Hiding From Generative AI

Sijie Lin

University of Toronto

January 09, 2025

Motivation: Copyright Concerns Cause Pushback Against Generative AI

- The power of generative AI lies in its extensive training on a substantial volume of data, much of which consists of copyrighted materials.
- Multiple copyright lawsuits across different industries:
  1. Andersen v. Stability AI Ltd.: Artists against AI companies
  2. Doe v. GitHub: Programmers against GitHub
  3. Authors Guild v. OpenAI: Authors including George Martin (Game of Thrones) sue OpenAI
- Anti-AI protests on online art platforms: DeviantArt, ArtStation, LOFTER

How do copyright concerns impact the decision of creators?

Motivation: Why Is This Question Important?

Relevant to knowledge spillover

- May discourage future human innovation due to restricted access to existing content
  Murray&Stern 2007, Williams 2013, Galasso&Schankerman 2015, Nagaraj 2018, Biasi&Moser 2021
- Could harm future productivity of AI: AI models can collapse if it is trained on AI-generated content
  Shumailov, Shumaylov, Zhao, Gal, Papernot, Anderson 2023

This Paper

How do copyright concerns impact the decision of creators?

Find an empirical setting to answer this question

- DeviantArt, a leading online arts platform
  - Artists display and sell artworks
  - Companies (ad, games, etc) recruit employees
  - One of the largest platforms
- Nov 11, 2022: DeviantArt introduced DreamUp, an AI image generator

"Confused artists discover their work will be used for AI training by default."

—— *Ars Technica, Nov 11, 2022*

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Why choose this platform?

1. Earliest copyright concerns on online art platform
2. Much attention on ongoing lawsuit (Andersen v. Stability AI Ltd.)

Main Findings

1. Diff-in-diff: 21% decline in publication volume of non-AI digital artists
2. Multi-homing artists: only withhold artworks on DeviantArt, not on Instagram
3. No evidence of quality change in published artworks

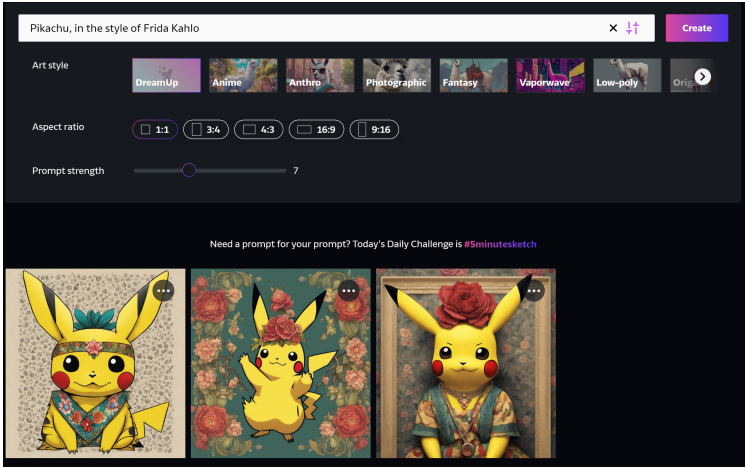
Timeline

There are 3 other well-known AI image generators: Stable Diffusion, Midjourney and DALL-E 2.

1. 12 July 2022: Midjourney image generation platform first entered open beta
2. 22 August 2022: Stability AI announced the public release of stable diffusion
3. 28 September 2022: DALL-E 2 was opened to anyone, and the waitlist requirement was removed
4. **11 November 2022**: DreamUp (based on Stability AI) was introduced on DeviantArt
5. 30 November 2022: ChatGPT released

Features of AI Image Generators

- Can specify style of a particular artist
- Time-efficient
  - 60 seconds for 3 artworks
- Cheap
  - $<$ 10 cents per prompt



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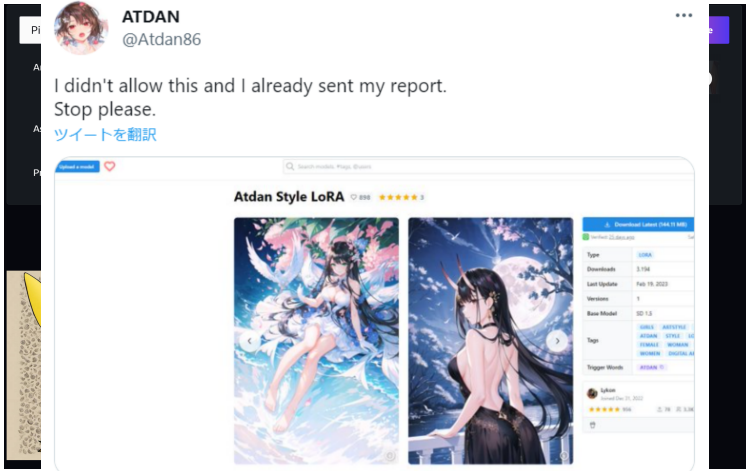


