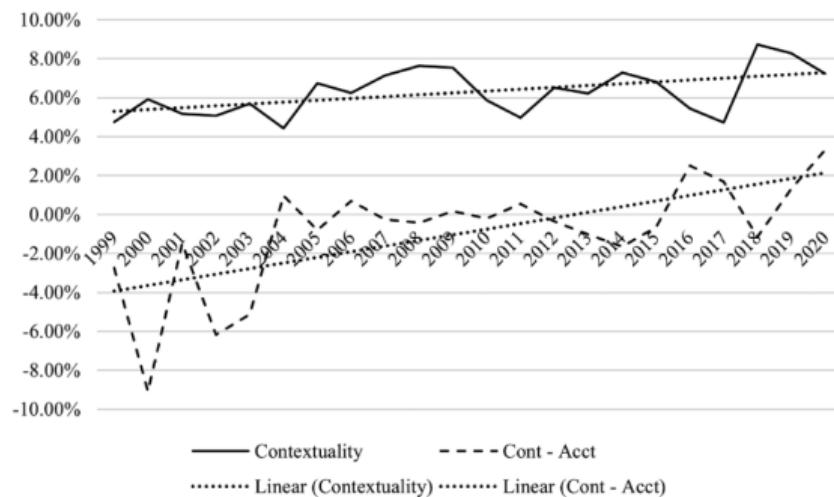
- Training procedure
  - Predict time t target T_t based on A_{t-1}, and C_{t-1}
  - Rolling training windows: four preceding years
  - Out-of-sample forecast using estimated parameters: $\hat{T}_{t+1|t} = \Lambda_{t-1}(A_t, C_t)$
- Hyperparameter selection
  - Grid search batch size(0, 64, 128), dropout rate(0, 0.2, 0.4), learning rate(e^{-1}, e^{-2}, e^{-4})
  - Choose hyperparameters yield highest averaged accuracy for each target over all years.
- Training detail
  - Optimizer: Adam
  - Loss function: CE
  - Validation strategy: randomly sample 20% training set
  - Initialization: Parameters reinitialized after each year training to avoid time dependence.

Using Narrative Context to Make Inferences about Earnings

Year	Accounting Info Only (1)	Contextual Info Only (2)	Partially Connected (3)	Fully Connected (4)	Contextuality (4) − (3)
1999	55.94%	53.19%	58.15%	62.89%	4.74%***
2000	54.80%	45.71%	55.21%	61.12%	5.91%***
2001	54.90%	53.44%	59.27%	64.43%	5.16%***
2002	57.38%	51.19%	60.23%	65.29%	5.06%***
2003	59.60%	54.47%	61.36%	67.05%	5.69%***
2004	58.75%	59.71%	62.12%	66.55%	4.43%***
2005	59.32%	58.52%	61.16%	67.89%	6.73%***
2006	54.71%	55.40%	58.15%	64.38%	6.23%***
2007	42.90%	42.64%	46.42%	53.56%	7.14%***
2008	53.49%	53.06%	54.73%	62.36%	7.63%***
2009	58.90%	59.06%	59.23%	66.78%	7.54%***
2010	57.16%	56.97%	58.86%	64.74%	5.88%***
2011	55.62%	56.15%	58.23%	63.19%	4.97%***
2012	58.55%	58.21%	59.85%	66.37%	6.53%***
2013	58.95%	57.94%	61.05%	67.26%	6.21%***
2014	55.57%	53.93%	55.34%	62.62%	7.28%***
2015	58.16%	57.51%	59.79%	66.60%	6.82%***
2016	55.64%	58.15%	59.88%	65.33%	5.45%***
2017	58.61%	60.31%	63.72%	68.44%	4.72%***
2018	55.73%	54.59%	57.03%	65.75%	8.72%***
2019	44.28%	45.60%	48.31%	56.58%	8.27%***
2020	65.24%	68.55%	70.35%	77.60%	7.25%***
Average	56.10%	55.19%	58.57%	64.86%	6.29%***
					(4.66)
AUC	0.5190	0.5096	0.5023	0.5889	0.0866***
					(7.32)
Macro F1	0.4812	0.4759	0.4733	0.6126	0.1393***
					(11.52)
Trend	0.0003	0.0032	0.0008	0.0017	0.0010**
	(0.15)	(1.48)	(0.39)	(0.93)	(2.74)

