

## TOWARD A DIGITAL ATTRIBUTION MODEL: MEASURING THE IMPACT OF DISPLAY ADVERTISING ON ONLINE CONSUMER BEHAVIOR

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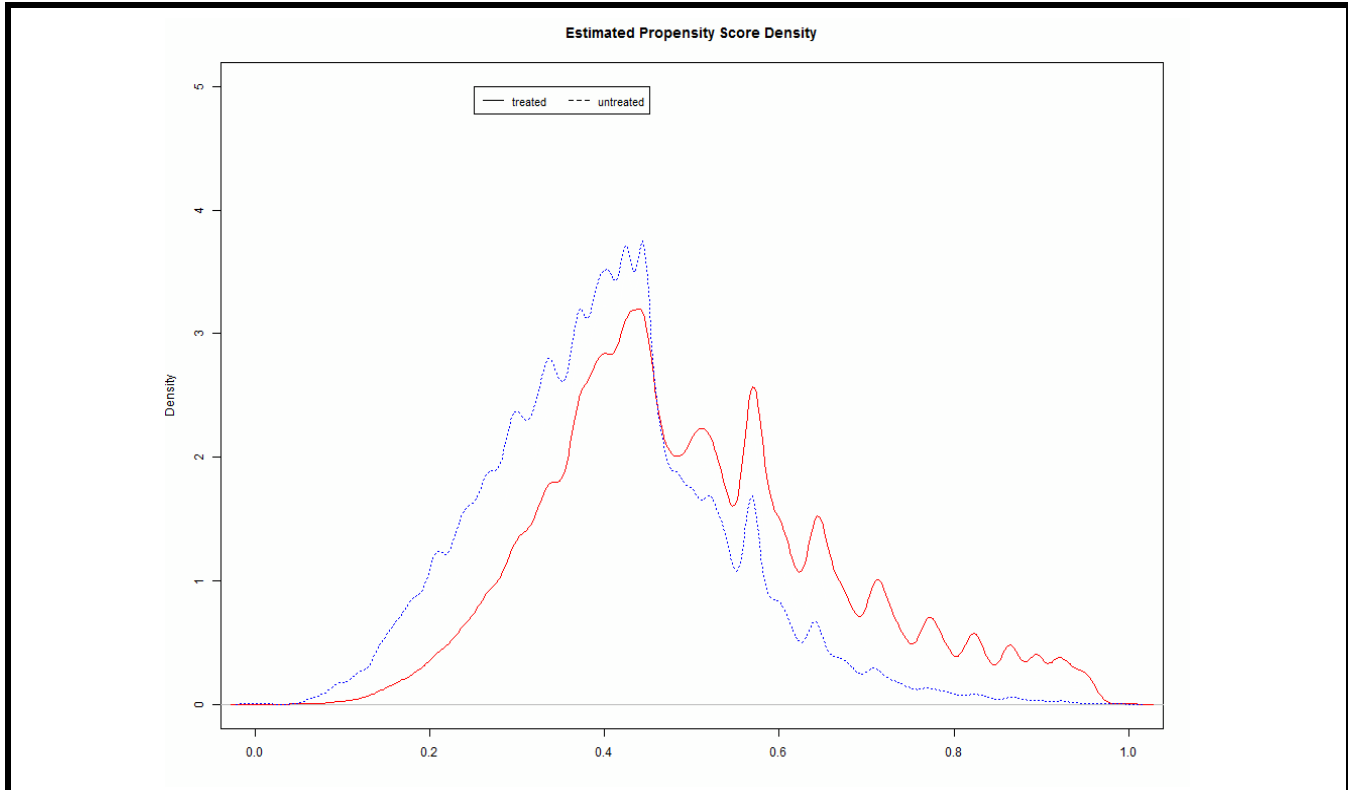
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### Appendix

**Table A1. Summary Statistics of Advertising Exposure Data at the Observation Level**

|                         | <b>Observations</b>    | <b>Mean</b> | <b>St. Deviation</b> | <b>Min</b> | <b>Max</b> |
|-------------------------|------------------------|-------------|----------------------|------------|------------|
| <b>Search Brand</b>     | 3,000,000              | 0.028       | 0.165                | 0          | 1          |
| <b>Direct Visit</b>     | 3,000,000              | 0.028       | 0.166                | 0          | 1          |
| <b>Organic Search</b>   | 3,000,000              | 0.026       | 0.158                | 0          | 1          |
| <b>Search Non-Brand</b> | 3,000,000              | 0.021       | 0.144                | 0          | 1          |
| <b>Display Clicks</b>   | 3,000,000              | 0.013       | 0.113                | 0          | 1          |
| <b>Conversion</b>       | 3,000,000              | 0.031       | 0.173                | 0          | 1          |
| <b>Treat</b>            | 3,000,000              | 0.449       | 0.497                | 0          | 1          |
| <b>Treat Duration</b>   | 2,820,934 <sup>1</sup> | 1.114       | 1.439                | 0          | 55.39      |
| <b>Dynamic Ad</b>       | 3,000,000              | 0.852       | 0.355                | 0          | 1          |

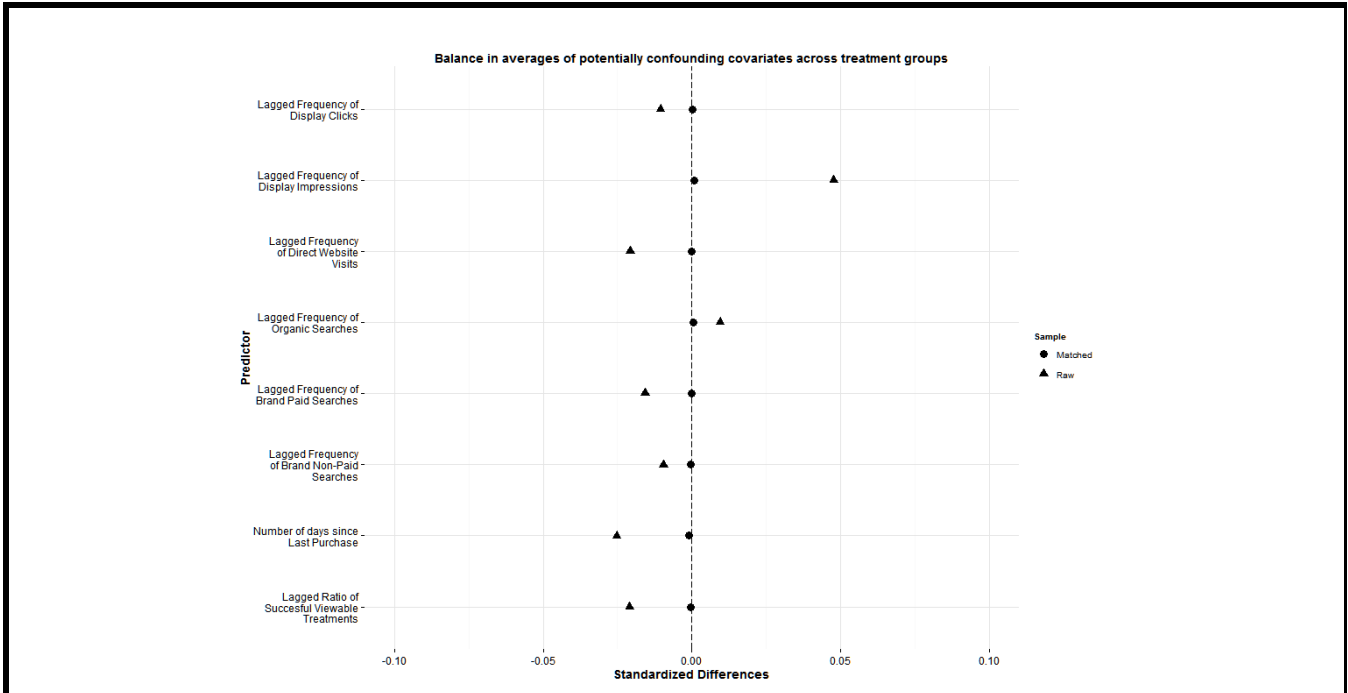
<sup>1</sup> The duration of the exposure of the consumer to the display advertisement is not known for a small sample of the consumers who were indeed treated. Thus, the tables referring to the duration of the treatment have slightly fewer observations.