Data

Data

7118 artists from daily featured section on DeviantArt

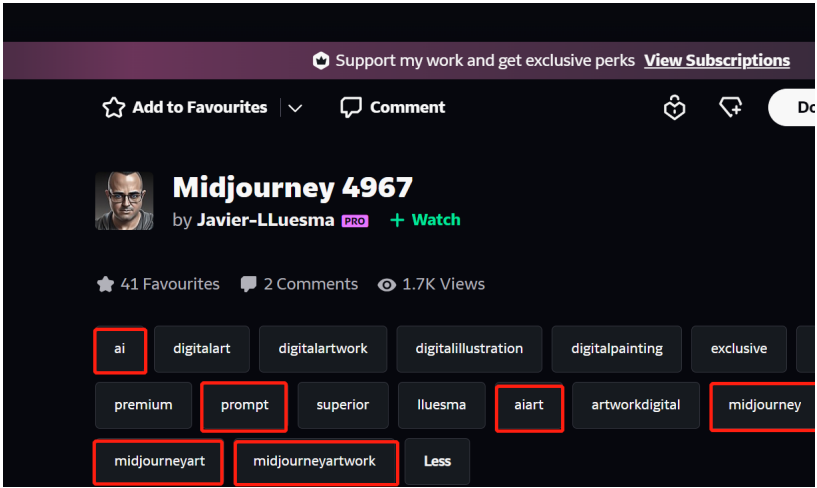
1. Information on DeviantArt
   - Artists demographics
   - History of publication: publish date; number of views, downloads, favorites, comments; description and tags
   - Other platforms they are using
2. Information on Instagram
   - Obtain data of professional/business accounts
   - History of publication: publish date; number of likes, comments; description and tags

Dbn of Multi-homing Artists	Artists%
Instagram	63%
Twitter	51%
Facebook	38%
YouTube	22%
Tumblr	21%
Fraction of Multi-homing artists	77%

Artist Summary stat

Data: Identify AI Artworks

Title, Tags, Description



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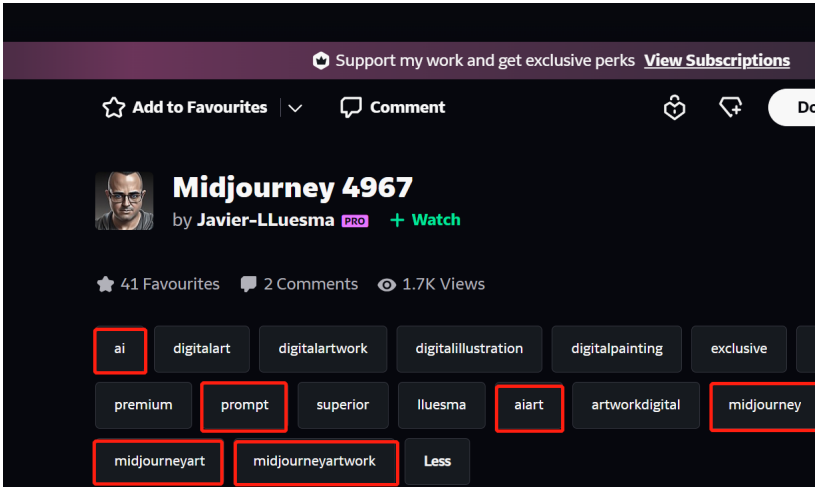


89% Non-AI Artists

11% AI Artists

all artist time trend

Identification Strategy

Identification Strategy: Difference-in-Differences

Control Group:

Non-AI Artists specialize in **Artisan Crafts**

- Usually hand-made
- Jewelries, dolls, cross stitch, etc.
- **Less exposed to AI**

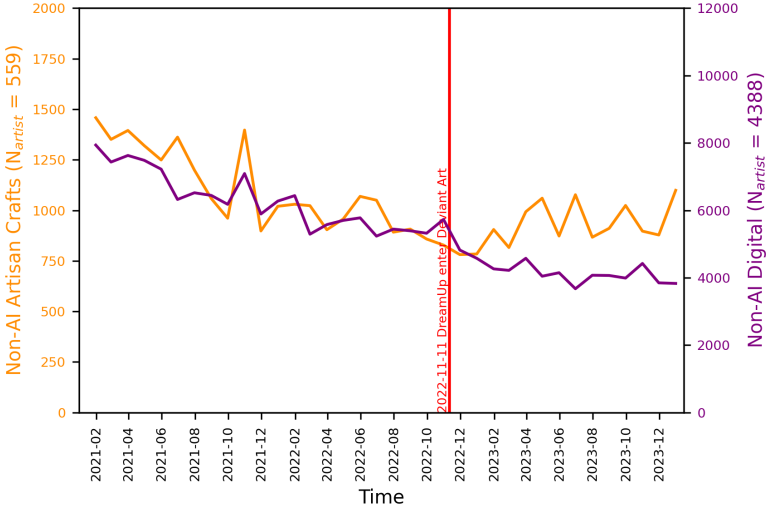
Treatment Group:

