

Post-hoc Study of Climate Microtargeting on Social Media Ads with LLMs: Thematic Insights and Fairness Evaluation

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Climate Change

- One of the most **urgent** challenges of the 21st century.
- Requires **broad public engagement** and **effective communication** to drive environmental action (*Moritz & Agudo, 2013; Dessler & Theater, 1995*).



Climate Debate in Social Media

- One of the most **urgent** challenges of the 21st century.
- Requires **broad public engagement** and **effective communication** to drive environmental action (*Moritz & Agudo, 2013; Dessler & Theater, 1995*).
- Social media has become a key arena for climate communication.
- Empowers organizations, activists, and policymakers to:
 - ▶ Disseminate information, Mobilize public support, Shape climate discourse (*Nosek, 2020; Hestres & Hopke, 2017; Adger et al., 2003*).



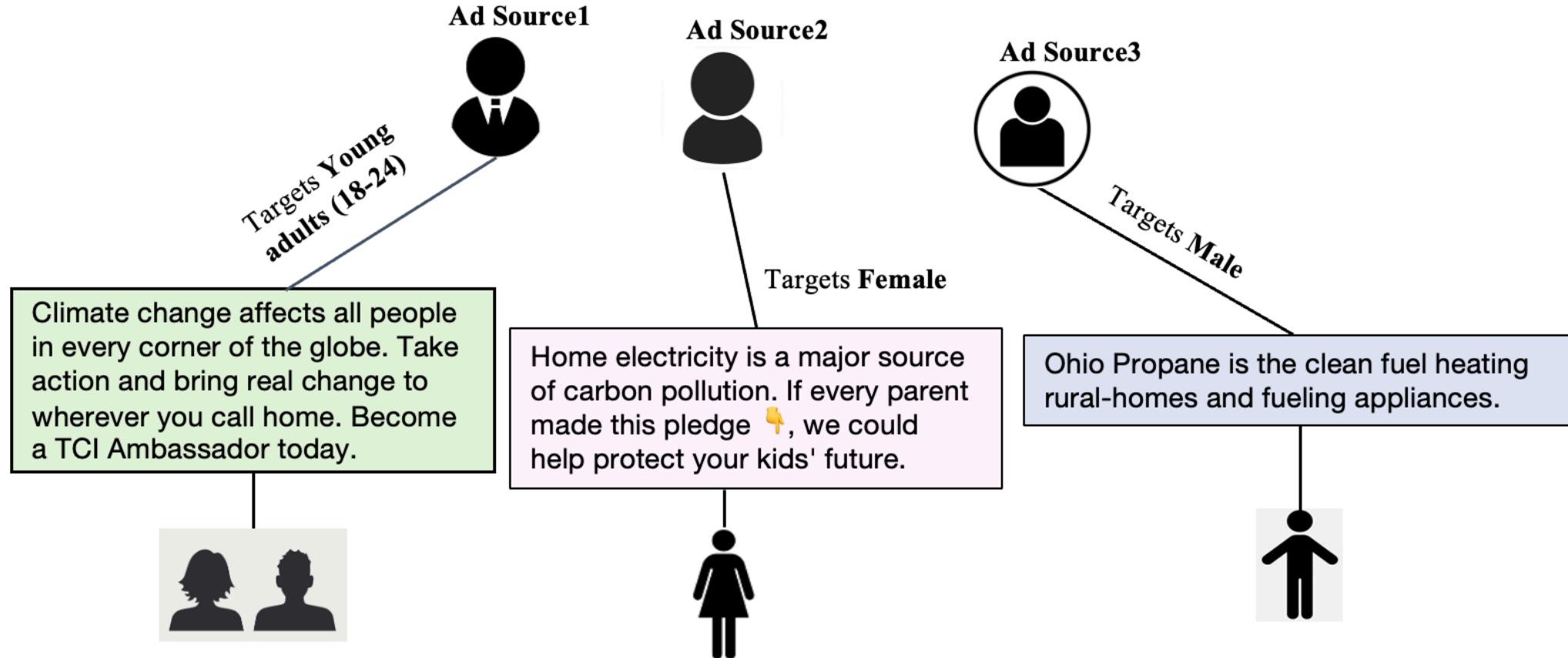
Microtargeting

Targeted Messaging Power

- Enables tailoring of messages to **specific demographics**.
- Increases message **relevance, engagement, and persuasive impact** (*Bloomfield & Tillary, 2019; Walter et al., 2018; Stoddart et al., 2016*).
- Risk reinforcing bias, exclusion, and inequity — raising critical questions about **fairness and transparency** in digital climate communication.