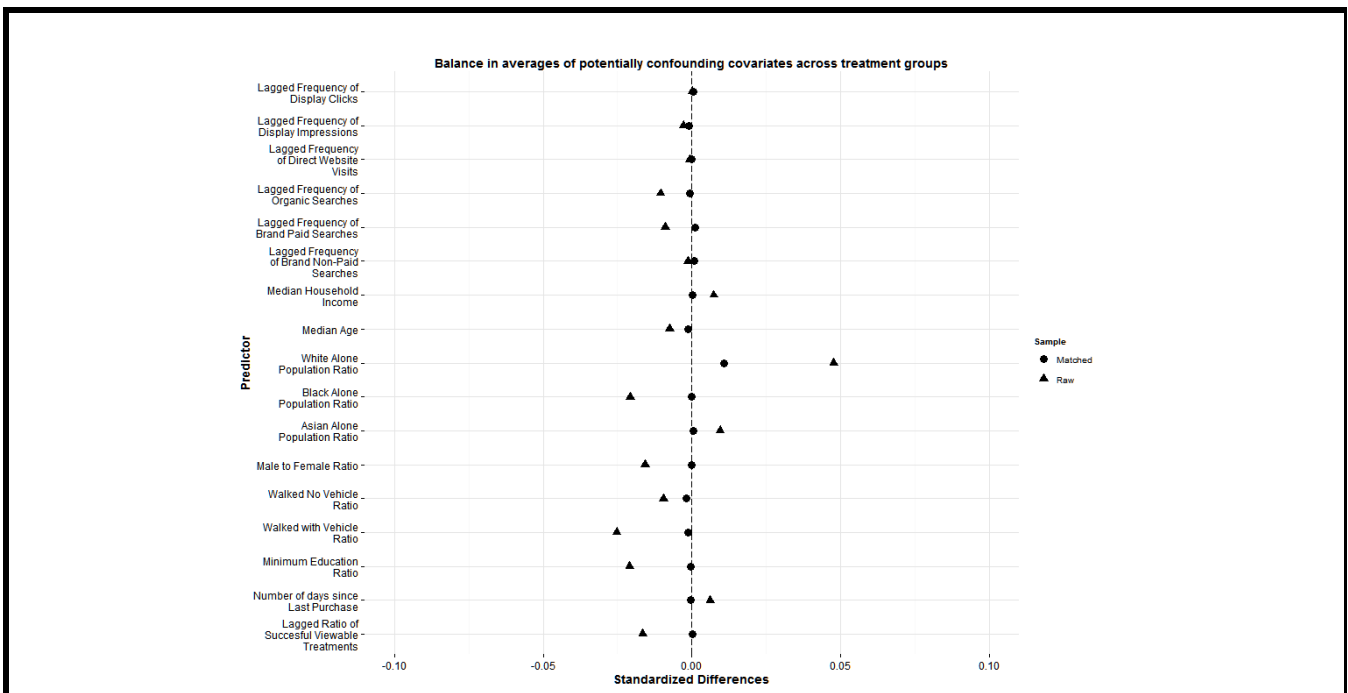
**Figure A1. Overlap of Estimated Propensity Score Matching Probability Distributions of Treated and Untreated Individuals with Demographics**

**Table A2. Covariate Balance Summary for Matching Estimator Including Demographic Variables (2)**

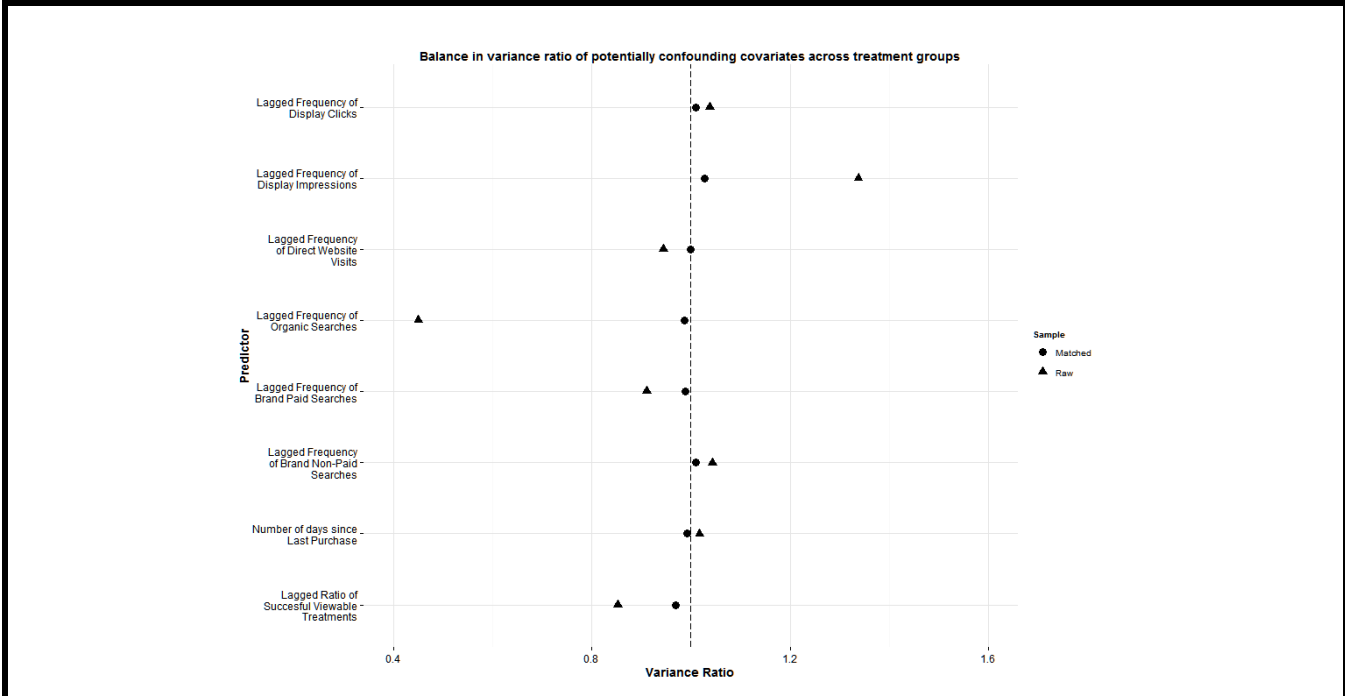
|  | Standardized Differences |         | Variance Ratio |         |
|--|--------------------------|---------|----------------|---------|
|  | Raw                      | Matched | Raw            | Matched |
| Lagged Frequency of Display Clicks             | -0.0158                  | -0.0002 | 0.9110         | 0.9910  |
| Lagged Frequency of Display Impressions        | 0.0095                   | 0.0004  | 0.4504         | 0.9811  |
| Lagged Frequency of Direct Website Visits      | -0.0095                  | -0.0020 | 1.0434         | 1.0097  |
| Lagged Frequency of Organic Searches           | -0.0207                  | -0.0002 | 0.9442         | 1.0000  |
| Lagged Frequency of Brand Paid Searches        | -0.0253                  | -0.0014 | 1.0174         | 0.9915  |
| Lagged Frequency of Brand Non-Paid Searches    | -0.0209                  | -0.0005 | 0.8523         | 0.9688  |
| Median Household Income                        | -0.0013                  | 0.0009  | 1.0189         | 0.9994  |
| Median Age                                     | 0.0074                   | 0.0001  | 1.0233         | 0.9993  |
| White Alone Population Ratio                   | 0.0001                   | 0.0004  | 0.9883         | 0.9988  |
| Black Alone Population Ratio                   | 0.0062                   | -0.0005 | 1.0068         | 0.9992  |
| Asian Alone Population Ratio                   | -0.0165                  | 0.0001  | 0.9324         | 0.9991  |
| Male to Female Ratio                           | -0.0075                  | -0.0012 | 0.9856         | 0.9968  |
| Walked No Vehicle Ratio                        | -0.0008                  | -0.0002 | 1.0203         | 1.0010  |
| Walked with Vehicle Ratio                      | -0.0029                  | -0.0010 | 0.9853         | 0.9982  |
| Minimum Education Ratio                        | -0.0089                  | 0.0010  | 0.9987         | 0.9976  |
| Number of days since Last Purchase             | -0.0106                  | -0.0007 | 1.0379         | 1.0093  |
| Lagged Ratio of Successful Viewable Treatments | 0.0477                   | 0.0109  | 1.3381         | 1.0281  |