Non-AI Artists specialize in **Digital Arts**

- Usually made with Adobe Photoshop, Procreate on drawing tablets or iPad
- Dragons, fantasy, wallpapers, etc.
- **More exposed to AI**

Identification Strategy: Difference-in-Differences

Similar Trends Before Shock



Results

Result 1: 21% Decline of Publication Volume on DeviantArt

$$Artwork_{it} = \beta Post_t \times Treated_i + \delta_i + \delta_t + \epsilon_{it}$$

Table 1: Effect on Artist Publication Volume

Sample:	All Users	Instagram Users	Instagram Users
Dep Var:	Artworks on DeviantArt	Artworks on DeviantArt	Artworks on Instagram
	(1)	(2)	(3)
$Post_t \times Treated_j$	-0.24***	-0.27*	-0.06
	(0.09)	(0.14)	(0.07)
Implied %Change	-21%	-24%	-6%
Artist FE	Y	Y	Y
Month FE	Y	Y	Y
N(Artist-Month)	178,092	52,812	52,812
N(Artists)	4,947	1,467	1,467
Pseudo R^2	0.52	0.41	0.46

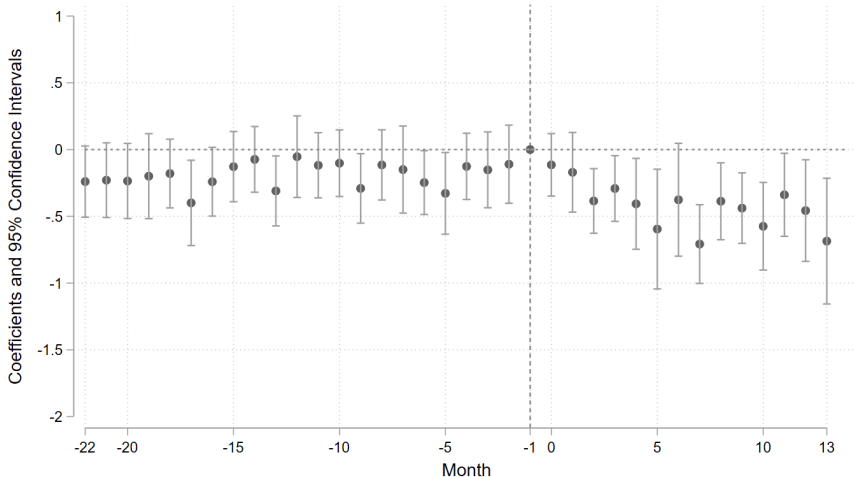
Notes: *** denotes significance at 1 percent, ** at 5 percent, and * at 10 percent. Standard errors are clustered at artist level.

Likely to be an **underestimation**: By the time I started collecting the data, some artists have already deactivated their accounts. robustness check

Result 1: 21% Decline of Publication Volume on DeviantArt

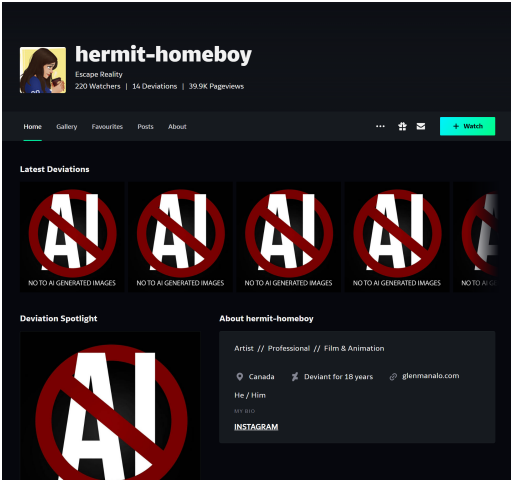
Pre-Trend

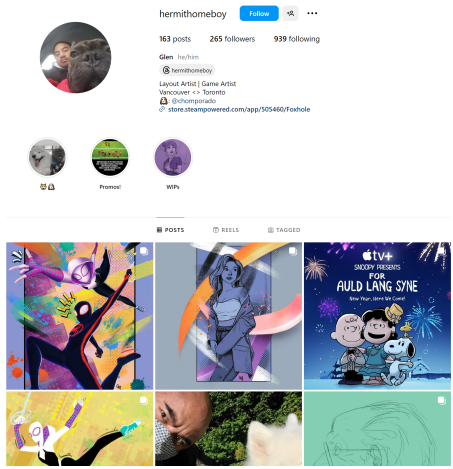
$$Artwork_{it} = \sum_t \beta_t Treated_i \times Month_t + \delta_i + \delta_t + \epsilon_{it}$$



Not Producing or Not Disclosing?

