

Is ChatGPT Transforming Academics' Writing Style?

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ChatGPT Fever?



Valerio Capraro ✓

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To all prospective PhD students of the world:

If you generate your research statement using chatGPT, your grade will be 0, and you will not be invited to the interview.

So, please save your and the committee's time.

Research Statement

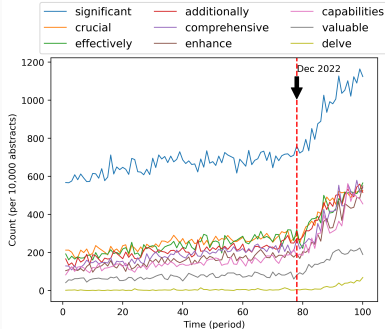
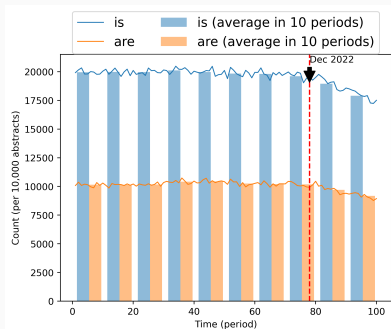
1.1 Academic Background

My journey into the realm of economics commenced with my undergraduate studies, where I was captivated by the intricate interplay between economic theory and real-world phenomena. I have completed my 4 years of BS Economics degree in 2018. After graduating with honors in Economics, I delved deep into subjects ranging from microeconomic analysis to econometric methods, honing my analytical skills and cultivating a keen understanding of economic principles. I have obtained my master of philosophy in economics in 2021. Subsequently, my postgraduate studies further fortified my expertise, providing me with advanced knowledge in areas such as macroeconomic theory, international trade, and monetary policy. Besides this, I am excellent and efficient as well in the application of econometrics as I comprehend the application of Stata, E-views SPSS, and R software which are integral for conducting empirical economics research.

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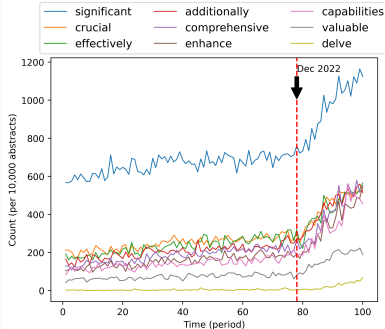
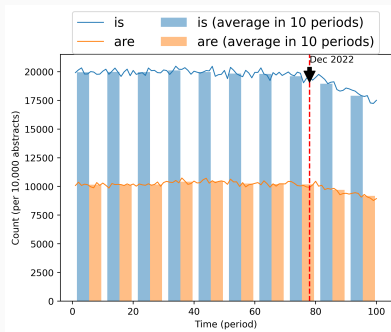
Word Frequency in arXiv Abstracts (Geng, Trotta, 2024)

- 1 million arXiv abstracts submitted from May 2018 to Jan 2024
- 100 periods (10,000 abstracts in each period)
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What happened?

LLM Simualtions

- **Prompt:** "Revise the following sentences:"
- Model: GPT-3.5
- word i , arXiv category j , time period t
- $q_{ij}^d, \tilde{q}_{ij}^d$: word frequency in arXiv abstracts before and after ChatGPT processing for estimating word change rate \hat{r}_{ij}

$$\hat{r}_{ij} = \frac{\tilde{q}_{ij}^d - q_{ij}^d}{q_{ij}^d} = \frac{\tilde{q}_{ij}^d}{q_{ij}^d} - 1 \quad (1)$$

- \tilde{f}_{ij}, f_{ij}^* : word frequency in arXiv abstracts for the corresponding word change rate \bar{r}_{ij}

$$\bar{r}_{ij} = \frac{\tilde{f}_{ij}^* - f_{ij}^*}{f_{ij}^*} = \frac{\tilde{f}_{ij}^*}{f_{ij}^*} - 1 \quad (2)$$

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- $\epsilon_{ij}(\cdot)$ and $\epsilon_{ij}^s(\cdot)$: the noise for word i due to ChatGPT processing

$$\frac{\tilde{f}_{ij}^* - \epsilon_{ij}(f_{ij}^*) - f_{ij}^*}{f_{ij}^*} = \frac{\tilde{q}_{ij}^d - \epsilon_{ij}^s(q_{ij}^d) - q_{ij}^d}{q_{ij}^d} \quad (3)$$

LLM Impact Model

- $\eta_j(t)$: ChatGPT impact (“proportion”)
- Without noise

$$\begin{aligned}\bar{f}_{ij}(t) &= (1 - \eta_j(t))f_{ij}^*(t) + \eta_j(t)f_{ij}^*(t)(\bar{r}_{ij} + 1) \\ &= f_{ij}^*(t) + \eta_j(t)f_{ij}^*(t)\bar{r}_{ij}\end{aligned}\tag{4}$$