Overview
○

Introduction
○○○

Research Design
○○○○○○

Results
○●○○○○

Future Research Direction
○

Time trend in Contextuality
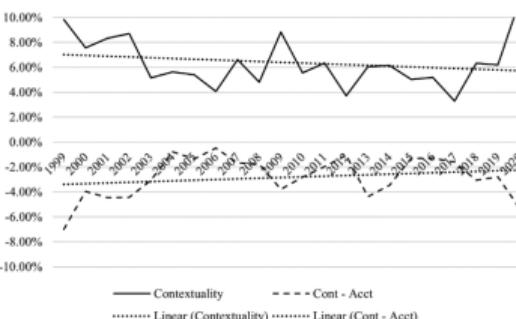
- Contextuality: difference between accuracy of fully and partially connected model
  - Contextuality = $\text{Accuracy}_{\text{Full}} - \text{Accuracy}_{\text{Partial}}$
- Time trend in contextuality: regression contextuality on time
  - $\text{Contextuality}_t = \lambda_0 + \lambda_1 \text{Time}_t + \epsilon_t$
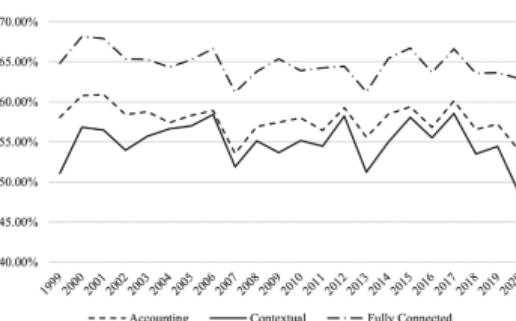
Using Narrative Context to Predict Cash Flows

Year	Accounting Info Only (1)	Contextual Info Only (2)	Partially Connected (3)	Fully Connected (4)	Contextuality (4) − (3)
1999	58.07%	51.09%	55.01%	64.84%	9.83%***
2000	60.76%	56.81%	60.59%	68.15%	7.56%***
2001	60.91%	56.47%	59.60%	67.93%	8.33%***
2002	58.40%	53.97%	56.65%	65.37%	8.71%***
2003	58.75%	55.69%	60.14%	65.30%	5.16%***
2004	57.40%	56.62%	58.70%	64.32%	5.63%***
2005	58.31%	56.97%	59.84%	65.24%	5.40%***
2006	58.90%	58.43%	62.60%	66.65%	4.05%***
2007	53.54%	51.87%	54.59%	61.20%	6.61%***
2008	56.89%	55.13%	58.98%	63.80%	4.82%***
2009	57.43%	53.65%	56.53%	65.37%	8.83%***
2010	57.98%	55.18%	58.34%	63.91%	5.56%***
2011	56.45%	54.48%	57.91%	64.24%	6.34%***
2012	59.27%	58.21%	61.69%	64.42%	3.73%***
2013	55.60%	51.22%	55.16%	61.22%	6.06%***
2014	58.45%	54.99%	59.25%	65.41%	6.16%***
2015	59.39%	58.08%	61.69%	66.72%	5.03%***
2016	56.82%	55.52%	58.50%	63.67%	5.17%***
2017	60.11%	58.53%	63.31%	66.61%	3.30%***
2018	56.54%	53.49%	57.22%	63.55%	6.32%***
2019	57.21%	54.43%	57.45%	63.64%	6.19%***
2020	53.85%	48.50%	52.52%	62.90%	11.39%***
Average	57.77%	54.97%	58.47%	64.74%	6.27%***
					(8.28)
AUC	0.5158	0.5093	0.5193	0.6213	0.1020***
					(9.22)
Macro F1	0.5089	0.4888	0.5239	0.6836	0.1597***
					(9.86)
Trend	−0.0011*	−0.0006	−0.0004	−0.0010*	−0.0006
	(−1.89)	(−0.55)	(−0.34)	(−1.89)	(−0.69)

(a) Time Trend in Contextuality

(b) Time Trend in the Predictive Accuracy of Accounting vs. Contextual Information