Example of hermit-homeboy





Result 2: No Reduction on Instagram, Only on DeviantArt

$$Artwork_{it} = \beta Post_t \times Treated_i + \delta_i + \delta_t + \epsilon_{it}$$

Table 2: Effect on Artist Publication Volume

Sample:	All Users	Instagram Users	Instagram Users
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} ↓volume knowledge spillover

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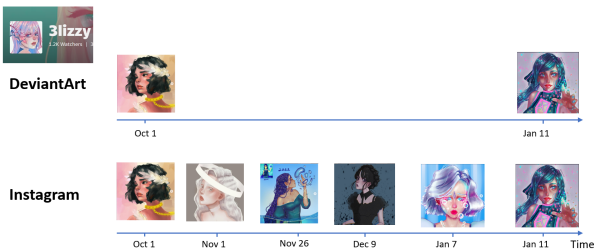
Results

1. ↓21% publication volume
2. ↓ disclosure, not in production
3. Effect on Quality of future artworks?

} ↓volume knowledge spillover

Are They Withholding High-Quality Artworks from DeviantArt?

Compare Quality of "Only-Instagram" and "Also-DeviantArt"



$$y_{ijt}^{Ins} = \beta_1 Post_t \times Matched_j + \beta_2 Matched_j + \mu_i + \mu_t + \epsilon_{ijt}$$

Match Artworks Across Platforms

1. For a given artist, each pair $(Artwork^{Ins}, Artwork^{DA})$, calculate similarity score based on title, date, description, tags
2. $m \times n$ matrix of similarity scores
3. Match artworks using Hungarian Algorithm
4. Randomly sample 150 artworks and manually check: 85% correct

Result 3: No Evidence of Withholding High-Quality Artworks

Compare Quality of "Only-Instagram" and "Also-DeviantArt"

$$y_{ijt}^{Ins} = \beta_1 Post_t \times Matched_j + \beta_2 Matched_j + \mu_i + \mu_t + \epsilon_{ijt}$$

Table 3

Dep Var	$Likes^{Ins}$	$Comments^{Ins}$
	(1)	(2)
$Post_t \times Matched_j$	0.07	-0.03
	(0.10)	(0.06)
$Matched_j$	0.09*	0.11***
	(0.05)	(0.03)
Artist FE	Y	Y
Month FE	Y	Y
N(Artwork)	145,202	145,265
Pseudo R^2	0.77	0.62

Notes: *** denotes significance at 1 percent, ** at 5 percent, and * at 10 percent. Standard errors are clustered at artist level.

validate measure on instagram

Are Better Artists Withholding More?

- Quality can change not only at the intensive margin, but also extensive margin
- If better artists withhold more, quality of artworks can still decrease

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- Measure artists quality with artist fixed effects following Waldfogel(2012):

$$downloads_{ijt}^{DA} = f(date_{ijt}^{collect\ data} - date_{ijt}^{publish}) + \mu_i + \mu_{month} + \epsilon_{ijt}$$

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- Quality measured based on artworks prior to the regression period
- Divide digital artists evenly into high, median, low quality groups

Result 4: Better Artists Do Not Withhold More

$$Artwork_{it} = \sum_{m \in \{High, Median, Low\}} \beta^m Post_t \times Treated_i^m + \delta_i + \delta_t + \epsilon_{it}$$

If $\beta^{High} < \beta^{Median} < \beta^{Low} < 0$, better artists withhold more.

Result 4: Better Artists Do Not Withhold More

$$Artwork_{it} = \sum_{m \in \{High, Median, Low\}} \beta^m Post_t \times Treated_i^m + \delta_i + \delta_t + \epsilon_{it}$$

If $\beta^{High} < \beta^{Median} < \beta^{Low} < 0$, better artists withhold more.

