

## Execution Report

**Title: The Impact of the General Data Protection Regulation (GDPR) on Online Tracking**

**Authors: Klaus M. Miller, Karlo Lukic, Bernd Skiera**

**Full reference:** Miller, Klaus M., Lukic, Karlo and Skiera, Bernd "The Impact of the General Data Protection Regulation (GDPR) on Online Tracking" Working paper, March 7, 2025.

The structure and contents of this execution report provided by **cascad** for the certification are similar to those recommended by the [AEA Data Editor](#).

### 1. DATA DESCRIPTION

This study uses data from WhoTracks.me, which spans 32 months from May 2017 to December 2019, to analyse how the number of trackers used by publishers changed before and after the GDPR implementation. It is supplemented with traffic shares data from SimilarWeb and information on trackers from Evidon.

For a thorough description of the data, please refer to Table 3.

### 2. CODE DESCRIPTION

The verification package is divided into three self-explanatory folders: *01\_data*, *02\_r\_scripts* and *03\_results*. The *02\_r\_scripts* folder contains two R scripts: *reproducible\_analysis-2025-03-07-KL.R* and *packages\_and\_functions-2025-03-07-KL.R*. The former generates all the Tables and Figures (including those without numerical results).

In addition, the package contains a *renv* file to use the same packages and their versions as the authors.

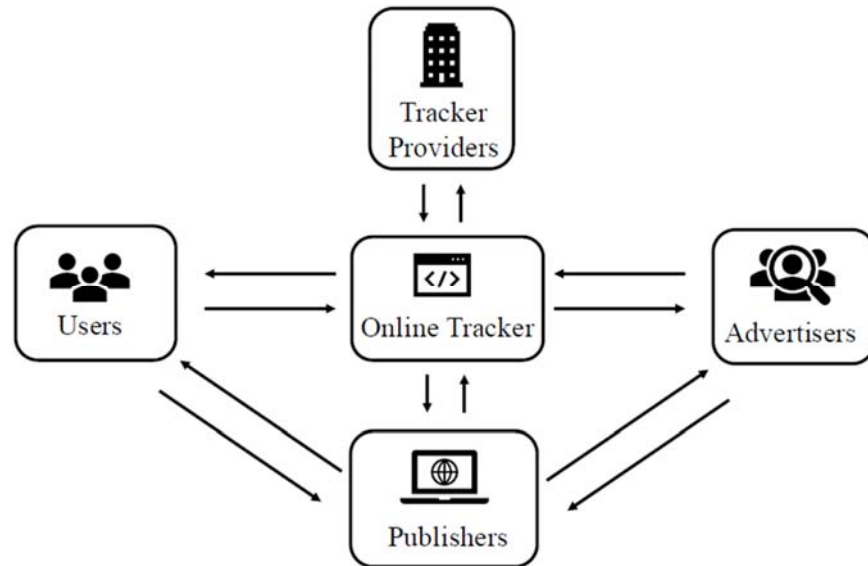
### 3. VERIFICATION STEPS

The verification materials were downloaded from the Github repository on March 10 and run as per readme, using R 4.4.3 on a computer with 256 GB RAM, Intel Xeon Silver 4210R 2.40GHz (32 cores), NVIDIA RTX™ A5000 and Windows 10 OS. We encountered no issues during the verification.

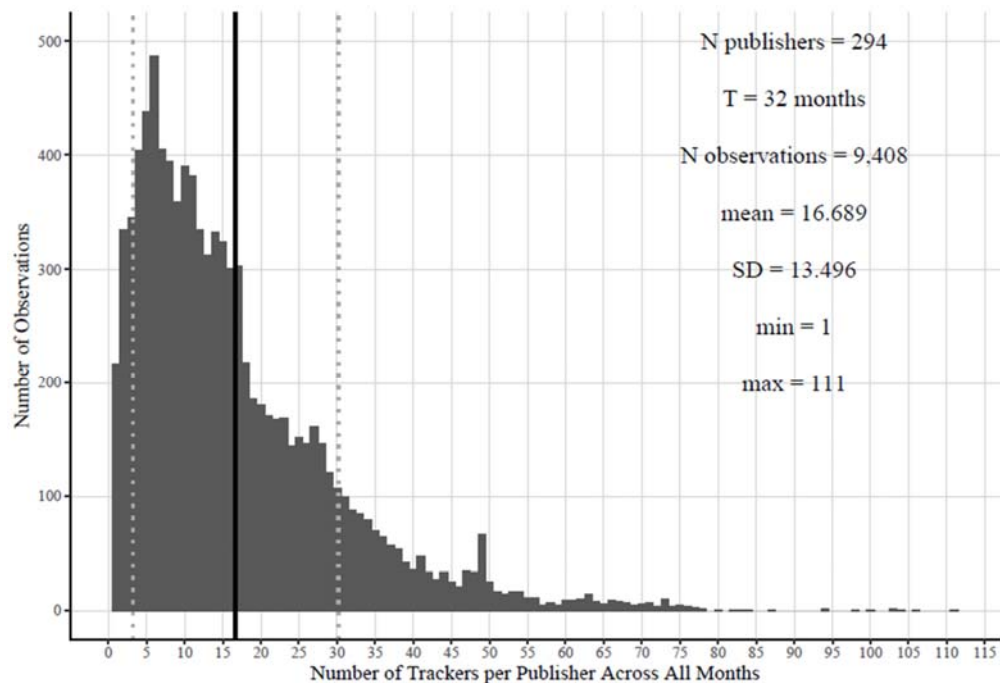
## 4. FINDINGS

We reproduced Figures 1-5 and Tables 1-12 with accuracy.