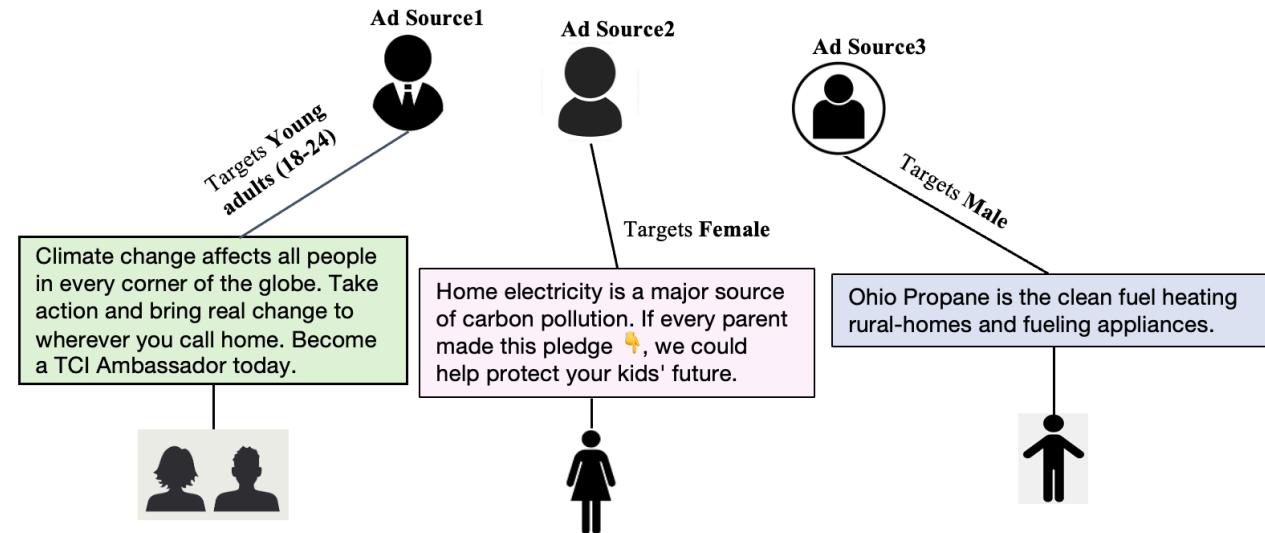


Microtargeting in Climate Debate



Microtargeting in Climate Debate

- **Problem:** Limited understanding of *how* microtargeting strategies are crafted and whether they're **fair or biased**.
- **Goal:** Leverage LLMs to analyze microtargeting and evaluate **demographic targeting and fairness**.



Research Questions (RQ)

- RQ1: Can LLMs **identify** targeted demographics and **explain** their reasoning?
- RQ2: What are the recurring themes and aspects of **explanations** provided by LLMs?
- RQ3: How **fair** are LLM predictions across demographic groups?

Dataset: Climate Campaigns Case Study

- Source
 - Based on Islam et al. (2023) and Islam & Goldwasser (2025)
 - **Corpus:** 21,372 English climate-related Meta ads (U.S.)
 - **Time span:** Jan 2021 – Jan 2022
- Ad Attributes:
 - Ad ID, description, body, funding entity, spend, impressions
 - Impression breakdowns by: **Gender, Age, Location:** U.S. state level
- **Demographics Indicators:**
 - **Gender:**
 - *Male,*
 - *Female*
 - **Age groups:**
 - *Young adults 18-24,*
 - *Early working 25-44,*
 - *Late working 45-64,*
 - *Seniors 65+*

Dataset: Climate Campaigns Case Study

- Targeting Definition
 - Meta API does **not** provide explicit targeting
 - Targeting **inferred** from *exclusive impression* distributions
 - Ads viewed **only by one gender** or **only by one age group**
 - Ads overlapping multiple categories **excluded**
- Filtered Dataset

Category	Targeting Basis	# Ads
Gender-targeted	Male-only / Female-only	106
Age-targeted	Exclusive to one age group	121
Total (after filtering)	—	227