Overview
○

Introduction
○○○

Research Design
○○○○○○

Results
○○○●○○

Future Research Direction
○
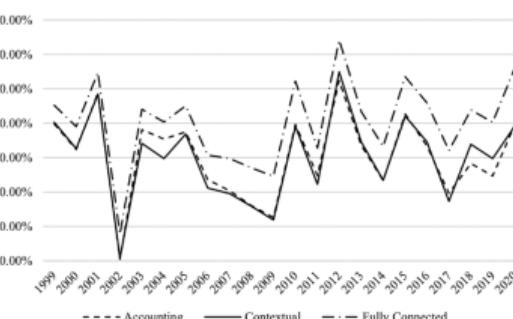
Using Narrative Context to Predict Annual Stock Returns

Year	Accounting Info Only (1)	Contextual Info Only (2)	Partially Connected (3)	Fully Connected (4)	Contextuality (4) − (3)
1999	59.79%	60.25%	63.85%	65.24%	1.38%*
2000	52.34%	52.63%	58.30%	59.01%	0.72%
2001	68.82%	68.43%	72.97%	74.75%	1.78%**
2002	20.44%	20.87%	26.09%	27.76%	1.67%*
2003	58.05%	54.16%	62.14%	64.01%	1.87%**
2004	55.41%	49.74%	55.92%	60.35%	4.42%***
2005	57.50%	56.87%	62.01%	65.06%	3.05%***
2006	43.55%	41.14%	45.95%	50.72%	4.76%***
2007	40.33%	39.58%	46.92%	49.70%	2.78%**
2008	35.98%	35.80%	41.84%	46.97%	5.13%***
2009	32.61%	31.92%	36.99%	44.54%	7.55%***
2010	59.65%	59.10%	65.67%	72.28%	6.61%***
2011	44.77%	42.20%	50.91%	52.81%	1.90%*
2012	72.42%	74.92%	80.68%	84.26%	3.58%***
2013	53.57%	54.58%	60.98%	63.43%	2.45%**
2014	43.36%	43.43%	46.17%	53.24%	7.07%***
2015	62.73%	62.04%	68.36%	73.54%	5.19%***
2016	53.37%	54.55%	58.62%	65.94%	7.33%***
2017	39.63%	37.32%	48.80%	52.09%	3.28%***
2018	48.27%	53.89%	54.39%	63.86%	9.47%***
2019	44.69%	49.74%	54.70%	60.30%	5.60%***
2020	59.45%	59.05%	63.46%	75.93%	12.47%***
Average	50.31%	50.10%	55.71%	60.26%	4.55%***
					(5.30)
AUC	0.5099	0.5121	0.5335	0.5982	0.0647***
					(6.35)
Macro F1	0.4682	0.4893	0.5223	0.5833	0.0610***
					(5.89)
Trend	−0.0002	0.0014	0.0013	0.0045	0.0032***
	(−0.05)	(0.35)	(0.33)	(1.1)	(4.22)

(a) Time Trend in Contextuality
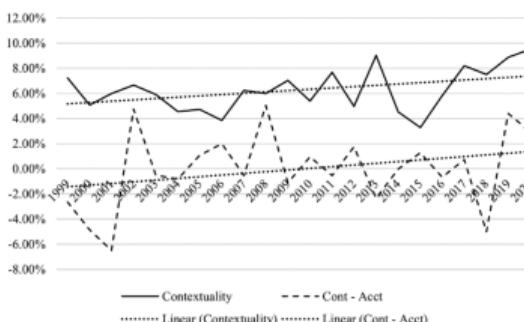
(b) Time Trend in the Predictive Accuracy of Accounting vs. Contextual Information
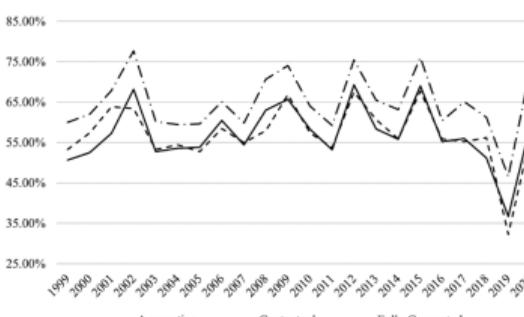
Using Narrative Context to Predict 60-Day Stock Returns