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- f_{ij}^d : word frequency (observed in the data) for word i in category j
- $\delta_{ij}(\cdot)$: noise and word usage variability which are not directly related to the internal parameters of ChatGPT
- With noise

$$f_{ij}^d = f_{ij}^* + \delta_{ij}(f_{ij}^*)\tag{5}$$

$$f_{ij}^{\delta,\eta}(t) = \eta_j(t)f_{ij}^*(t) + \delta_{ij}(\eta_j(t)f_{ij}^*(t))\tag{6}$$

$$f_{ij}^{\delta,1-\eta}(t) = (1 - \eta_j(t))f_{ij}^*(t) + \delta_{ij}((1 - \eta_j(t))f_{ij}^*(t))\tag{7}$$

$$f_{ij}^d(t) = f_{ij}^{\delta,1-\eta}(t) + C_{ij}(f_{ij}^{\delta,\eta}(t))\tag{8}$$

Linear Regression?

The difference in word frequency with and without ChatGPT can be rewritten as

$$h_{ij}(t) = \eta_j(t)x_{ij}(t) + g_{ij}(t) + \xi_{ij}(t) \quad (9)$$

where

$$h_{ij}(t) = f_{ij}^d(t) - f_{ij}^*(t) \quad (10)$$

$$x_{ij}(t) = f_{ij}^*(t)\hat{r}_{ij} \quad (11)$$

$$g_{ij}(t) = \eta_j(t)f_{ij}^*(t)\epsilon_{ij}^\eta(q, f, t) \quad (12)$$

$$\begin{aligned} \xi_{ij}(t) = & (\hat{r}_{ij} + 1 + \epsilon_{ij}^\eta(q, f, t))\delta_{ij}(\eta_j(t)f_{ij}^*(t)) \\ & + \delta'_{ij}((1 - \eta_j(t))f_{ij}^*(t)) \end{aligned} \quad (13)$$

and

$$C_{ij}(f_{ij}^{\delta, \eta}(t)) = f_{ij}^{\delta, \eta}(t)(\hat{r}_{ij} + 1 + \epsilon_{ij}^\eta(q, f, t)) \quad (14)$$

$$\epsilon_{ij}^\eta(q, f, t) = \frac{\epsilon_{ij}(f_{ij}^{\delta, \eta}(t))}{f_{ij}^{\delta, \eta}(t)} - \frac{\epsilon_{ij}^s(q_{ij}^d)}{q_{ij}^d} \quad (15)$$

Impact Estimation

The quadratic loss function

$$L_{j,t}(\eta_j) = \frac{1}{n_j} \sum_{i \in I_j} (h_{ij}(t) - \eta_j(t)x_{ij}(t))^2 = \frac{1}{n_j} \sum_{i \in I_j} (g_{ij}(t) + \xi_{ij}(t))^2. \quad (16)$$

Ordinary Least Squares (OLS) estimator

$$\hat{\eta}_j(t) = \frac{\sum_{i \in I_j} h_{ij}(t)x_{ij}(t)}{\sum_{i \in I_j} x_{ij}^2(t)}. \quad (17)$$

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Case 1: if the effect of $\eta_j(t)$ on $\xi_{ij}(t)$ can be ignored compared to other terms, e.g., the following simple scenario,

$$\text{Var}[\delta_{ij}(\eta_j(t)f_{ij}^*(t))] \ll \eta_j(t)f_{ij}^*(t)\text{Var}[\epsilon_{ij}^\eta(q, f, t)] \quad (18)$$

$$L_{j,t,g}(\eta_j) = \frac{1}{n_j} \sum_{i \in I_j} (h_{ij}(t) - \eta_j(t)x_{ij}(t) - g_{ij}(t))^2 = \frac{1}{n_j} \sum_{i \in I_j} \xi_{ij}^2(t) \quad (19)$$

$$\hat{\eta}_j(t) - \hat{\eta}_j^g(t) = \frac{\sum_{i \in I_j} \text{E} \left[g_{ij}(t) \frac{\partial g_{ij}(t)}{\partial \eta_j(t)} \right]}{\sum_{i \in I_j} (f_{ij}^*(t)\hat{r}_{ij})^2}. \quad (20)$$

Calibration and Test

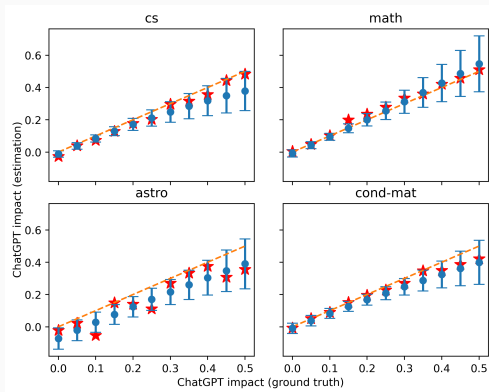
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- Different words produce different estimates
- How to chose the words?