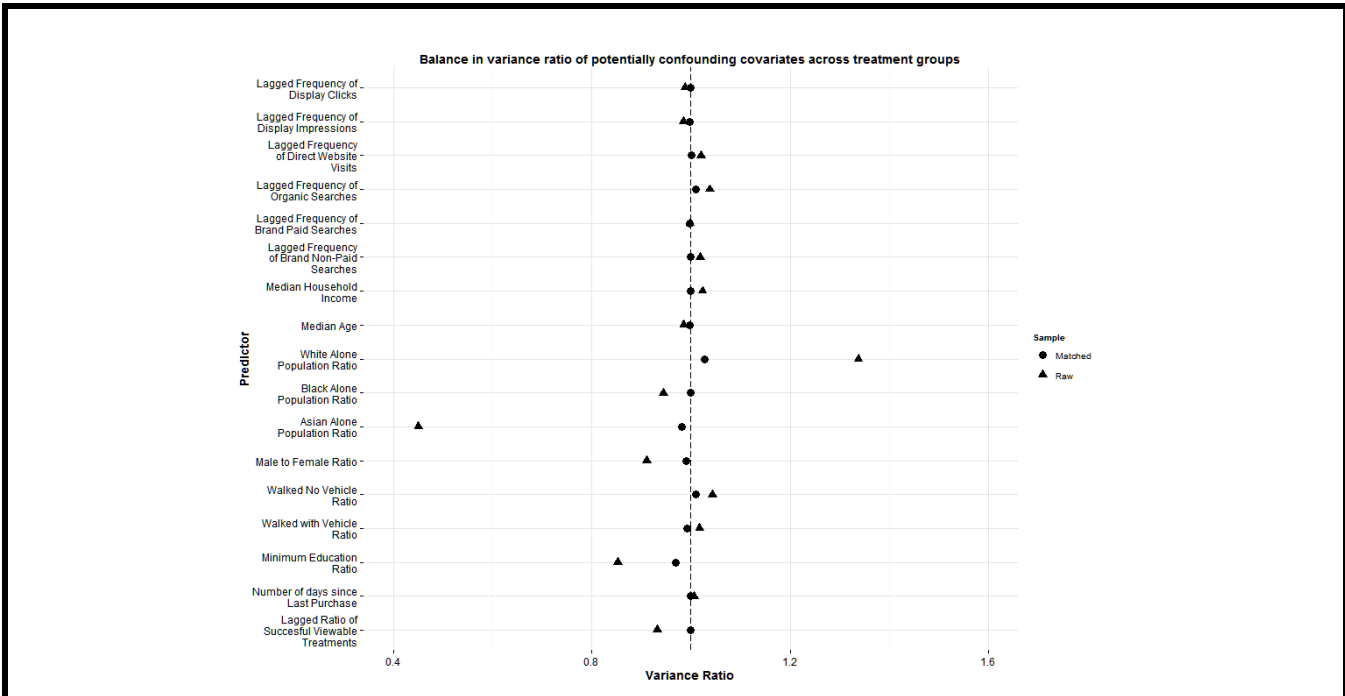
**Figure A2. Covariate Balance Summary (Standardized Differences in Means) for the Difference-in-Differences Matching Estimator**



**Figure A3. Covariate Balance Summary (Standardized Differences in Means) for the Difference-in-Differences Matching Estimator with Demographics**



**Figure A4. Covariate Balance Summary (Variance Ratios) for the Difference-in-Differences Matching Estimator**



**Figure 5. Covariate Balance Summary (Variance Ratios) for the Difference-in-Differences Matching Estimator with Demographics**

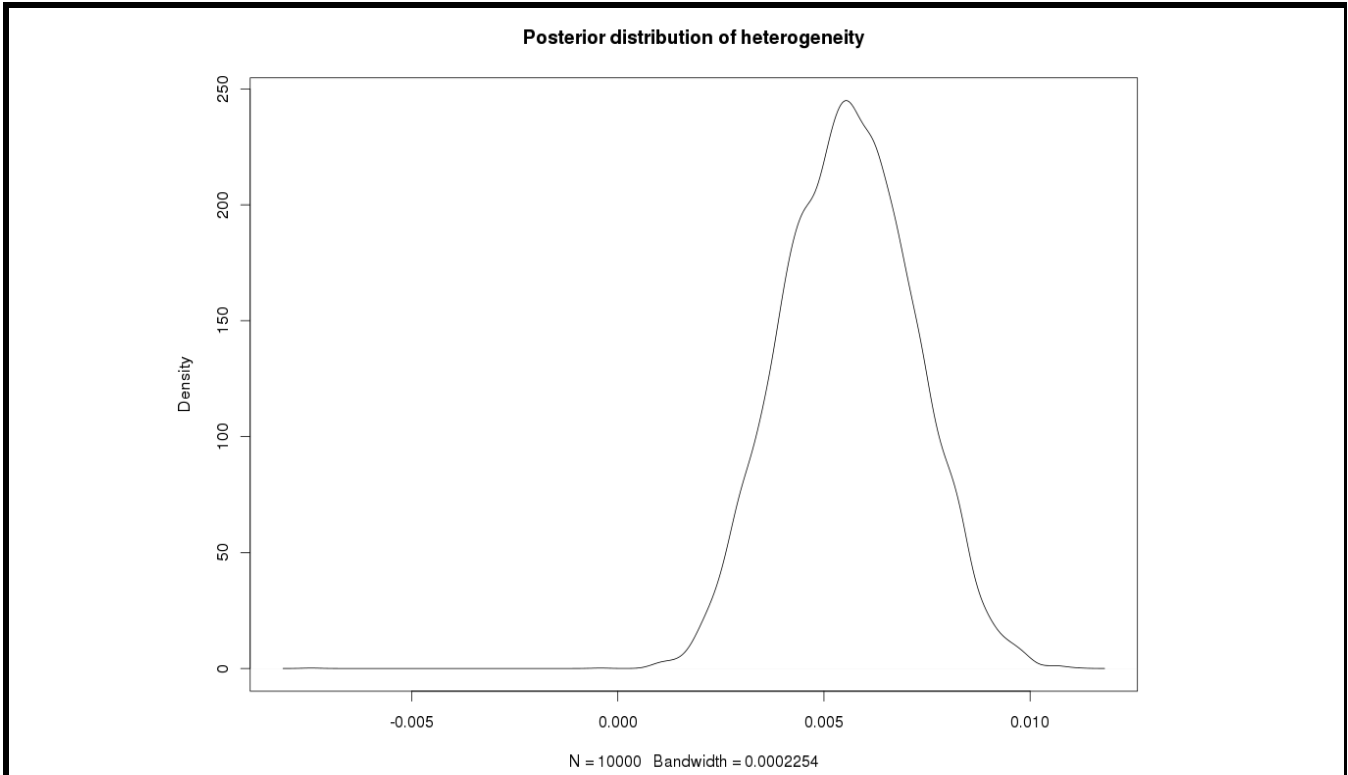


Figure A6. Allowing for Heterogeneity in tau (Search Brand)