Table 4: Similar Effects Between Artists of Different Quality

Dep Var	$Artwork_{it}$			
Quality Measured By	Downloads	Favorites	Views	Comments
	(1)	(2)	(3)	(4)
$Post_t \times Treated_i^{High}$	-0.24**	-0.25***	-0.22**	-0.18**
	(0.10)	(0.09)	(0.09)	(0.09)
$Post_t \times Treated_i^{Median}$	-0.32***	-0.23**	-0.27***	-0.31***
	(0.10)	(0.09)	(0.10)	(0.10)
$Post_t \times Treated_i^{Low}$	-0.17*	-0.25**	-0.24**	-0.24**
	(0.10)	(0.11)	(0.10)	(0.11)
Artist FE	Y	Y	Y	Y
Month FE	Y	Y	Y	Y
N(Artist-Month)	140,364	140,364	140,364	140,364
Pseudo R^2	0.52	0.52	0.52	0.52

Notes: *** denotes significance at 1 percent, ** at 5 percent, and * at 10 percent. Standard errors are clustered at artist level.

Conclusion

How do copyright concerns related to AI training data impact the decision of creators?

1. Diff-in-Diff: $\downarrow$ 21% in publication volume
2. $\downarrow$ disclosure, not in production
3. No evidence of quality change
   - Not selectively withholding high-quality artworks for a given artist (intensive margin)
   - Better artists do not withhold more (extensive margin)

Thank You!

All comments and suggestions are welcomed!

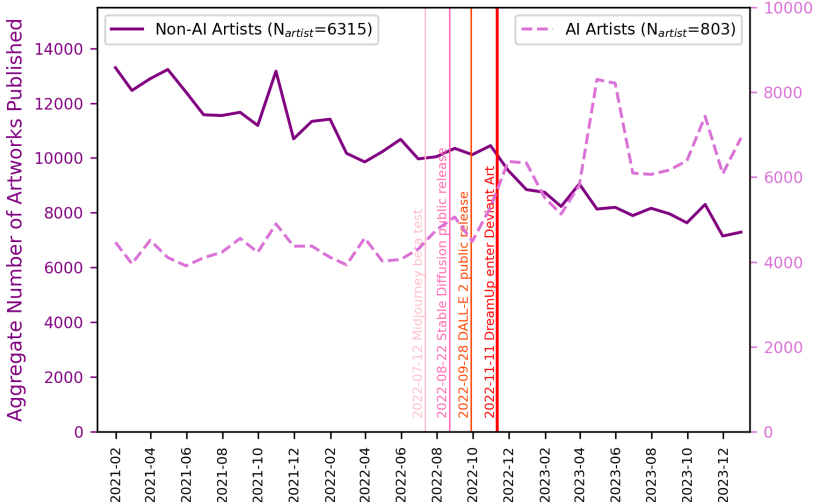
sijie.lin@mail.utoronto.ca

Literature

1. Copyright concerns associated with generative AI
   - Theory: ↓ monopoly profits of original creators, welfare implication under different copyright regimes, data availability (Gans 2024; Yang&Zhang 2024)
   - Empirical: ↓ availability of training data (Huang, Fu&Ghose 2023; Peukert, Abeillon, Haese, Kaiser&Staub 2024)
   - This paper: ↓ disclosure, not in production; AI adopters ↑ publication volume by 55%-60%
2. Effect of piracy on revenue of information products
   - ↓ sales due to displacement (Hui&Png 2003; Rob&Waldfogel 2006, 2007; Zentner 2006)
   - ↑ sales due to word-of-mouth (Aguiar&Martens 2016; Givon, Mahajan&Muller 1995; Peukert, Claussen&Kretschmer 2007; Oberholzer-Gee&Strumpf 2007; Blackburn 2004)
   - This paper: even if AI art does not divert consumers' attention away from them, non-AI artists still withhold artworks
3. Impact of copyright protection on innovation and knowledge diffusion
   - ↑ prices, ↓ knowledge diffusion (Reimers 2019)
   - ↑ quantity, ↑ quality of new products (Giorcelli&Moser 2020)
   - This paper: volume of innovation remains unchanged, knowledge diffusion ↓

Appendix: Time Trends

AI artists increase publication, while Non-AI artists decrease



ai tags

Appendix: Difference in Differences

Summary Statistics

Table 5: Summary Statistics

	Artisan Crafts Artists				Digital Art Artists			
	Mean	Min	Max	sd	Mean	Min	Max	sd
Monthly Pre-Period Artworks	1.97	0	369	11	1.43	0	474	5.00
Profile Pageviews	1.05e+05	639	3.25e+06	2.30e+05	2.81e+05	799	5.38e+07	1.14e+06
Followers	1977	11	6.31e+04	4727	6613	5.00	6.76e+05	1.96e+04
$Views^{DA}$ per Artwork	5586	15	1.09e+06	4.04e+04	1.80e+04	14	5.49e+06	7.42e+04
$Downloads^{DA}$ per Artwork	5.85	0	1253	34	16	0	2.25e+04	102
$Favourites^{DA}$ per Artwork	39	0	2486	89	182	0	1.09e+04	400
$Comments^{DA}$ per Artwork	2.42	0	151	6.50	6.07	0	2887	14
N(Artist)	559				4388			