Calibration and Test

- No explicit expression
- Different words produce different estimates
- How to chose the words?
- Calibration on mixture of real abstracts and ChatGPT-modified abstracts (simulated data)
- Grid search: e.g.,

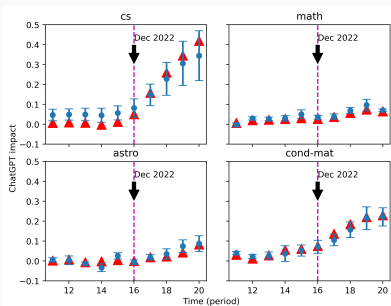
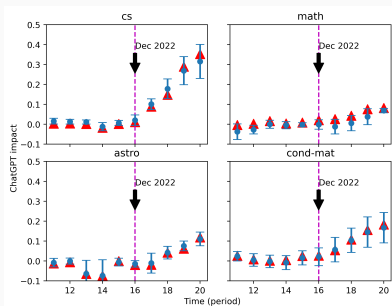
$$q_{ij}^d > 0.1 \text{ and } \frac{\hat{r}_{ij}+1}{\hat{r}_{ij}^2} < \frac{0.1+1}{0.1^2}$$

- Red star points: optimal word set with the same mixed ratio η_n as in the calibration data.



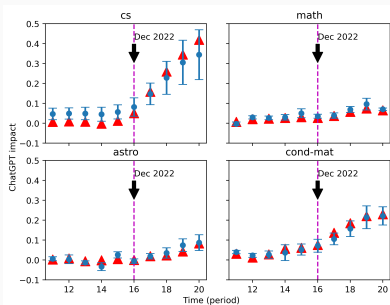
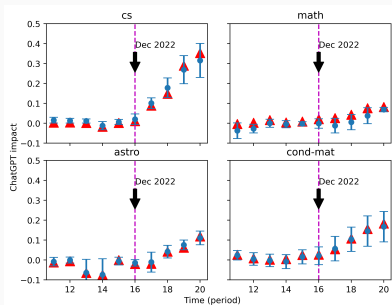
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- Period 16: Jan 2023 - April 2023
- Different ways of normalizing
- Triangle points: average of 3 estimates



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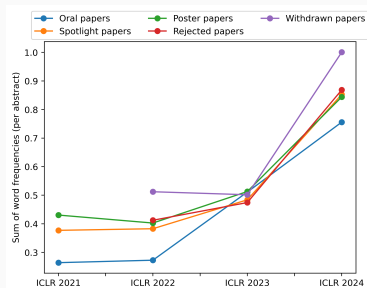
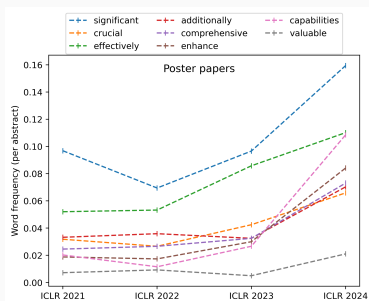
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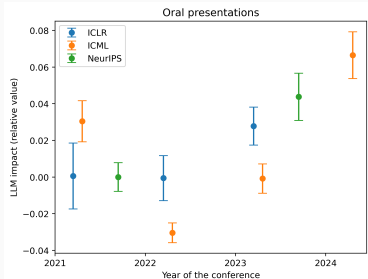
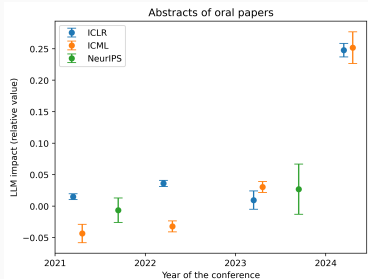
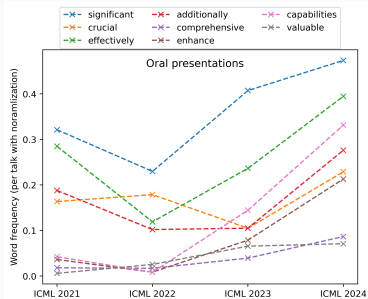
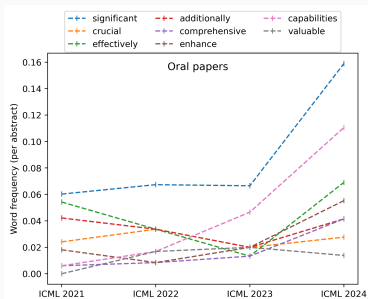
Proportion?

Machine Learning Conferences (Geng et al., 2024)

- ICLR, ICML, NeurIPS
- More than 30,000 papers (oral, spotlight, poster, *rejected*, *withdrawn*) and 1,000 presentations (of oral papers)



From Writing to Speaking



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 - Knowledge collapse

Questions?



M. Geng, C. Chen, Y. Wu, D. Chen, Y. Wan, and P. Zhou.

The impact of large language models in academia: from writing to speaking.

arXiv preprint arXiv:2409.13686, 2024.



M. Geng and R. Trotta.

Is chatgpt transforming academics' writing style?

arXiv preprint arXiv:2404.08627, 2024.