### 4.1. FIGURE 1: MAIN ACTORS INVOLVED IN ONLINE TRACKING

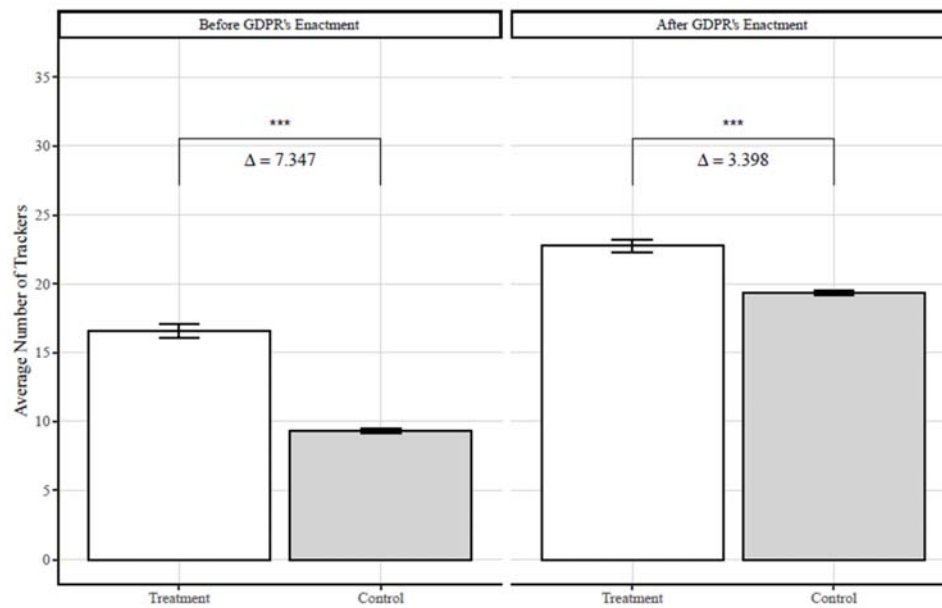


### 4.2. FIGURE 2: DISTRIBUTION OF THE AVERAGE NUMBER OF TRACKERS PER PUBLISHER

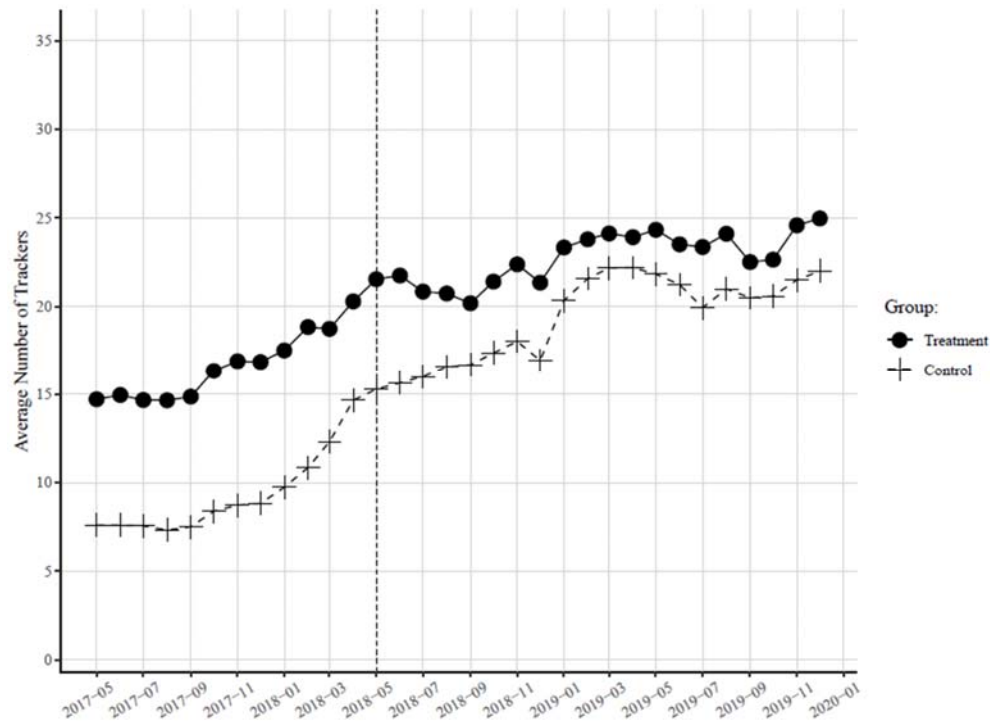


Notes: Multiplying the number of publishers (N publishers = 294) and the number of months (T = 32 months) yields the number of observations (N observations = 9,408). The black vertical line indicates the mean number of trackers per publisher, while the gray lines represent  $\pm$  one standard deviation from the mean.