TableA3. DID Binary Exposure with Targeting Controls

|                                | Search Brand           | Direct Visit           | Organic Search         | Search Non-Brand       | Display Click          | Conversion             |
|--------------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| Time                           | -0.0551***<br>(0.0002) | -0.0547***<br>(0.0002) | -0.0501***<br>(0.0002) | -0.0418***<br>(0.0002) | -0.0246***<br>(0.0001) | 0.0131***<br>(0.0001)  |
| Treat                          | -0.0020***<br>(0.0002) | -0.0018***<br>(0.0002) | -0.0011***<br>(0.0002) | -0.0008***<br>(0.0002) | -0.0011***<br>(0.0002) | -0.0011***<br>(0.0001) |
| ATE                            | 0.0071***<br>(0.0003)  | 0.0101***<br>(0.0003)  | 0.0053***<br>(0.0003)  | 0.0031***<br>(0.0003)  | 0.0037***<br>(0.0002)  | 0.0022***<br>(0.0001)  |
| Constant                       | 0.0575***<br>(0.0006)  | 0.0570***<br>(0.0006)  | 0.0514***<br>(0.0006)  | 0.0429***<br>(0.0005)  | 0.0278***<br>(0.0004)  | 0.0243***<br>(0.0003)  |
| Type of Targeting Controls     | ✓                      | ✓                      | ✓                      | ✓                      | ✓                      | ✓                      |
| Individual-level Heterogeneity | ✓                      | ✓                      | ✓                      | ✓                      | ✓                      | ✓                      |
| Ad-level Heterogeneity         | ✓                      | ✓                      | ✓                      | ✓                      | ✓                      | ✓                      |
| R <sup>2</sup>                 | 0.0475                 | 0.0443                 | 0.0437                 | 0.0385                 | 0.0192                 | 0.0141                 |
| F-statistic                    | 2827.3846              | 2630.3258              | 2589.9686              | 2268.9049              | 1113.4152              | 813.9582               |
| No. of observ.                 | 3,000,000              | 3,000,000              | 3,000,000              | 3,000,000              | 3,000,000              | 3,000,000              |

Notes: Controlling for time-varying unobserved confounders with type of targeting dummies. Significance levels defined as \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001; robust standard errors are in parentheses.

**Table A4. DID Binary Exposure with Targeting Controls (2)**

|                                | Search Brand | Direct Visit | Organic Search | Search Non-Brand | Display Click | Conversion |
|--------------------------------|--------------|--------------|----------------|------------------|---------------|------------|
| Time                           | -0.0551***   | -0.0547***   | -0.0501***     | -0.0418***       | -0.0246***    | 0.0131***  |
|                                | (0.0002)     | (0.0002)     | (0.0002)       | (0.0002)         | (0.0001)      | (0.0001)   |
| Treat                          | -0.0019***   | -0.0017***   | -0.0010***     | -0.0007***       | -0.0010***    | -0.0011*** |
|                                | (0.0002)     | (0.0002)     | (0.0002)       | (0.0002)         | (0.0002)      | (0.0001)   |
| ATE                            | 0.0069***    | 0.0101***    | 0.0053***      | 0.0030***        | 0.0038***     | 0.0022***  |
|                                | (0.0003)     | (0.0003)     | (0.0003)       | (0.0003)         | (0.0002)      | (0.0001)   |
| Constant                       | 0.0598***    | 0.0585***    | 0.0526***      | 0.0440***        | 0.0309***     | 0.0243***  |
|                                | (0.0009)     | (0.0009)     | (0.0008)       | (0.0007)         | (0.0006)      | (0.0004)   |
| Type of Targeting Controls     | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| Network Targeting Controls     | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| Individual-level Heterogeneity | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| Ad-level Heterogeneity         | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| R <sup>2</sup>                 | 0.0476       | 0.0443       | 0.0437         | 0.0385           | 0.0194        | 0.0141     |
| F-statistic                    | 1945.0753    | 1807.6042    | 1779.3672      | 1559.0867        | 771.2577      | 558.8322   |
| No. of observ.                 | 2,999,984    | 2,999,984    | 2,999,984      | 2,999,984        | 2,999,984     | 2,999,984  |

Notes: Controlling for time-varying unobserved confounders with advertising network dummies. Significance levels defined as \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001; robust standard errors are in parentheses.

**Table A5. DID Binary Exposure with Targeting Controls (3)**

|                                   | Search Brand | Direct Visit | Organic Search | Search Non-Brand | Display Click | Conversion |
|-----------------------------------|--------------|--------------|----------------|------------------|---------------|------------|
| Time                              | -0.0551***   | -0.0547***   | -0.0501***     | -0.0418***       | -0.0246***    | 0.0131***  |
|                                   | (0.0002)     | (0.0002)     | (0.0002)       | (0.0002)         | (0.0001)      | (0.0001)   |
| Treat                             | -0.0018***   | -0.0017***   | -0.0010***     | -0.0007***       | -0.0009***    | -0.0011*** |
|                                   | (0.0002)     | (0.0002)     | (0.0002)       | (0.0002)         | (0.0002)      | (0.0001)   |
| ATE                               | 0.0067***    | 0.0100***    | 0.0051***      | 0.0030***        | 0.0037***     | 0.0020***  |
|                                   | (0.0003)     | (0.0003)     | (0.0003)       | (0.0003)         | (0.0002)      | (0.0001)   |
| Constant                          | 0.0516       | 0.0512       | 0.0479         | 0.0394           | 0.0213        | 0.0243     |
|                                   | (0.0579)     | (0.0582)     | (0.0555)       | (0.0503)         | (0.0409)      | (0.0292)   |
| Campaign level targeting controls | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| Individual-level Heterogeneity    | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| Ad-level Heterogeneity            | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| R <sup>2</sup>                    | 0.0477       | 0.0445       | 0.0438         | 0.0385           | 0.0195        | 0.0141     |
| F-statistic                       | 1166.7978    | 1084.5281    | 1066.1234      | 933.0788         | 464.1052      | 334.2958   |
| No. of observ.                    | 3,000,000    | 3,000,000    | 3,000,000      | 3,000,000        | 3,000,000     | 3,000,000  |

Notes: Controlling for time-varying unobserved confounders with campaign dummies. Significance levels defined as \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001; robust standard errors are in parentheses.

**Table A6. DID Binary Exposure with Control for Relevant Website Content**

|                                | Search Brand | Direct Visit | Organic Search | Search Non-Brand | Display Click | Conversion |
|--------------------------------|--------------|--------------|----------------|------------------|---------------|------------|
| Time                           | -0.0551***   | -0.0547***   | -0.0501***     | -0.0418***       | -0.0246***    | 0.0131***  |
|                                | (0.0002)     | (0.0002)     | (0.0002)       | (0.0002)         | (0.0001)      | (0.0001)   |
| Treat                          | -0.0019***   | -0.0017***   | -0.0010***     | -0.0008***       | -0.0010***    | -0.0011*** |
|                                | (0.0002)     | (0.0002)     | (0.0002)       | (0.0002)         | (0.0002)      | (0.0001)   |
| ATE                            | 0.0071***    | 0.0101***    | 0.0053***      | 0.0031***        | 0.0037***     | 0.0022***  |
|                                | (0.0003)     | (0.0003)     | (0.0003)       | (0.0003)         | (0.0002)      | (0.0001)   |
| Constant                       | 0.0579***    | 0.0576***    | 0.0515***      | 0.0431***        | 0.0267***     | 0.0243***  |
|                                | (0.0007)     | (0.0007)     | (0.0007)       | (0.0006)         | (0.0005)      | (0.0004)   |
| Viewability Ratio Control      | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| Individual-level Heterogeneity | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| Ad-level Heterogeneity         | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| R <sup>2</sup>                 | 0.0475       | 0.0443       | 0.0437         | 0.0384           | 0.0192        | 0.0141     |
| F-statistic                    | 3023.4639    | 2813.6266    | 2770.4000      | 2426.7234        | 1187.7859     | 870.7470   |
| No. of observ.                 | 3,000,000    | 3,000,000    | 3,000,000      | 3,000,000        | 3,000,000     | 3,000,000  |

Notes: Controlling for time-varying unobserved confounders with a proxy variable. Significance levels defined as \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001; robust standard errors are in parentheses.