Notes: Use panel from January 2021 to December 2023.

data

Appendix: Difference in Differences

Summary Statistics

Table 6: Summary Statistics

	Artisan Crafts Artists				Digital Art Artists			
	Mean	Min	Max	sd	Mean	Min	Max	sd
Monthly Pre-Period Artworks	1.75	0	67	4.87	1.60	0	271	4.86
Profile Pageviews	1.39e+05	1668	3.25e+06	3.35e+05	3.35e+05	799	1.04e+07	9.22e+05
Followers	2889	24	6.31e+04	7203	9252	33	3.43e+05	2.35e+04
$Views^{DA}$ per Artwork	1.19e+04	35	1.09e+06	5.42e+04	2.79e+04	19	1.64e+06	9.63e+04
$Downloads^{DA}$ per Artwork	19	0	955	60	20	0	7042	116
$Favourites^{DA}$ per Artwork	91	0	2486	144	256	0	1.09e+04	503
$Comments^{DA}$ per Artwork	2.51	0	90	4.59	7.82	0	373	16
$Likes^{Ins}$ per Artwork	800	0	2.23e+05	4362	2024	0	1.29e+06	9114
$Comments^{Ins}$ per Artwork	13	0	1.17e+04	73	15	0	7906	67
N(Artist)	170				1297			

Notes: Use panel from January 2021 to December 2023.

data

Result 1: 21% Decline of Publication Volume on DeviantArt

Extensive Margins

$$Stay_{it} = \beta Treated_i \times Month_t + \delta_i + \delta_t + \epsilon_{it}$$

Table 7: Effect on Artist Publication Volume at Extensive Margin

	(1) Linear Probability Model	(2) Logit
$Post_t \times Treated_i$	-0.02	-32.82
	(0.01)	(36453.91)
Artist FE	Y	Y
Month FE	Y	Y
N(Artist-Month)	178,092	143,100
N(Artist)	4,931	3,966
R^2	0.66	
Pseudo R^2		0.46

Notes: *** denotes significance at 1 percent, ** at 5 percent, and * at 10 percent. Standard errors are clustered at artist level.

Possibly because those who chose to exit had already deactivated accounts before data collection

Appendix: Difference in Differences

Robustness Check

Table 8: Effect on Artist Publication Volume

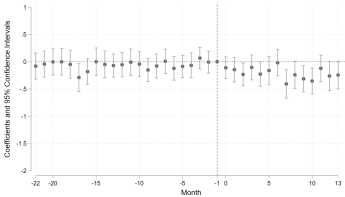
	Baseline Estimation		Winsorize 99% of Dep Var		Drop 1% Largest SD. Artists	
	(1)	(2)	(3)	(4)	(5)	(6)
	PPML	OLS	PPML	OLS	PPML	OLS
$Post_t \times Treated_i$	-0.24***	-0.17	-0.15**	-0.13*	-0.21**	-0.24**
	(0.09)	(0.12)	(0.06)	(0.07)	(0.09)	(0.10)
Pre-Treatment Mean		1.43		1.27		1.40
Implied %Change	-21%	-12%	-14%	-10%	-19%	-17%
Artist FE	Y	Y	Y	Y	Y	Y
Month FE	Y	Y	Y	Y	Y	Y
N(Artist-Month)	178,092	178,092	178,092	178,092	176,616	176,616
N(Artist)	4,947	4,947	4,947	4,947	4,906	4,906
R^2		0.57		0.51		0.39
Pseudo R^2	0.52		0.45		0.48	

Notes: *** denotes significance at 1 percent, ** at 5 percent, and * at 10 percent. Standard errors are clustered at artist level.

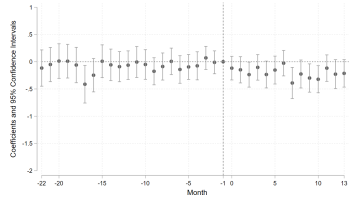
main did

Appendix: Difference in Differences

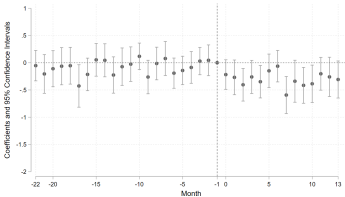
Robustness Check



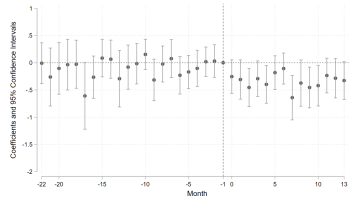
(a) Winsorize PPML



(b) Winsorize OLS



(c) Drop 1% largest SD PPML



(d) Drop 1% largest SD OLS

main did

Are They Withholding High-Quality Artworks from DeviantArt?