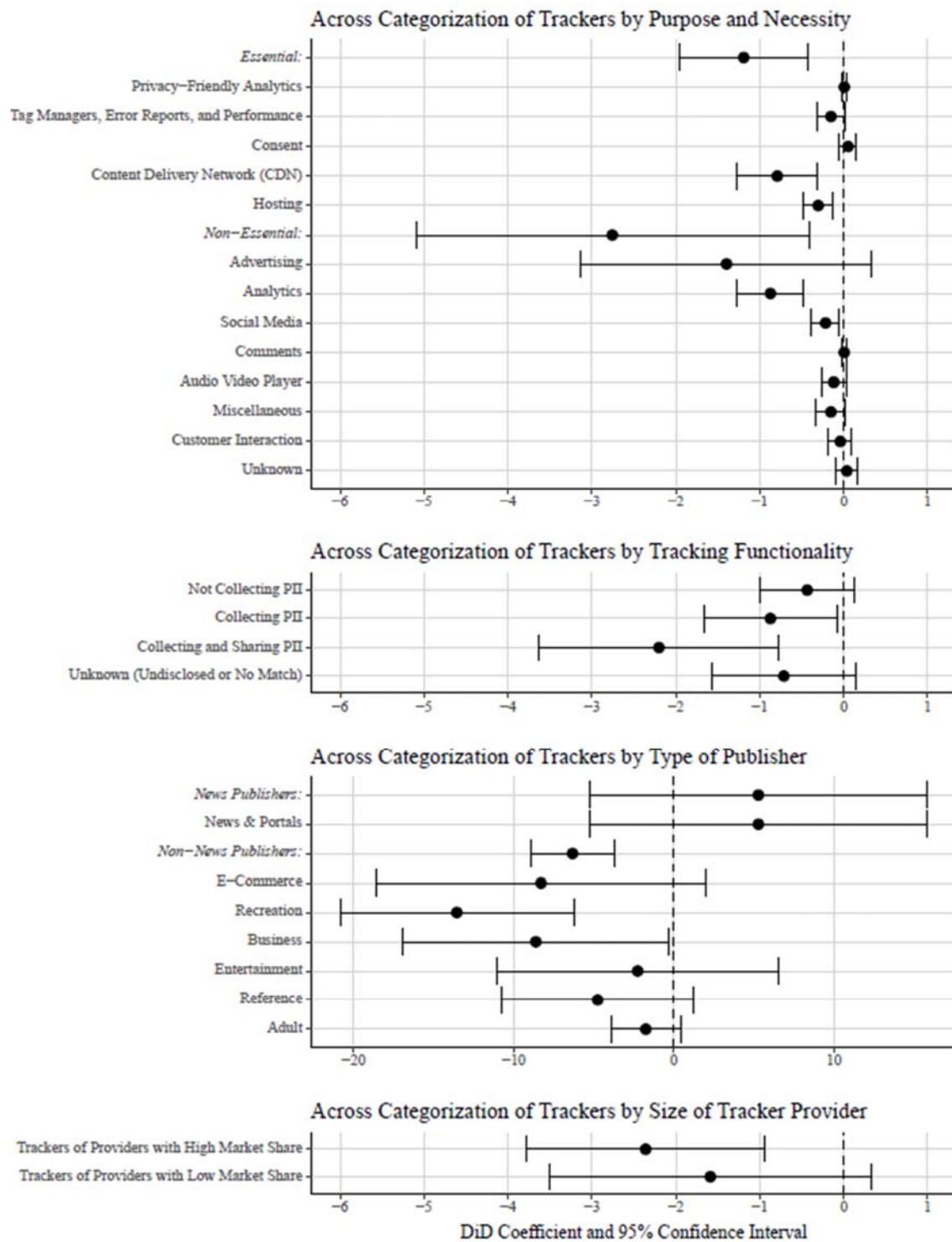
4.3. FIGURE 3: COMPARISON OF THE AVERAGE NUMBER OF TRACKERS IN THE TREATMENT AND CONTROL GROUPS BEFORE AND AFTER THE GDPR'S ENACTMENT



4.4. FIGURE 4: CHANGE IN THE NUMBER OF ONLINE TRACKERS IN THE TREATMENT AND CONTROL GROUP



4.5. FIGURE 5: DISTRIBUTION OF THE GDPR'S IMPACT ACROSS CATEGORIZATIONS OF TRACKERS



#### 4.6. TABLE 1: CATEGORIZATION OF ONLINE TRACKERS BY PURPOSE AND NECESSITY

Purpose	Description of Purpose	Examples of Trackers Defined By		Necessity	Description of Necessity
Privacy-Friendly Site Analytics	Collects and analyses data related to website usage and performance.	Piwik Pro, eTracker, eStat	CNIL	Essential	Strictly necessary for the basic functionality of the website. Exempt from user consent requirement under GDPR.
Tag Managers, Error Reports and Performance	Site requests that may be critical to website functionality, such as tag manager, privacy notices, error reports and performance.	Google Tag Manager, Google Recaptcha, Adobe Typekit	WhoTracks.me		
Consent	Cookie consent managers, allowing websites different levels of tracking user activity.	OneTrust, Cookiebot, IAB Consent	WhoTracks.me		
Content Delivery Network (CDN)	Content delivery network (CDN) delivers resources for different site utilities and usually for many other customers.	Amazon CDN, CloudFlare, jQuery	WhoTracks.me		
Hosting	Service used by the content provider or site owner.	Github Pages, FastPic, Amazon CloudFront	WhoTracks.me		
Advertising	Provides advertising or advertising-related services such as data collection, behavioral analysis, or re-targeting.	DoubleClick, ShareThis, Experian Marketing Services	WhoTracks.me	Non-Essential	Not strictly necessary for the basic functionality of the website. Not exempt from user consent requirement under GDPR.
Site Analytics	Collects and analyses data related to website usage and performance.	Google Analytics, Adobe Analytics, Hotjar	WhoTracks.me		
Social Media	Integrates features related to social media sites.	Facebook Social Plugins, Giphy, Twitter	WhoTracks.me		
Comments	Enables comments sections for articles and product reviews.	Disqus, eKomi, Livefyre	WhoTracks.me		
Audio Video Player	Enables websites to publish, distribute, and optimize video and audio content.	YouTube, Twitch, Spotify	WhoTracks.me		
Miscellaneous	This tracker does not fit in other categories.	Autoscout24, Oracle RightNow, Vinted	WhoTracks.me		
Customer Interaction	Includes chat, email messaging, customer support, and other interaction tools.	PayPal, Google Translate, LiveChat	WhoTracks.me		
Unknown	This tracker has either not been labeled yet or does not have enough information to label it.	boudja.com, xen-media.com, statsy.net	WhoTracks.me		