**Table A7. IV (2SLS) Fixed Effects Estimation (2)**

|                                | Search Brand | Direct Visit | Organic Search | Search Non-Brand | Display Click | Conversion |
|--------------------------------|--------------|--------------|----------------|------------------|---------------|------------|
| Treat                          | -0.0004      | -0.0003      | -0.0020        | -0.0009          | -0.0005       | -0.0010    |
|                                | (0.0042)     | (0.0041)     | (0.0040)       | (0.0037)         | (0.0029)      | (0.0021)   |
| Time                           | -0.0556***   | -0.0516***   | -0.0494***     | -0.0430***       | -0.0244***    | 0.0133***  |
|                                | (0.0013)     | (0.0013)     | (0.0012)       | (0.0011)         | (0.0009)      | (0.0007)   |
| ATE                            | 0.0061*      | 0.0093***    | 0.0059*        | 0.0037           | 0.0033        | 0.0020     |
|                                | (0.0028)     | (0.0027)     | (0.0027)       | (0.0025)         | (0.0020)      | (0.0014)   |
| Constant                       | 0.0555***    | 0.0516***    | 0.0495***      | 0.0425***        | 0.0244***     | 0.0248***  |
|                                | (0.0017)     | (0.0016)     | (0.0016)       | (0.0015)         | (0.0012)      | (0.0009)   |
| Individual-level Heterogeneity | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| Ad-level Heterogeneity         | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| Centered R <sup>2</sup>        | 0.0487       | 0.0423       | 0.0430         | 0.0395           | 0.0193        | 0.0143     |
| F-statistic                    | 1298.70      | 1119.71      | 1140.68        | 1043.17          | 499.47        | 368.01     |
| No. of observ.                 | 1,307,342    | 1,307,342    | 1,307,342      | 1,307,342        | 1,307,342     | 1,307,342  |

Notes: IV (2SLS) Fixed Effect estimation with precipitation level as instrument. Significance levels defined as \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001; robust standard errors are in parentheses.

**Table A8. ATE of Display Advertising Exposure by Type of Targeting (Exposure in minutes)**

|                           | Search Brand | Direct Visit | Organic Search | Search Non-Brand | Display Click | Conversion |
|---------------------------|--------------|--------------|----------------|------------------|---------------|------------|
| Time                      | -0.0528***   | -0.0508***   | -0.0488***     | -0.0412***       | -0.0237***    | 0.0140***  |
|                           | (0.0002)     | (0.0002)     | (0.0002)       | (0.0002)         | (0.0001)      | (0.0001)   |
| Treated                   | 0.0053***    | 0.0027***    | 0.0048***      | 0.0037***        | 0.0019***     | -0.0011*** |
|                           | (0.0002)     | (0.0002)     | (0.0002)       | (0.0002)         | (0.0002)      | (0.0001)   |
| ATE Duration Retargeting  | -0.0087***   | -0.0038***   | -0.0077***     | -0.0069***       | -0.0032***    | 0.0022***  |
|                           | (0.0001)     | (0.0001)     | (0.0001)       | (0.0001)         | (0.0001)      | (0.0001)   |
| ATE Duration Affiliate    | -0.0021***   | -0.0014***   | -0.0024***     | -0.0020***       | -0.0013***    | 0.0007***  |
|                           | (0.0002)     | (0.0002)     | (0.0002)       | (0.0002)         | (0.0002)      | (0.0001)   |
| ATE Duration Seeding CPM  | 0.0130***    | 0.0128***    | 0.0119***      | 0.0100***        | 0.0057***     | -0.0026*** |
|                           | (0.0001)     | (0.0001)     | (0.0001)       | (0.0001)         | (0.0001)      | (0.0001)   |
| ATE Duration Targeted CPA | 0.0128***    | 0.0129***    | 0.0121***      | 0.0101***        | 0.0059***     | -0.0028*** |
|                           | (0.0004)     | (0.0004)     | (0.0004)       | (0.0003)         | (0.0003)      | (0.0002)   |
| Constant                  | 0.0508***    | 0.0500***    | 0.0469***      | 0.0393***        | 0.0235***     | 0.0252***  |
|                           | (0.0005)     | (0.0005)     | (0.0005)       | (0.0004)         | (0.0003)      | (0.0002)   |
| R <sup>2</sup>            | 0.0560       | 0.0468       | 0.0515         | 0.0456           | 0.0223        | 0.0159     |
| F-statistic               | 3224.4167    | 2667.1417    | 2948.8987      | 2598.2613        | 1241.8777     | 877.1480   |
| No. of observ.            | 2,820,934    | 2,820,934    | 2,820,934      | 2,820,934        | 2,820,934     | 2,820,934  |

Notes: Significance levels defined as \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001; robust standard errors are in parentheses.

**Table A9. ATE of Display Advertising Exposure (Falsification Check)**

|                                | Search Brand | Direct Visit | Organic Search | Search Non-Brand | Display Click | Conversion |
|--------------------------------|--------------|--------------|----------------|------------------|---------------|------------|
| Time                           | -0.0519***   | -0.0502***   | -0.0477***     | -0.0405***       | -0.0229***    | 0.0140***  |
|                                | (0.0002)     | (0.0002)     | (0.0002)       | (0.0002)         | (0.0001)      | (0.0001)   |
| Treated                        | 0.0016***    | 0.0033***    | 0.0016***      | 0.0007***        | 0.0008***     | -0.0000    |
|                                | (0.0002)     | (0.0002)     | (0.0002)       | (0.0002)         | (0.0001)      | (0.0001)   |
| Average Treatment Effect       | -0.0001      | 0.0003       | 0.0001         | 0.0001           | -0.0000       | 0.0000     |
|                                | (0.0002)     | (0.0002)     | (0.0002)       | (0.0002)         | (0.0002)      | (0.0001)   |
| Constant                       | 0.0534***    | 0.0530***    | 0.0489***      | 0.0411***        | 0.0243***     | 0.0238***  |
|                                | (0.0005)     | (0.0005)     | (0.0005)       | (0.0004)         | (0.0003)      | (0.0002)   |
| Individual-level Heterogeneity | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| Ad-level Heterogeneity         | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| R <sup>2</sup>                 | 0.0472       | 0.0439       | 0.0435         | 0.0384           | 0.0191        | 0.0141     |
| F-statistic                    | 3079.0830    | 2850.0415    | 2826.3297      | 2480.5812        | 1207.5744     | 886.0775   |
| No. of observ.                 | 3,000,000    | 3,000,000    | 3,000,000      | 3,000,000        | 3,000,000     | 3,000,000  |

Notes: Significance levels defined as \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001; robust standard errors are in parentheses.



| <b>Table A10. ATE of Display Advertising Exposure (Falsification Check)</b> |                     |                     |                       |                         |                      |                   |
|---|---------------------|---------------------|-----------------------|-------------------------|----------------------|-------------------|
|   | <b>Search Brand</b> | <b>Direct Visit</b> | <b>Organic Search</b> | <b>Search Non-Brand</b> | <b>Display Click</b> | <b>Conversion</b> |
| <b>Time</b>   | -0.0519***          | -0.0502***          | -0.0477***            | -0.0405***              | -0.0229***           | 0.0141***         |
|   | (0.0002)            | (0.0002)            | (0.0002)              | (0.0002)                | (0.0001)             | (0.0001)          |
| <b>Treated</b>  | 0.0016***           | 0.0033***           | 0.0016***             | 0.0007***               | 0.0008***            | 0.0000            |
|   | (0.0002)            | (0.0002)            | (0.0002)              | (0.0002)                | (0.0001)             | (0.0001)          |
| <b>ATE Duration</b>   | -0.0034             | 0.0039              | -0.0001               | 0.0041                  | -0.0025              | -0.0008           |
|   | (0.0043)            | (0.0043)            | (0.0041)              | (0.0038)                | (0.0031)             | (0.0022)          |
| <b>Constant</b>   | 0.0534***           | 0.0530***           | 0.0490***             | 0.0411***               | 0.0243***            | 0.0238***         |
|   | (0.0005)            | (0.0005)            | (0.0005)              | (0.0004)                | (0.0004)             | (0.0003)          |
| <b>Individual-level Heterogeneity</b>                                       | ✓                   | ✓                   | ✓                     | ✓                       | ✓                    | ✓                 |
| <b>Ad-level Heterogeneity</b>   | ✓                   | ✓                   | ✓                     | ✓                       | ✓                    | ✓                 |
| <b>R<sup>2</sup></b>  | 0.0473              | 0.0439              | 0.0436                | 0.0383                  | 0.0191               | 0.0141            |
| <b>F-statistic</b>  | 2858.8320           | 2649.3417           | 2624.4127             | 2297.5775               | 1121.5676            | 821.6368          |
| <b>No. of observ.</b>   | 2,801,016           | 2,801,016           | 2,801,016             | 2,801,016               | 2,801,016            | 2,801,016         |