Experimental Setup

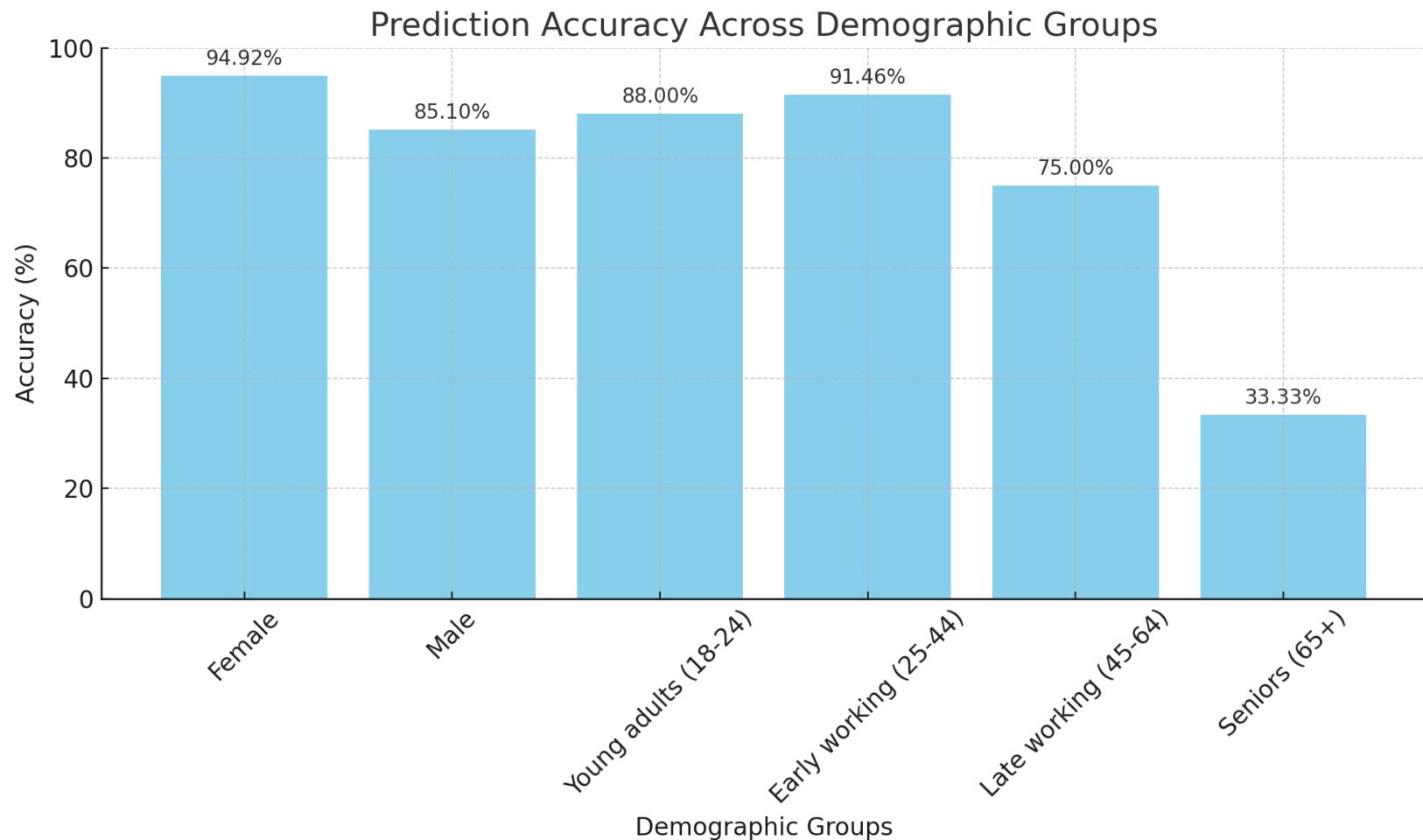
- Task: Identify the targeted demographic in a text and provide an explanation.
- Pipeline steps
 - **Gender prediction with explanation:** Given a text, predict the targeted gender and justify the choice.
 - **Age group prediction with explanation:** Given a text, predict the targeted age group and justify the choice.

Experimental Setup

- **Tools used:** OpenAI's latest LLM (**o1-preview**)
- **Baseline comparisons:** LR_{TF-IDF}, BERT, Llama 3, Mistral Large 2
- **Fairness metrics:**
 - Demographic Parity,
 - Equal Opportunity,
 - Predictive Equality.

Results

- Prediction Accuracy Across Demographic Groups



Results

Model	Demo.	Acc. (%)	F1 (%)
LR_tf-idf	gender	69.00	65.00
	age	73.00	31.00
BERT	gender	72.00	70.00
	age	70.00	26.00
Llama 3	gender	80.19	79.67
	age	58.68	36.84
Mistral Large 2	gender	82.08	82.07
	age	74.38	48.68
o1-preview	gender	90.57	90.35
	age	85.95	71.00

Table 1: Baseline Comparisons.