4.7. TABLE 2: SUMMARY OF KEY FINDINGS OF RELATED LITERATURE AND OUR CONTRIBUTION

Literature Stream	Main Studies	Key Findings	Our Contribution
1. User Privacy Concerns	Eggers et al. (2023), Beke et al. (2022), Bleier et al. (2020), Schumacher et al. (2023), Lobschat et al. (2021), Martin et al. (2017), Wieringa et al. (2021), Gopal et al. (2023), Kannan and Li (2017), Beke et al. (2018), Schumann et al. (2014), Tucker (2012), Ahamdi et al. (2024), Verhoef et al. (2022), Rocher et al. (2019), Sweeney (2002), Dinur and Nissim (2003), Lin (2022), Jerath and Miller (2024)	<ul style="list-style-type: none"> <li>• Privacy calculus &amp; paradox: Users weigh costs (data misuse) against benefits (personalization, convenience), often sharing data despite stating serious concerns.</li> </ul>	<ul style="list-style-type: none"> <li>• Examine publishers' privacy practices, particularly large-scale information collection (see Beke et al. (2018), by analyzing online advertising and the GDPR's impact thereon, specifically for high-risk trackers.</li> </ul>
		<ul style="list-style-type: none"> <li>• Contextual integrity: Comfort with sharing data depends on the perceived alignment of data use with user expectations; violations heighten privacy concerns.</li> </ul>	<ul style="list-style-type: none"> <li>• Determine effectiveness of privacy regulation in reducing number of trackers, which may help mitigate privacy concerns (Martin et al. 2017, Gopal et al. 2023).</li> </ul>
		<ul style="list-style-type: none"> <li>• Transparency &amp; Control: Clear explanation of data practices and user control features consistently mitigate privacy concerns and build trust.</li> </ul>	<ul style="list-style-type: none"> <li>• Determine how different types of publishers respond to GDPR (Beke et al. 2022; Lobschat et al. 2021).</li> </ul>
		<ul style="list-style-type: none"> <li>• Personalized ads: While valuable, they can exacerbate privacy concerns if users feel uninformed about how firms use or share their data.</li> </ul>	
		<ul style="list-style-type: none"> <li>• Corporate digital responsibility: Proactive privacy measures and accountability in data handling can reduce user unease; however, re-identification risks persist as data analytics advances.</li> </ul>	
2. Describing Online Trackers	Mayer and Mitchell (2012), Lerner et al. (2016), Karaj et al. (2018b)	<ul style="list-style-type: none"> <li>• High pervasiveness of trackers pre-GDPR: Multiple trackers per publisher have become the norm, funding free content and enabling data-driven services.</li> </ul>	<ul style="list-style-type: none"> <li>• Examine online tracking from 2017 to 2019, extending earlier research on older periods.</li> </ul>
		<ul style="list-style-type: none"> <li>• Market concentration: A small group of dominant tracker providers (e.g., Google, Facebook) is embedded on most websites, reflecting an increasing consolidation and raising privacy concerns.</li> </ul>	<ul style="list-style-type: none"> <li>• Assess regulatory interventions on trackers and how GDPR impacts tracker usage across publisher types.</li> </ul>
		<ul style="list-style-type: none"> <li>• Power imbalance: Large tracker providers like Google Analytics, DoubleClick, and Facebook often collect data on vast swaths of user traffic- up to 70-80%- highlighting their expansive reach.</li> </ul>	<ul style="list-style-type: none"> <li>• Impact of GDPR on market concentration.</li> </ul>

3. Impact of Privacy Regulation on Online Trackers	<p>Goldfarb and Tucker (2011), Peukert et al. (2022), Johnson et al. (2023), Godinho De Matos and Adjerid (2022), Wang et al. (2024), Goldberg et al. (2024), Laub et al. (2024), Lefriere et al. (2024), Miller et al. (2024), Miller and Skiera (2024)</p>	<ul style="list-style-type: none"> <li>• Expand prior studies that relied on web crawlers primarily simulating user behavior. We use data from actual users who automatically reported the trackers they encountered.</li> </ul>
	<ul style="list-style-type: none"> <li>• Market concentration: Larger tracker providers often handle compliance costs more efficiently, potentially reinforcing their dominance.</li> <li>• Consent mechanisms: GDPR-compliant banners can raise user consent rates, sometimes enhancing targeted marketing effectiveness rather than diminishing it.</li> <li>• Limited negative impact on engagement: Some EU publishers see no decline in user engagement or content provision despite fewer trackers, making the overall effect on the online advertising market uncertain.</li> <li>• Tension with ad revenues: Reduced tracker usage and reduced access to user data may lower ad-targeting effectiveness and publisher revenues; some publishers compensate via alternative approaches (e.g., via contextual or first-party data).</li> </ul>	<ul style="list-style-type: none"> <li>• Document actual user exposure to different trackers, providing more nuanced assessment of GDPR's effects on user privacy.</li> <li>• Assessment of number of trackers may reflect users' privacy concerns.</li> </ul>