Notes: Significance levels defined as \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001; robust standard errors are in parentheses.

| <b>Table A11. Falsification Check by Exposure (DID Matching Estimator)</b> |                     |                     |                       |                         |                      |                   |
|--|---------------------|---------------------|-----------------------|-------------------------|----------------------|-------------------|
|  | <b>Search Brand</b> | <b>Direct Visit</b> | <b>Organic Search</b> | <b>Search Non-Brand</b> | <b>Display Click</b> | <b>Conversion</b> |
| <b>1st Exposure</b>  | 0.0002              | 0.0001              | -0.0010               | 0.0004                  | -0.0005              | 0.0009            |
|  | (0.0008)            | (0.0009)            | (0.0008)              | (0.0007)                | (0.0005)             | (0.0008)          |
| <b>2nd Exposure</b>  | -0.0015             | 0.0022*             | -0.0006               | -0.0007                 | 0.0001               | -0.0001           |
|  | (0.0010)            | (0.0010)            | (0.0009)              | (0.0008)                | (0.0006)             | (0.0007)          |
| <b>3rd Exposure</b>  | -0.0011             | -0.0009             | -0.0009               | 0.0005                  | -0.0019**            | 0.0003            |
|  | (0.0011)            | (0.0011)            | (0.0010)              | (0.0009)                | (0.0007)             | (0.0006)          |
| <b>4th Exposure</b>  | -0.0014             | 0.0018              | 0.0006                | 0.0003                  | -0.0001              | 0.0004            |
|  | (0.0011)            | (0.0012)            | (0.0011)              | (0.0010)                | (0.0008)             | (0.0006)          |
| <b>5th Exposure</b>  | -0.0019             | -0.0004             | -0.0001               | 0.0001                  | 0.0022**             | -0.0001           |
|  | (0.0012)            | (0.0012)            | (0.0011)              | (0.0010)                | (0.0008)             | (0.0006)          |

Notes: Significance levels defined as \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001; robust standard errors are in parentheses.

| <b>Table A12. DID Unconfoundedness Binary Treatment (Robustness Check)</b> |                     |                     |                       |                         |                      |                   |
|--|---------------------|---------------------|-----------------------|-------------------------|----------------------|-------------------|
|  | <b>Search Brand</b> | <b>Direct Visit</b> | <b>Organic Search</b> | <b>Search Non-Brand</b> | <b>Display Click</b> | <b>Conversion</b> |
| <b>ATE</b>   | 0.0051***           | 0.0091***           | 0.0048***             | 0.0023***               | 0.0031***            | -0.0001           |
|  | (0.0002)            | (0.0002)            | (0.0002)              | (0.0001)                | (0.0001)             | (0.0001)          |
| <b>Lag Search Brand</b>  | -1.6351***          |                     |                       |                         |                      |                   |
|  | (0.0018)            |                     |                       |                         |                      |                   |
| <b>Lag Direct Visit</b>  |                     | -1.4829***          |                       |                         |                      |                   |
|  |                     | (0.0022)            |                       |                         |                      |                   |
| <b>Lag Organic Search</b>  |                     |                     | -1.5707***            |                         |                      |                   |
|  |                     |                     | (0.0019)              |                         |                      |                   |
| <b>Lag Search Non-Brand</b>  |                     |                     |                       | -1.6779***              |                      |                   |
|  |                     |                     |                       | (0.0018)                |                      |                   |
| <b>Lag Display Click</b>   |                     |                     |                       |                         | -1.5135***           |                   |
|  |                     |                     |                       |                         | (0.0015)             |                   |
| <b>Lag Conversion</b>  |                     |                     |                       |                         |                      | 0.0000            |
|  |                     |                     |                       |                         |                      | (.)               |
| <b>Constant</b>  | 0.0257***           | 0.0215***           | 0.0212***             | 0.0199***               | 0.0088***            | -0.0276***        |
|  | (0.0004)            | (0.0006)            | (0.0004)              | (0.0003)                | (0.0004)             | (0.0001)          |
| <b>Individual-level Heterogeneity</b>                                      | ✓                   | ✓                   | ✓                     | ✓                       | ✓                    | ✓                 |
| <b>Ad-level Heterogeneity</b>  | ✓                   | ✓                   | ✓                     | ✓                       | ✓                    | ✓                 |
| <b>R<sup>2</sup></b>   | 0.7193              | 0.5811              | 0.6832                | 0.7287                  | 0.7466               | 0.0003            |
| <b>F-statistic</b>   | 11456.5678          | 6200.3400           | 9640.4826             | 12003.6341              | 13170.2782           | 1.1741            |

Notes: Significance levels defined as \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001; robust standard errors are in parentheses.

| <b>Table A13. DID Unconfoundedness Non-Binary Treatment (Robustness Check)</b> |                     |                     |                       |                         |                      |                   |
|--|---------------------|---------------------|-----------------------|-------------------------|----------------------|-------------------|
|  | <b>Search Brand</b> | <b>Direct Visit</b> | <b>Organic Search</b> | <b>Search Non-Brand</b> | <b>Display Click</b> | <b>Conversion</b> |
| <b>ATE Duration</b>  | 0.0002***           | 0.0005***           | 0.0002***             | 0.0001***               | 0.0004***            | -0.0000           |
|  | (0.0001)            | (0.0001)            | (0.0001)              | (0.0000)                | (0.0001)             | (0.0000)          |
| <b>Lag Search Brand</b>  | -1.6305***          |                     |                       |                         |                      |                   |
|  | (0.0019)            |                     |                       |                         |                      |                   |
| <b>Lag Direct Visit</b>  |                     | -1.4770***          |                       |                         |                      |                   |
|  |                     | (0.0023)            |                       |                         |                      |                   |
| <b>Lag Organic Search</b>  |                     |                     | -1.5695***            |                         |                      |                   |
|  |                     |                     | (0.0019)              |                         |                      |                   |
| <b>Lag Search Non-Brand</b>  |                     |                     |                       | -1.6737***              |                      |                   |
|  |                     |                     |                       | (0.0018)                |                      |                   |
| <b>Lag Display Click</b>   |                     |                     |                       |                         | -1.5094***           |                   |
|  |                     |                     |                       |                         | (0.0016)             |                   |
| <b>Lag Conversion</b>  |                     |                     |                       |                         |                      | 0.0000            |
|  |                     |                     |                       |                         |                      | (.)               |
| <b>Constant</b>  | 0.0274***           | 0.0222***           | 0.0226***             | 0.0207***               | 0.0092***            | -0.0282***        |
|  | (0.0004)            | (0.0006)            | (0.0004)              | (0.0003)                | (0.0004)             | (0.0001)          |
| <b>Individual-level Heterogeneity</b>  | ✓                   | ✓                   | ✓                     | ✓                       | ✓                    | ✓                 |
| <b>Ad-level Heterogeneity</b>  | ✓                   | ✓                   | ✓                     | ✓                       | ✓                    | ✓                 |
| <b>R<sup>2</sup></b>   | 0.7174              | 0.5798              | 0.6835                | 0.7327                  | 0.7471               | 0.0003            |
| <b>F-statistic</b>   | 10570.2735          | 5745.9138           | 8993.1679             | 11415.5008              | 12301.5474           | 1.2590            |

Notes: Significance levels defined as \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001; robust standard errors are in parentheses.