Results

Gender	p-value	Conclusion
Male	5.35×10^{-7}	Reject H_0
Female	5.95×10^{-14}	Reject H_0

Table 2: Significance tests by subgroup (gender).

Age Group	p-value	Conclusion
Senior	4.66×10^{-1}	Fail Reject H_0
Early Working	1.04×10^{-35}	Reject H_0
Young	5.76×10^{-11}	Reject H_0
Late Working	4.23×10^{-3}	Reject H_0

Table 3: Significance tests by subgroup (age).

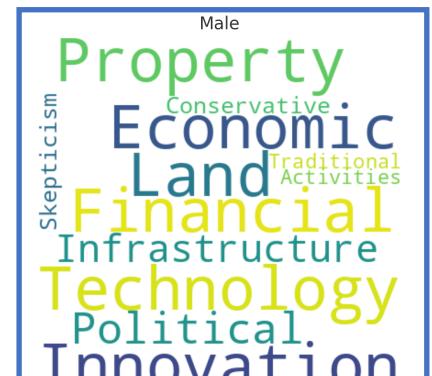
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Table 1: Baseline Comparisons.

Thematic Insights (Explanations from LLM)



perceived interests and roles in technology, finance, property, traditional male activities, and political or economic discourse



Male
Skepticism
Early Working
Conservative
Traditional Activities
Property
Economic
Land
Financial
Technology
Innovation
Parental
Financial
Innovation
Stability
Career
Proactive
Technology
Responsible
Social
Political

Female
Leadership
Community
Environmental
Health
Welfare
Advocacy
Empathy
Safety
Empowerment
Caregiving
Emotional
Social
Late Working
Voter

Policy
Financial
Stability
Economic
Homeownership
Responsibility
Engagement

Young Adults
Activism
Bold
Passion
Leadership
Change Advocacy
Action
Environmental
Immediate

Seniors
Health
Safety

Vulnerability
Wellness

Thematic Insights (Explanations from LLM)



Roles as Caregivers,
Environmental Advocates, and
Socially Conscious Individuals

perceived interests and roles in technology, finance, property, traditional male activities, and political or economic discourse

Male
Skepticism
Property
Conservative
Economic
Traditional Activities
Land
Infrastructure
Financial
Technology
Political
Innovation

Early Working
Parental
Financial
Innovation
Stability
Career
Proactive
Technology
Responsible
Social

Female
Leadership
Community
Health
Environmental
Welfare
Advocacy
Empathy
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Empowerment
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Thematic Insights (Explanations from LLM)

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Health
Safety
Empowerment
Early Working
Parental
Financial
Innovation
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Career
Proactive
Technology
Responsible
Social

Young Adults
Activism
Bold
Passion
Leadership
Climate Change Advocacy
Action
Environmental Training
Immediate

Seniors
Health
Safety
Vulnerability
Wellness



Activism and Environmental Consciousness

Thematic Insights (Explanations from LLM)



Activism and Environmental Consciousness

Seniors Health Safety

Vulnerability Wellness

Thematic Insights (Explanations from LLM)



Male
Property
Conservative
Economic
Traditional Activities
Land
Infrastructure
Financial
Technology
Political
Innovation

Skepticism
Early Working
Parental
Financial
Innovation
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Career
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Social

Female
Leadership
Community
Health
Environmental
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Empowerment
Caregiving
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Late Working
Voter
Policy
Financial
Stability
Economic
Homeownership
Responsibility
Engagement