---

#### 4.8. TABLE 3: DESCRIPTION OF THE DATA SETS

Data Set	Source	Contained Information	Period	Purpose
WhoTracks.me	Public	<ul style="list-style-type: none"> <li>• Publishers' use of trackers</li> <li>• Trackers (e.g., purpose, tracker provider)</li> <li>• Monthly data for 294 publishers over 32 months</li> <li>• Balanced panel of 9,408 observations (294 publishers * 32 months)</li> <li>• Information about publisher types</li> <li>• For each publisher, top-level domain used to categorize as EU vs. Non-EU, in combination with SimilarWeb data</li> </ul>	05/2017 - 12/2019	Main data set to empirically describe market of trackers and to measure impact of GDPR's enactment on market of trackers
SimilarWeb	Public	<ul style="list-style-type: none"> <li>• Traffic shares from the top five (EU and non-EU) countries</li> <li>• Information on 294 out of 294 (100%) publishers in the balanced panel</li> </ul>	08/2021	Augments WhoTracks.me data set to categorize publishers as EU vs. Non-EU based on majority of traffic shares
	Proprietary	<ul style="list-style-type: none"> <li>• Daily-level information on shares of traffic for 7,332 publishers</li> <li>• Traffic shares for US users and specific EU countries</li> <li>• Information on 200 out of 294 (68%) publishers in the balanced panel</li> </ul>	01/2018 - 12/2019	Augments public SimilarWeb data set to check the consistency of publisher's website traffic distribution over time
Evidon	Public	<ul style="list-style-type: none"> <li>• Information on trackers from their privacy policies</li> <li>• 724 (76%) matched trackers of 949 unique trackers from WhoTracks.me</li> <li>• 546 (75%) of 724 disclose data collection and sharing practices</li> <li>• 35 (4%) disclose only data sharing, 0 disclose only data collection, 143 (15%) disclose neither practices</li> <li>• 225 (24%) trackers do not match</li> </ul>	03/2021	Augments WhoTracks.me data set to categorize trackers based on tracking functionality from their disclosed data collection and sharing practices



4.9. TABLE 4: STEPS TAKEN TO PREPARE THE SAMPLE OF 294 PUBLISHERS

Step	Number of Publishers	Percent Change
Raw global sample (unbalanced; average number of publishers released monthly)	8,334	
Balanced global sample (May 2017 to December 2019)	962	-88.46%
Raw EU/US sample (unbalanced; average number of publishers released monthly)	7,264	
Balanced EU/US sample (April 2018 to December 2019)	717	-90.13%
Publishers present in both global and EU/US samples	354	-63.20%
Removing outliers in the control group of global sample (ensuring parallel trends assumption)	294	-16.95%

4.10. TABLE 5: DISTRIBUTION OF OBSERVATIONS (MONTHLY PUBLISHERS) ACROSS PUBLISHER DESIGNATION

Publisher Designation	Number and Percentage of Observations
EU publisher <sup>1</sup>	2,144 (22.79%)
Non-EU publisher <sup>2</sup>	7,264 (77.21%)
$\Sigma$	9,408 (100.00%)

<sup>1</sup>A publisher is designated as an “EU publisher” if (1) the publisher uses an EU top-level domain (e.g., .de) or (2) the publisher receives more traffic from EU than non-EU users. <sup>2</sup>A publisher is designated as a “non-EU publisher” if (1) the publisher uses a non-EU top-level domain (e.g., .com) and (2) the publisher receives more traffic from non-EU users than EU users.

Notes: The cells in this table show the number and percentage of observations in our sample corresponding to each case. The cell belonging to the control group—where GDPR does not apply—is colored gray, and the cell belonging to the treatment group—where GDPR applies—is not colored. In total, 23% (N observations = 2,144) of all observations (N observations = 9,408) belong to the treatment group and 77% (N observations = 7,264) to the control group.

4.11. TABLE 6: DISTRIBUTION OF THE AVERAGE NUMBER OF TRACKERS PER PUBLISHER BY CATEGORIZATIONS OF TRACKERS

Number of Trackers per Publisher Across All Months				
Categorization of Trackers By Purpose and Necessity	mean	SD	min	max
<i>Essential:</i>	<i>4.432</i>	<i>3.232</i>	<i>0</i>	<i>20</i>
Privacy-Friendly Analytics	0.032	0.215	0	3
Tag Managers, Error Reports and Performance	0.774	0.886	0	5
Consent	0.139	0.438	0	4
Content Delivery Network (CDN)	2.931	2.127	0	12
Hosting	0.556	0.759	0	4
<i>Non-Essential:</i>	<i>12.258</i>	<i>11.125</i>	<i>0</i>	<i>92</i>
Advertising	7.257	8.103	0	76
Analytics	2.864	2.386	0	18
Social Media	0.659	0.937	0	8
Comments	0.064	0.248	0	2
Audio Video Player	0.408	0.731	0	5
Miscellaneous	0.452	0.828	0	6
Customer Interaction	0.404	0.785	0	6
Unknown	0.181	0.502	0	5

Number of Trackers per Publisher Across All Months				
Categorization of Trackers By Tracking Functionality	mean	SD	min	max
Not Collecting PII	1.872	2.641	0	25
Collecting PII	3.258	3.553	0	31
Collecting and Sharing PII	8.424	6.764	0	46
Unknown (Undisclosed or No Match)	4.227	3.519	0	32