High Performance Correlation Across Platforms

$$y_{ijt}^{Ins} = \beta y_{ijt}^{DA} + \delta_i + \delta_t + \epsilon_{ijt}$$

Dep Var	$Likes^{Ins}$				$Comments^{Ins}$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Favorites^{DA}$	2.765***				0.014***			
	(0.420)				(0.002)			
$Comments^{DA}$		61.213***				0.535***		
		(13.099)				(0.074)		
$Downloads^{DA}$			1.573**				0.010*	
			(0.789)				(0.005)	
$Views^{DA}$				0.005***				0.000***
				(0.001)				(0.000)
Artists FE	Y	Y	Y	Y	Y	Y	Y	Y
Month FE	Y	Y	Y	Y	Y	Y	Y	Y
N(Artwork)	35,655	35,655	35,655	35,655	35,655	35,655	35,655	35,655
R^2	0.48	0.47	0.47	0.47	0.47	0.48	0.46	0.46

Notes: *** denotes significance at 1 percent, ** at 5 percent, and * at 10 percent. Standard errors are clustered at artist level.

compare quality on instagram

Roadmap

Motivation

Data

Identification Strategy

Results

1. ↓21% publication volume
2. ↓ disclosure, not in production

} ↓volume knowledge spillover

3. Artists do not selectively withhold high-quality artworks
4. Better artists do not withhold more

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} Quality Unchanged

5. Is this withholding driven by shifted attention towards AI art?

Result 5: Consumer Attention Remains Unchanged

- Is this reduction caused by AI artists diverting consumer attention away from non-AI digital artists?

Table 9: Similarly Engagement with Audience per Artwork as Before

Dep Var	Views	Downloads	Favorites	Comments
	(1)	(2)	(3)	(4)
$Post_t \times Treated_i$	0.02	1.10	-0.06	-0.04
	(0.15)	(0.89)	(0.09)	(0.08)
Implied %Change	2%	200%	-0.06%	-0.04%
Artist FE	Y	Y	Y	Y
Month FE	Y	Y	Y	Y
N(Artwork)	233,482	157,028	233,459	231,061
Pseudo R^2	0.59	0.81	0.82	0.52

Result 5: Consumer Attention Remains Unchanged

- Is this reduction caused by AI artists diverting consumer attention away from non-AI digital artists?

Table 10: Conditional on Being Seen, Similarly Engagement as Before

Dep Var	(1) Downloads / Views	(2) Favorites / Views	(3) Comments / Views
$Post_t \times Treated_i$	-0.82	-11.60	29.05*
	(3.50)	(13.07)	(17.17)
Implied %Change	-5%	-5%	217%
Artist FE	Y	Y	Y
Month FE	Y	Y	Y
N(Artwork)	233,482	233,482	233,482
R^2	0.23	0.54	0.16

Result 5: Consumer Attention Remains Unchanged

- Is this reduction caused by AI artists diverting consumer attention away from non-AI digital artists?

Table 10: Conditional on Being Seen, Similarly Engagement as Before

	(1)	(2)	(3)
Dep Var	$\frac{Downloads}{Views}$	$\frac{Favorites}{Views}$	$\frac{Comments}{Views}$
$Post_t \times Treated_i$	-0.82	-11.60	29.05*
	(3.50)	(13.07)	(17.17)
Implied %Change	-5%	-5%	217%
Artist FE	Y	Y	Y
Month FE	Y	Y	Y
N(Artwork)	233,482	233,482	233,482
R^2	0.23	0.54	0.16

No, $\downarrow$ publication volume more likely to be caused by fear of future competition or anger.