Proactive and Responsible
Mindset

Responsibilities and Concerns



Young Adults
Activism
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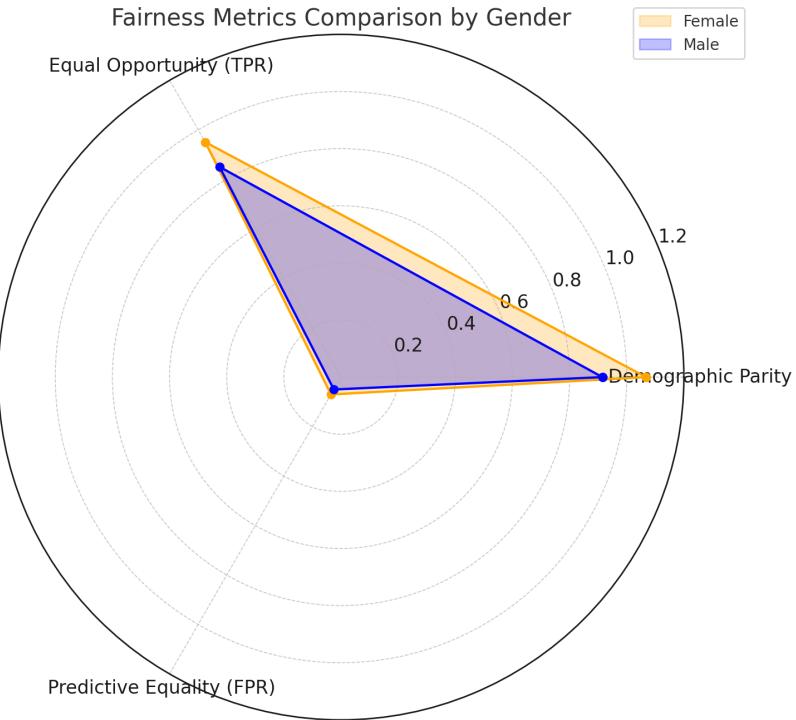


Activism and Environmental
Consciousness

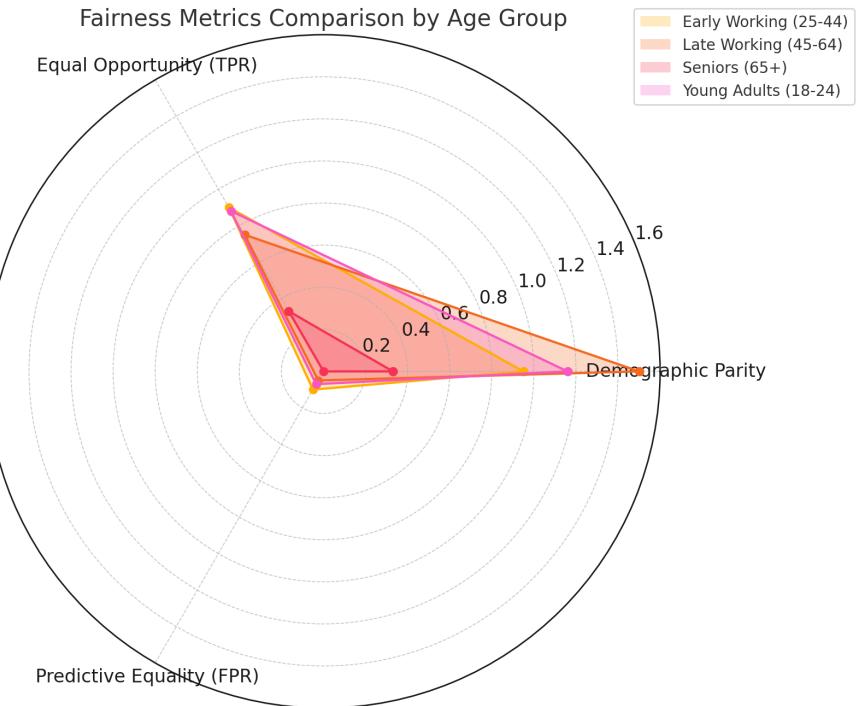
Thematic Insights (Explanations from LLM)



Fairness Evaluation



Minor bias favoring females.



- Minor bias favoring late working age group.
- Significant bias against seniors.

Key Takeaways

LLMs as Auditors

- LLMs can act as **independent, third-party auditors** of microtargeted climate ads.
- They can **identify intended audiences, explain reasoning**, and reveal **fairness issues** that are otherwise opaque.

Strong Predictive Capability

- **Gender prediction:** Highly accurate (Female = 94.92%, Male = 85.10%).
- **Age prediction:** More variable — highlights complexity of age-based targeting.

Key Takeaways

Explainable Insights

- LLM-generated **explanations** support creation of a **reusable taxonomy** of thematic appeals used in ads.
- These explanations make demographic targeting **interpretable and actionable** for researchers and practitioners.

Fairness & Equity

- **Fairness analysis** reveals **disparities** across gender and age groups.
- Demonstrates the **need for inclusive, equitable ad-targeting** and **bias-aware AI evaluation frameworks**.

References

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THANK YOU 😊

Slide: <https://tunazislam.github.io/files/PosthocClimateLLM.pdf>



Questions?

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