| <b>Table A14. DID Exposure as Function of Relative Position</b> |                     |                     |                       |                         |                      |                   |
|---|---------------------|---------------------|-----------------------|-------------------------|----------------------|-------------------|
|   | <b>Search Brand</b> | <b>Direct Visit</b> | <b>Organic Search</b> | <b>Search Non-Brand</b> | <b>Display Click</b> | <b>Conversion</b> |
| <b>Time</b>   | -0.0434***          | -0.0453***          | -0.0402***            | -0.0329***              | -0.0169***           | 0.0154***         |
|   | (0.0002)            | (0.0003)            | (0.0002)              | (0.0002)                | (0.0002)             | (0.0002)          |
| <b>Treated</b>  | -0.0032***          | -0.0018***          | -0.0026***            | -0.0024***              | -0.0014***           | -0.0014***        |
|   | (0.0003)            | (0.0003)            | (0.0003)              | (0.0003)                | (0.0002)             | (0.0002)          |
| <b>Average Treatment Effect</b>                                 | 0.0133***           | 0.0141***           | 0.0115***             | 0.0085***               | 0.0058***            | 0.0037***         |
|   | (0.0004)            | (0.0004)            | (0.0004)              | (0.0003)                | (0.0003)             | (0.0002)          |
| <b>Constant</b>   | 0.0422***           | 0.0451***           | 0.0390***             | 0.0317***               | 0.0170***            | 0.0279***         |
|   | (0.0007)            | (0.0008)            | (0.0007)              | (0.0006)                | (0.0005)             | (0.0005)          |
| <b>Individual-level Heterogeneity</b>                           | ✓                   | ✓                   | ✓                     | ✓                       | ✓                    | ✓                 |
| <b>Ad-level Heterogeneity</b>                                   | ✓                   | ✓                   | ✓                     | ✓                       | ✓                    | ✓                 |
| <b>R<sup>2</sup></b>  | 0.0345              | 0.0351              | 0.0325                | 0.0280                  | 0.0120               | 0.0170            |
| <b>F-statistic</b>  | 989.9772            | 1008.0952           | 930.1717              | 798.0168                | 335.3563             | 479.8568          |
| <b>No. of observ.</b>   | 1,500,000           | 1,500,000           | 1,500,000             | 1,500,000               | 1,500,000            | 1,500,000         |

Notes: Effects of display advertising (ATE as Function of Relative Position). Significance levels defined as \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001; robust standard errors are in parentheses.

| <b>Table A15. DID Exposure as Function of Relative Position (Non-Binary Exposure)</b> |                     |                     |                       |                         |                      |                   |
|---|---------------------|---------------------|-----------------------|-------------------------|----------------------|-------------------|
|   | <b>Search Brand</b> | <b>Direct Visit</b> | <b>Organic Search</b> | <b>Search Non-Brand</b> | <b>Display Click</b> | <b>Conversion</b> |
| <b>Time</b>   | -0.0411***          | -0.0412***          | -0.0386***            | -0.0318***              | -0.0160***           | 0.0168***         |
|   | (0.0002)            | (0.0002)            | (0.0002)              | (0.0002)                | (0.0002)             | (0.0001)          |
| <b>ATE Duration</b>   | 0.1308***           | 0.2390***           | 0.1274***             | 0.0928***               | 0.0648***            | 0.0195***         |
|   | (0.0070)            | (0.0070)            | (0.0067)              | (0.0060)                | (0.0046)             | (0.0044)          |
| <b>Constant</b>   | 0.0416***           | 0.0415***           | 0.0385***             | 0.0313***               | 0.0166***            | 0.0279***         |
|   | (0.0008)            | (0.0008)            | (0.0007)              | (0.0006)                | (0.0005)             | (0.0005)          |
| <b>Individual-level Heterogeneity</b>   | ✓                   | ✓                   | ✓                     | ✓                       | ✓                    | ✓                 |
| <b>Ad-level Heterogeneity</b>   | ✓                   | ✓                   | ✓                     | ✓                       | ✓                    | ✓                 |
| <b>R<sup>2</sup></b>  | 0.0345              | 0.0323              | 0.0327                | 0.0283                  | 0.0120               | 0.0171            |
| <b>F-statistic</b>  | 943.7914            | 881.0574            | 893.0538              | 769.3703                | 320.6975             | 461.0108          |
| <b>No. of observ.</b>   | 1,406,380           | 1,406,380           | 1,406,380             | 1,406,380               | 1,406,380            | 1,406,380         |

Notes: Significance levels defined as \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001; robust standard errors are in parentheses.

| <b>Table A16. Effects of Display Advertising DID Matching Estimator with Demographics</b> |                     |                      |                       |                         |                       |                   |
|---|---------------------|----------------------|-----------------------|-------------------------|-----------------------|-------------------|
|   | <b>Search Brand</b> | <b>Direct Visits</b> | <b>Organic Search</b> | <b>Search Non-Brand</b> | <b>Display Clicks</b> | <b>Conversion</b> |
| <b>ATE Exposure 1</b>   | 0.0082***           | 0.0159***            | 0.0076***             | 0.0022***               | 0.0039***             | 0.0081***         |
|   | (0.0008)            | (0.0009)             | (0.0007)              | (0.0005)                | (0.0004)              | (0.0014)          |
| <b>ATE Exposure 2</b>   | 0.0072***           | 0.0088***            | 0.0070***             | 0.0039***               | 0.0034***             | 0.0002            |
|   | (0.0007)            | (0.0008)             | (0.0006)              | (0.0006)                | (0.0005)              | (0.0008)          |
| <b>ATE Exposure 3</b>   | 0.0064***           | 0.0090***            | 0.0064***             | 0.0022**                | 0.0042***             | 0.0017*           |
|   | (0.0008)            | (0.0009)             | (0.0008)              | (0.0007)                | (0.0005)              | (0.0008)          |
| <b>ATE Exposure 4</b>   | 0.0028***           | 0.0054***            | 0.0033***             | 0.0009                  | 0.0026***             | -0.0011           |
|   | (0.0006)            | (0.0008)             | (0.0006)              | (0.0005)                | (0.0004)              | (0.0007)          |
| <b>ATE Exposure 5</b>   | 0.0005              | 0.0058***            | -0.0002               | 0.0014*                 | 0.0023***             | 0.0005            |
|   | (0.0007)            | (0.0009)             | (0.0007)              | (0.0007)                | (0.0005)              | (0.0007)          |

Notes: Significance levels defined as \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001; robust standard errors are in parentheses.

**Table A17. DID Binary Exposure with Monthly Time Dummies**

|                                | Search Brand | Direct Visit | Organic Search | Search Non-Brand | Display Click | Conversion |
|--------------------------------|--------------|--------------|----------------|------------------|---------------|------------|
| Time                           | -0.0551***   | -0.0547***   | -0.0501***     | -0.0418***       | -0.0246***    | 0.0131***  |
|                                | (0.0002)     | (0.0002)     | (0.0002)       | (0.0002)         | (0.0001)      | (0.0001)   |
| Treat                          | -0.0018***   | -0.0016***   | -0.0009***     | -0.0007***       | -0.0009***    | -0.0011*** |
|                                | (0.0002)     | (0.0002)     | (0.0002)       | (0.0002)         | (0.0002)      | (0.0001)   |
| ATE                            | 0.0072***    | 0.0101***    | 0.0054***      | 0.0031***        | 0.0037***     | 0.0022***  |
|                                | (0.0003)     | (0.0003)     | (0.0003)       | (0.0003)         | (0.0002)      | (0.0001)   |
| Constant                       | 0.0514***    | 0.0517***    | 0.0476***      | 0.0405***        | 0.0231***     | 0.0243***  |
|                                | (0.0005)     | (0.0005)     | (0.0005)       | (0.0004)         | (0.0004)      | (0.0003)   |
| Individual-level Heterogeneity | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| Ad-level Heterogeneity         | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| Monthly Time Dummies           | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| R <sup>2</sup>                 | 0.0477       | 0.0445       | 0.0438         | 0.0385           | 0.0193        | 0.0141     |
| F-statistic                    | 2779.8676    | 2586.1707    | 2543.2289      | 2222.1008        | 1094.8877     | 796.6396   |
| No. of observ.                 | 3,000,000    | 3,000,000    | 3,000,000      | 3,000,000        | 3,000,000     | 3,000,000  |

Notes: Controlling for average time-varying unobserved confounders with monthly dummies. Significance levels defined as \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001; robust standard errors are in parentheses.