Categorization of Trackers by Type of Publisher	Number of Trackers per Publisher Across All Months			
	mean	SD	min	max
<i>News Publishers:</i>	<i>28.902</i>	<i>19.044</i>	<i>1</i>	<i>111</i>
News & Portals	28.902	19.044	1	111
<i>Non-News Publishers:</i>	<i>15.353</i>	<i>12.013</i>	<i>1</i>	<i>103</i>
E-Commerce	24.971	13.166	1	71
Recreation	18.781	10.405	1	51
Business	18.682	13.991	1	77
Entertainment	16.947	12.694	1	103
Reference	13.803	11.282	1	78
Adult	9.545	5.075	1	33
Government	7.281	3.429	2	11

Categorization of Trackers by Size of Tracker Provider	Number of Trackers per Publisher Across All Months			
	mean	SD	min	max
Trackers of Providers with High Market Share	8.351	5.708	0	30
Trackers of Providers with Low Market Share	8.338	9.087	0	83

Notes: This table displays descriptive statistics for the number of trackers per publisher across all months and types of tracker categorizations. Italicized labels represent grouped variables, where category descriptives (e.g., “Essential:”) are followed by descriptives for subcategories within that group (e.g., “Privacy-Friendly Analytics”). Multiplying the number of publishers (N publishers = 294) and the number of months (T = 32 months) yields the number of observations (N observations = 9,408).

4.12. TABLE 7: DISTRIBUTION OF THE AVERAGE NUMBER OF TRACKERS PER PUBLISHER BY CATEGORIZATIONS OF TRACKERS IN THE TREATMENT AND CONTROL GROUPS

Categorization of Trackers	Treatment Group	Control Group	Difference	Difference (%)
Number of Trackers per Publisher Across All Months	20.457	15.577	4.879	31.32%

Categorization of Trackers by Purpose and Necessity	Treatment Group	Control Group	Difference	Difference (%)
Essential:	5.078	4.241	0.838	(19.75%)
Privacy-Friendly Analytics	0.124	0.005	0.119	(2,620.71%)
Tag Managers, Error Reports and Performance	0.857	0.750	0.107	(14.28%)
Consent	0.145	0.137	0.008	(6.11%)
CDN	3.280	2.828	0.452	(15.98%)
Hosting	0.673	0.522	0.151	(28.96%)
Non-Essential:	15.378	11.337	4.042	(35.65%)
Advertising	10.170	6.397	3.773	(58.97%)
Analytics	3.049	2.810	0.239	(8.51%)
Social Media	0.505	0.704	-0.199	(-28.25%)
Comments	0.075	0.061	0.015	(23.97%)
Audio Video Player	0.443	0.397	0.045	(11.45%)
Miscellaneous	0.545	0.425	0.120	(28.19%)
Customer Interaction	0.424	0.398	0.025	(6.34%)
Unknown	0.292	0.149	0.143	(95.71%)

Categorization of Trackers by Tracking Functionality	Treatment Group	Control Group	Difference	Difference (%)
Not Collecting PII	3.064	1.520	1.544	(101.56%)
Collecting PII	3.779	3.104	0.676	(21.77%)
Collecting and Sharing PII	9.623	8.070	1.553	(19.24%)
Unknown (Undisclosed or No Match)	5.888	3.737	2.150	(57.54%)

Categorization of Trackers by Type of Publisher	Treatment Group	Control Group	Difference	Difference (%)
News Publishers:	34.833	22.547	12.286	(54.49%)
News & Portals	34.833	22.547	12.286	(54.49%)
Non-News Publishers:	16.309	15.119	1.190	(7.87%)
E-Commerce	25.554	24.461	1.093	(4.47%)
Recreation	18.711	18.875	-0.164	(-0.87%)
Business	29.823	18.134	11.689	(64.46%)
Entertainment	17.545	16.887	0.658	(3.90%)
Reference	13.812	13.800	0.012	(0.09%)
Adult	12.040	8.322	3.718	(44.67%)
Government		7.281		

Categorization of Trackers by Size of Tracker Provider	Treatment Group	Control Group	Difference	Difference (%)
Trackers of Providers with High Market Share	9.925	7.887	2.039	(25.85%)
Trackers of Providers with Low Market Share	10.531	7.691	2.840	(36.93%)

Publisher Characteristics	Treatment Group	Control Group	Difference	Difference (%)
Share of Traffic from EU Users	48.37%	10.24%		(38.12 pp)
Share of Traffic from Non-EU Users	15.63%	43.28%		(-27.65 pp)
5 Most Common TLDs	com, co.uk, de, fr, net	com, net, org, ru, tv		

Notes: This table shows the average number of trackers for the treatment and control groups across all months and types of tracker categorizations. Italicized labels represent grouped variables, where broad category descriptives (e.g., “Essential:”) are followed by descriptives for subcategories within that group (e.g., “Privacy-Friendly Analytics”). The table also shows the average share of traffic from (non)-EU users and the five most common TLDs for treatment and control groups. Percent differences are displayed as percentage points (pp) for shares of traffic from (non)-EU users. The Government publisher has been deliberately omitted from this analysis, given that only a single publisher of this type was present in the control group of our sample.