Year	Accounting Info Only (1)	Contextual Info Only (2)	Partially Connected (3)	Fully Connected (4)	Contextuality (4) − (3)
1999	53.23%	50.59%	52.75%	59.97%	7.23%***
2000	57.34%	52.49%	56.94%	62.00%	5.06%***
2001	63.80%	57.30%	61.87%	67.86%	5.98%***
2002	63.40%	68.14%	70.97%	77.64%	6.67%***
2003	53.22%	52.71%	54.19%	60.10%	5.92%***
2004	54.41%	53.58%	54.86%	59.42%	4.56%***
2005	52.72%	53.78%	54.83%	59.56%	4.73%***
2006	58.41%	60.41%	61.25%	65.09%	3.84%***
2007	54.95%	54.42%	53.55%	59.80%	6.25%***
2008	57.92%	62.98%	64.64%	70.64%	6.00%***
2009	66.84%	65.72%	66.95%	74.00%	7.04%***
2010	57.33%	58.28%	58.59%	63.98%	5.39%***
2011	53.72%	53.19%	51.50%	59.17%	7.67%***
2012	67.47%	69.23%	70.41%	75.39%	4.98%***
2013	60.66%	58.31%	56.43%	65.45%	9.03%***
2014	55.84%	55.81%	58.64%	63.16%	4.52%***
2015	67.73%	68.99%	72.77%	76.05%	3.28%***
2016	55.85%	55.17%	54.52%	60.32%	5.80%***
2017	55.20%	55.92%	56.88%	65.07%	8.19%***
2018	56.17%	51.16%	53.74%	61.24%	7.51%***
2019	32.22%	36.62%	37.68%	46.56%	8.87%***
2020	56.19%	59.14%	63.65%	73.18%	9.52%***
Average	57.03%	57.00%	58.53%	64.80%	6.27%***
					(8.35)
AUC	0.5189	0.5335	0.5395	0.5894	0.0499***
					(4.39)
Macro F1	0.5195	0.5339	0.5392	0.6662	0.1270***
					(9.88)
Trend	−0.0023	−0.0009	−0.0014	−0.0004	0.0011*
	(−0.77)	(−0.33)	(−0.46)	(−0.12)	(1.91)

(a) Time Trend in Contextuality

(b) Time Trend in the Predictive Accuracy of Accounting vs. Contextual Information

What Contributes to Contextuality?

Panel A. Cross-sectional analysis

Var =	Earning Volatility			Accruals			Loss			M/B			Political Uncertainty		
	High (1)	Low (2)	Diff (3)	High (4)	Low (5)	Diff (6)	=1 (7)	=0 (8)	Diff (9)	High (10)	Low (11)	Diff (12)	More (13)	Less (14)	Diff (15)
Earnings	7.15	5.36	**1.79** (2.45)	7.00	5.56	**1.34** (1.99)	7.95	5.01	**2.94** (3.98)	6.69	5.19	**1.50** (2.13)	7.32	5.24	**2.08** (2.47)
Cash Flow	6.85	5.81	1.04 (1.56)	6.41	6.13	0.28 (0.81)	6.98	5.46	**1.52** (2.15)	6.39	6.21	0.18 (0.52)	6.58	6.43	0.15 (0.48)
Return_Ann	5.12	4.01	1.11 (1.60)	5.32	3.99	**1.33** (1.95)	5.71	3.45	**2.26** (2.58)	5.17	4.03	1.14 (1.65)	6.51	3.99	**2.52** (3.01)
Return_60D	6.90	5.39	**1.51** (2.05)	6.94	5.21	**1.73** (2.36)	6.75	5.73	1.02 (1.33)	6.66	5.93	0.73 (1.02)	7.13	5.88	**1.25** (1.85)

Panel B. Time-series analysis

Dep Var =	Earnings (1)	Cash Flow (2)	Return_Annual (3)	Return_60Day (4)
EPU	0.010*** (3.09)	0.001 (0.33)	0.014* (1.94)	0.014*** (3.52)
Financial Crisis	0.015*** (5.18)	0.008 (0.47)	0.024** (2.37)	0.004 (0.91)
COVID	0.007** (2.49)	0.053*** (14.54)	0.080*** (11.32)	0.029*** (8.95)
N	22	22	22	22
Adjusted R^2	0.265	0.210	0.389	0.262

Future Research Directions

- Visual elements (charts, graphs, images) enhance understanding of textual and numeric information.
- Contextuality in multimodal corporate communication
  - Vocal Contextuality: Vocal cues provide context to narrative communication.
  - Visual Contextuality: Interactions between verbal communications and nonverbal cues (gestures, facial expressions, body language).