Roadmap

Motivation

Data

Identification Strategy

Results

1. ↓21% publication volume
2. ↓ disclosure, not in production

} ↓volume knowledge spillover

3. Artists do not selectively withhold high-quality artworks
4. Better artists do not withhold more

} Quality Unchanged

5. Withholding not driven by ↓attention of audience, but fear of future competition

Roadmap

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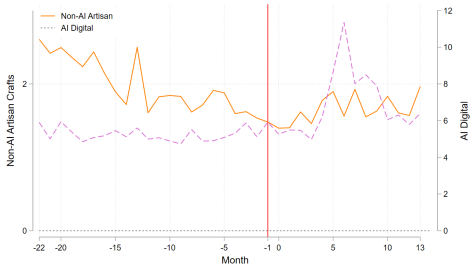
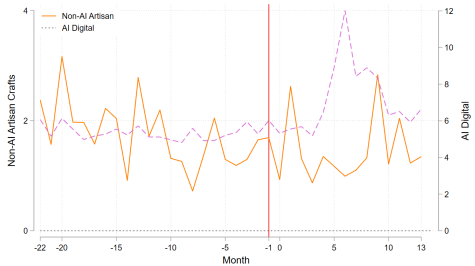
5. Withholding not driven by ↓attention of audience, but fear of future competition
6. Do AI adopters publish more?

Result 6: 11% Incumbents Adopted AI and ↑55%-60% Publication Volume

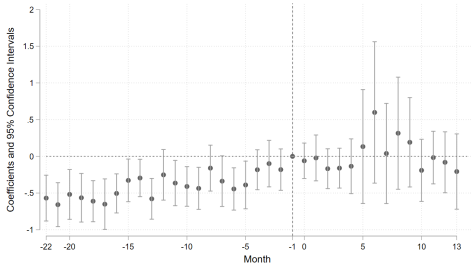


(a) Before Propensity Score Matching

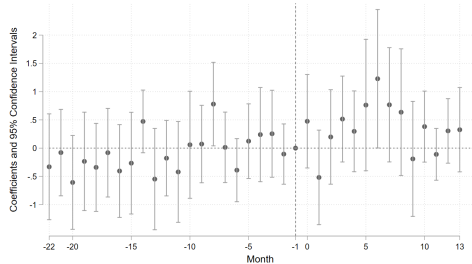


(b) After Propensity Score Matching

Result 6: 11% Incumbents Adopted AI, and ↑55%-60% Publication Volume



(a) Baseline Estimation PPML



(b) Propensity Score Matching PPML

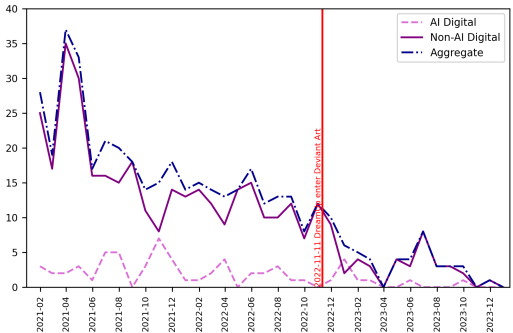
Result 6: 11% Incumbents Adopted AI, and ↑55%-60% Publication Volume

Table 11: AI Artists Publication Volume Change

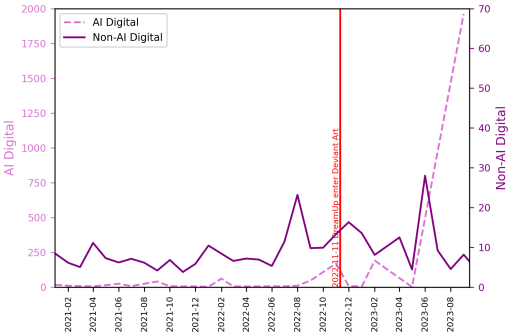
	Baseline Estimation	Propensity Score Matching
	(1)	(2)
$Post_t \times Treated_i$	0.44**	0.47*
	(0.20)	(0.25)
Implied %Change	55%	60%
Artist FE	Y	Y
Month FE	Y	Y
N(Artist-Month)	39,528	21,528
N(Artist)	1,098	598
N(Artist in Control)	559	99
N(Artist in Treatment)	539	499
Pseudo R^2	0.65	0.63

Notes: *** denotes significance at 1 percent, ** at 5 percent, and * at 10 percent. Standard errors are clustered at artist level. Single nearest neighbor matching is used in column (2).

Result 6: Few but Very Productive Entrants



(a) Number of Digital Artist Entrants



(b) Avg Monthly Artworks of Digital Artist Entrants within First 3 Months of Entry

Conclusion

How do copyright concerns related to AI training data impact the decision of creators?

1. Diff-in-Diff: $\downarrow$ 21% in publication volume
2. $\downarrow$ disclosure, not in production
3. No evidence of quality change
   - Not selectively withholding high-quality artworks for a given artist (intensive margin)
   - Better artists do not withhold more (extensive margin)
4. Not driven by current $\downarrow$ attention from audience, but fear of future competition
5. AI adopters $\uparrow$55%-60% publication volume, new entrants publish significantly more