4.13. TABLE 8: AVERAGE (MONTHLY) NUMBER OF TRACKERS IN THE TREATMENT AND CONTROL GROUPS BEFORE AND AFTER THE GDPR'S ENACTMENT

Group	Before GDPR's Enactment	After GDPR's Enactment	Difference
Treatment	16.610	22.765	6.155 (37.06%)
Control	9.262	19.366	10.104 (109.09%)
Difference	7.347	3.398	-3.949

This table shows the average (monthly) number of trackers for the treatment and control groups in periods before (May 2017-April 2018) and after (May 2018-December 2019) GDPR's enactment and the differences in the average (monthly) number of trackers between groups and periods. We use unrounded values to derive the differences. The values in parentheses represent the percent changes for each group from the period before to the period after the GDPR's enactment. The Difference-in-Differences (DiD) as a percentage is calculated by comparing the observed value in the treatment group after GDPR (22.765) with the expected value if the GDPR had not been enacted. The expected value is calculated by adding the pre-GDPR difference between groups (7.347) to the post-GDPR control group value (19.366), which equals 26.714. The percent decrease is then derived from the ratio of the difference between these two values to the expected value:  $\text{DiD (\%)} = [(26.714 - 22.765) / 26.714] \times 100 \approx 14.79\%$ .

4.14. TABLE 9: RESULT OF DIFFERENCE-IN-DIFFERENCES (DID) ANALYSIS FOR THE NUMBER OF TRACKERS

Dependent Variable:	Number of Trackers per Publisher and Month
Model:	(1)
Treatment x PostGDPR	-3.949* [-7.082; -0.816]
Publisher ID Fixed Effects	✓
Month ID Fixed Effects	✓
N Observations	9,408
R <sup>2</sup>	0.744

Significance levels: \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

Notes: This table shows the difference-in-differences coefficient (Treatment x PostGDPR) from the OLS regression. We assign treatment to each publisher according to the publisher's designation (EU or non-EU). Multiplying the number of publishers (N publishers = 294) and the number of months (T = 32 months) yields the number of observations (N observations = 9,408).

4.15. TABLE 10: SUMMARY OF ROBUSTNESS TESTS

Robustness Test	Fundamental Concern	Summary of Result	Web Appendix
Treatment assignment based on server location	Misclassification of publishers into treatment (EU) and control groups (non-EU) based on publisher's website traffic shares and top-level domain (TLD)	GDPR reduced the number of trackers by 3.867 per publisher with treatment assignment based on server location	9.1
Treatment assignment based on publisher designation and user location	Misclassification of publishers into treatment (EU) and control groups (non-EU) based on publisher's website traffic shares and top-level domain (TLD)	GDPR reduced the number of trackers by 1.692 per publisher instance with treatment assignment based on publisher designation and user location	9.2
Parallel trends assumption	Treatment and control groups do not follow same trends in the pre-treatment period (violation of parallel trends assumption)	Development of monthly DiD coefficients and placebo tests confirm the assumption likely holds	9.3
Spillover effects	GDPR spillovers affect control group (= violation of stable unit treatment value assumption)	GDPR reduced the number of trackers by 2.922 per publisher instance in the "cleanest" comparison between treatment (EU-located users visiting EU publishers) vs. control (US-located users visiting non-EU publishers) groups	9.4
Impact of GDPR on user behavior	GDPR inadvertently affects behavior of Ghostery users rather than publishers' use of trackers	No significant change in the number of Ghostery users (Chrome and Firefox) after GDPR's enactment	9.5
Anticipation and external shocks (early 2018)	Bias from publishers' early willingness to comply with GDPR (= anticipation assumption) or shocks unrelated to the GDPR (e.g., Cambridge Analytica)	GDPR reduced the number of trackers by 4.523 per publisher when removing the months of March, April, May and June 2018	9.10
Skewness of the dependent variable	Skewness in the distribution of the number of trackers	GDPR reduced the logged number of trackers by 0.490 per publisher	9.11
Stability of publishers' website traffic shares	Misclassification of publishers due to potential changes in website traffic distributions over time when using a single point-in-time SimilarWeb data set	The average difference for EU publishers' website traffic shares was 11.08 pp, indicating stable website traffic distributions between public (single point in time) and proprietary (over time) SimilarWeb data sets	9.12
Generalized synthetic control method	Potential model misspecifications in the difference-in-differences (DiD) analysis	GDPR reduced the number of trackers by 5.303 per publisher	9.14
Unbalanced panel	Potential lack of representativeness due to excluding a large number of publishers from the balanced panel	GDPR reduced the number of trackers by 1.081 (treatment assignment based on TLD) and 0.825 (treatment assignment based on server location) per publisher in the unbalanced panel of 29,735 unique publishers	9.15

**4.16. TABLE 11: SUMMARY OF EMPIRICAL FINDINGS ON DESCRIPTION OF ONLINE TRACKERS AND THEIR CONCLUSIONS**

Analysis	Summary of Findings	Conclusions
Average Effect	<ul style="list-style-type: none"> <li>• Average number of trackers per publisher (~17)</li> <li>• Most publishers use 1-10 trackers (Min=1, Max=111)</li> </ul>	<ul style="list-style-type: none"> <li>• Some publishers strongly rely on trackers for different purposes.</li> <li>• Distribution of trackers is heavily right-skewed.</li> </ul>
<i>Differences across categorizations of online trackers</i>		
Trackers by Necessity	<ul style="list-style-type: none"> <li>• 27% essential trackers per publisher (~4)</li> <li>• 73% non-essential trackers per publisher (~12)</li> </ul>	<ul style="list-style-type: none"> <li>• Publishers use three times as many non-essential than essential trackers.</li> <li>• Users are exposed to privacy risks from non-essential trackers.</li> </ul>
Trackers by Purpose	<ul style="list-style-type: none"> <li>• Top essential trackers: <ul style="list-style-type: none"> <li>◦ 66% content delivery (~3)</li> <li>◦ 17% tag managers (~1)</li> <li>◦ 13% hosting (~1)</li> </ul> </li> <li>• Top non-essential trackers: <ul style="list-style-type: none"> <li>◦ 59% advertising (~7)</li> <li>◦ 23% analytics (~3)</li> <li>◦ 5% social media (~1)</li> </ul> </li> <li>• Among essential trackers: <ul style="list-style-type: none"> <li>◦ 0.7% privacy-friendly analytics (&lt;1)</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Advertising, analytics, and content delivery trackers are most often used.</li> <li>• Publishers rarely use privacy-friendly analytics trackers.</li> </ul>
Trackers by Functionality	<ul style="list-style-type: none"> <li>• 11% of trackers do not collect personal data (~2)</li> <li>• 66% of trackers collect personal data <ul style="list-style-type: none"> <li>◦ 28% of those trackers do not share personal data (~3)</li> <li>◦ 72% of those trackers share personal data (~8)</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Most trackers are highly privacy invasive as they collect and share personal data.</li> </ul>
Trackers by Type of Publisher	<ul style="list-style-type: none"> <li>• 67% of trackers belong to news publishers (~30)</li> <li>• 33% of trackers belong to non-news publishers (~15)</li> </ul>	<ul style="list-style-type: none"> <li>• News publishers use twice as many trackers as non-news publishers.</li> <li>• News publishers rely on trackers to enhance and monetize their content through advertising.</li> </ul>
Trackers by Size	<ul style="list-style-type: none"> <li>• 50% of trackers belong to providers with a high market share (~8)</li> <li>• 50% of trackers belong to providers with a low market share (~8)</li> </ul>	<ul style="list-style-type: none"> <li>• Publishers use a similar amount of trackers from tracker providers with a high or low market share.</li> <li>• Across all trackers, our study does not find evidence for market concentration of large or small trackers.</li> </ul>



4.17. TABLE 12: SUMMARY OF OUR EMPIRICAL FINDINGS OF IMPACT OF GDPR ON THE NUMBER OF ONLINE TRACKERS AND THEIR CONCLUSIONS

Analysis	Summary of Findings <sup>A</sup>	Conclusions
Average Effect	<ul style="list-style-type: none"> <li>• Average reduction of trackers (~4)</li> <li>• Most publishers use 1-10 trackers (Min=1, Max=111)</li> </ul>	<ul style="list-style-type: none"> <li>• GDPR reaches its intended consequence and decreases trackers by 14.79% compared to expectations without GDPR.</li> <li>• Although trackers increase over time across EU and non-EU publishers before and after the GDPR, the increase is much smaller for EU publishers.</li> </ul>
<i>Differences across categorizations of online trackers</i>		
Trackers by Necessity	<ul style="list-style-type: none"> <li>• Average reduction of essential trackers (~1)</li> <li>• Average reduction of non-essential trackers (~3)</li> </ul>	<ul style="list-style-type: none"> <li>• GDPR led to the unintended consequence of decreasing essential trackers.</li> <li>• GDPR reached its intended consequence of decreasing non-essential trackers.</li> </ul>
Trackers by Purpose	<ul style="list-style-type: none"> <li>• Average reduction of essential trackers: <ul style="list-style-type: none"> <li>◦ Content delivery (~1)</li> <li>◦ Hosting (~1)</li> <li>◦ Privacy-friendly analytics (~0)</li> </ul> </li> <li>• Average reduction of non-essential trackers: <ul style="list-style-type: none"> <li>◦ Analytics (~1)</li> <li>◦ Social Media (~1)</li> <li>◦ Advertising (~0)</li> </ul> </li> <li>• Among essential trackers: <ul style="list-style-type: none"> <li>◦ 0.7% privacy-friendly analytics (&lt;1)</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• GDPR did not reach its intended consequence of decreasing advertising trackers and increasing privacy-friendly analytics trackers.</li> </ul>
Trackers by Functionality	<ul style="list-style-type: none"> <li>• Average reduction of trackers that do not collect personal data (~0)</li> <li>• Average reduction of trackers that do collect personal data: <ul style="list-style-type: none"> <li>◦ Tracker does not share personal data (~1)</li> <li>◦ Tracker shares personal data (~2)</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• GDPR achieved its intended consequence of decreasing highly invasive tracking.</li> </ul>
Trackers by Type of Publisher	<ul style="list-style-type: none"> <li>• Average reduction of trackers of news publishers (~0)</li> <li>• Average reduction of trackers of non-news publishers (~6): <ul style="list-style-type: none"> <li>◦ Recreation (~14)</li> <li>◦ Business (~9)</li> <li>◦ E-commerce (~0)</li> <li>◦ Entertainment (~0)</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• GDPR reached its intended consequence and decreased tracking of non-news publishers.</li> <li>• GDPR led to the unintended consequence of not decreasing trackers of news, e-commerce, and entertainment publishers.</li> </ul>
Trackers by Size	<ul style="list-style-type: none"> <li>• Reduction of average number of trackers of providers with high market share (~2)</li> <li>• Reduction of average number of trackers of providers with low market share (~0)</li> </ul>	<ul style="list-style-type: none"> <li>• GDPR reached its intended consequence of decreasing trackers of high market share tracker providers and did not increase market concentration.</li> <li>• GDPR reached the unintended consequence of not decreasing trackers of low market share tracker providers.</li> </ul>

Notes: A) The summary of findings refers to the average reduction of trackers per EU publisher.