**Table A18. DID Binary Exposure with Monthly Time Trend**

|                                | Search Brand | Direct Visit | Organic Search | Search Non-Brand | Display Click | Conversion |
|--------------------------------|--------------|--------------|----------------|------------------|---------------|------------|
| Time                           | -0.0551***   | -0.0547***   | -0.0501***     | -0.0418***       | -0.0246***    | 0.0131***  |
|                                | (0.0002)     | (0.0002)     | (0.0002)       | (0.0002)         | (0.0001)      | (0.0001)   |
| Treat                          | -0.0018***   | -0.0016***   | -0.0009***     | -0.0007***       | -0.0009***    | -0.0011*** |
|                                | (0.0002)     | (0.0002)     | (0.0002)       | (0.0002)         | (0.0002)      | (0.0001)   |
| ATE                            | 0.0072***    | 0.0101***    | 0.0054***      | 0.0031***        | 0.0037***     | 0.0022***  |
|                                | (0.0003)     | (0.0003)     | (0.0003)       | (0.0003)         | (0.0002)      | (0.0001)   |
| Constant                       | 0.0464***    | 0.0474***    | 0.0439***      | 0.0392***        | 0.0203***     | 0.0243***  |
|                                | (0.0006)     | (0.0006)     | (0.0006)       | (0.0005)         | (0.0004)      | (0.0003)   |
| Monthly Trend                  | 0.0058***    | 0.0053***    | 0.0042***      | 0.0017***        | 0.0032***     | 0.0000     |
|                                | (0.0002)     | (0.0002)     | (0.0002)       | (0.0002)         | (0.0002)      | (0.0001)   |
| Individual-level Heterogeneity | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| Ad-level Heterogeneity         | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| R <sup>2</sup>                 | 0.0477       | 0.0445       | 0.0438         | 0.0385           | 0.0193        | 0.0141     |
| F-statistic                    | 3036.9275    | 2824.6953    | 2778.1322      | 2428.2146        | 1195.8632     | 796.6396   |
| No. of observ.                 | 3,000,000    | 3,000,000    | 3,000,000      | 3,000,000        | 3,000,000     | 3,000,000  |

Notes: Controlling for average time-varying unobserved confounders with monthly time trend. Significance levels defined as \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001; robust standard errors are in parentheses.

| <b>Table A19. DID Binary Exposure with Weekly Time Dummies</b> |                     |                     |                       |                         |                      |                   |
|--|---------------------|---------------------|-----------------------|-------------------------|----------------------|-------------------|
|  | <b>Search Brand</b> | <b>Direct Visit</b> | <b>Organic Search</b> | <b>Search Non-Brand</b> | <b>Display Click</b> | <b>Conversion</b> |
| <b>Time</b>  | -0.0551***          | -0.0547***          | -0.0501***            | -0.0418***              | -0.0246***           | 0.0131***         |
|  | (0.0002)            | (0.0002)            | (0.0002)              | (0.0002)                | (0.0001)             | (0.0001)          |
| <b>Treat</b>   | -0.0017***          | -0.0016***          | -0.0009***            | -0.0007***              | -0.0009***           | -0.0011***        |
|  | (0.0002)            | (0.0002)            | (0.0002)              | (0.0002)                | (0.0002)             | (0.0001)          |
| <b>ATE</b>   | 0.0072***           | 0.0101***           | 0.0054***             | 0.0031***               | 0.0037***            | 0.0022***         |
|  | (0.0003)            | (0.0003)            | (0.0003)              | (0.0003)                | (0.0002)             | (0.0001)          |
| <b>Constant</b>  | 0.0471***           | 0.0457***           | 0.0436***             | 0.0393***               | 0.0185***            | 0.0243***         |
|  | (0.0007)            | (0.0007)            | (0.0007)              | (0.0006)                | (0.0005)             | (0.0004)          |
| <b>Individual-level Heterogeneity</b>                          | ✓                   | ✓                   | ✓                     | ✓                       | ✓                    | ✓                 |
| <b>Ad-level Heterogeneity</b>                                  | ✓                   | ✓                   | ✓                     | ✓                       | ✓                    | ✓                 |
| <b>Weekly Time Dummies</b>                                     | ✓                   | ✓                   | ✓                     | ✓                       | ✓                    | ✓                 |
| <b>R<sup>2</sup></b>   | 0.0477              | 0.0446              | 0.0438                | 0.0385                  | 0.0194               | 0.0141            |
| <b>F-statistic</b>   | 1982.6512           | 1846.2147           | 1813.1859             | 1582.7457               | 783.8970             | 567.2998          |
| <b>No. of observ.</b>  | 3,000,000           | 3,000,000           | 3,000,000             | 3,000,000               | 3,000,000            | 3,000,000         |

Notes: Controlling for average time-varying unobserved confounders with weekly dummies. Significance levels defined as \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001; robust standard errors are in parentheses.

| <b>Table A20. DID Binary Exposure with Weekly Time Trend</b> |                     |                     |                       |                         |                      |                   |
|--|---------------------|---------------------|-----------------------|-------------------------|----------------------|-------------------|
|  | <b>Search Brand</b> | <b>Direct Visit</b> | <b>Organic Search</b> | <b>Search Non-Brand</b> | <b>Display Click</b> | <b>Conversion</b> |
| <b>Time</b>  | -0.0551***          | -0.0547***          | -0.0501***            | -0.0418***              | -0.0246***           | 0.0131***         |
|  | (0.0002)            | (0.0002)            | (0.0002)              | (0.0002)                | (0.0001)             | (0.0001)          |
| <b>Treat</b>   | -0.0017***          | -0.0016***          | -0.0009***            | -0.0007***              | -0.0009***           | -0.0011***        |
|  | (0.0002)            | (0.0002)            | (0.0002)              | (0.0002)                | (0.0002)             | (0.0001)          |
| <b>ATE</b>   | 0.0072***           | 0.0101***           | 0.0054***             | 0.0031***               | 0.0037***            | 0.0022***         |
|  | (0.0003)            | (0.0003)            | (0.0003)              | (0.0003)                | (0.0002)             | (0.0001)          |
| <b>Weekly Trends</b>   | 0.0015***           | 0.0015***           | 0.0011***             | 0.0005***               | 0.0009***            | 0.0000            |
|  | (0.0001)            | (0.0001)            | (0.0001)              | (0.0001)                | (0.0000)             | (0.0000)          |
| <b>Constant</b>  | 0.0482***           | 0.0487***           | 0.0452***             | 0.0398***               | 0.0211***            | 0.0243***         |
|  | (0.0005)            | (0.0006)            | (0.0005)              | (0.0005)                | (0.0004)             | (0.0003)          |
| <b>Individual-level Heterogeneity</b>                        | ✓                   | ✓                   | ✓                     | ✓                       | ✓                    | ✓                 |
| <b>Ad-level Heterogeneity</b>                                | ✓                   | ✓                   | ✓                     | ✓                       | ✓                    | ✓                 |
| <b>R<sup>2</sup></b>   | 0.0477              | 0.0445              | 0.0438                | 0.0385                  | 0.0194               | 0.0141            |
| <b>F-statistic</b>   | 3039.3896           | 2828.1526           | 2779.7225             | 2428.3989               | 1198.6085            | 870.7470          |
| <b>No. of observ.</b>  | 3,000,000           | 3,000,000           | 3,000,000             | 3,000,000               | 3,000,000            | 3,000,000         |

Notes: Controlling for average time-varying unobserved confounders with weekly time trend. Significance levels defined as \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001; robust standard errors are in parentheses.

|                                | Search Brand | Direct Visit | Organic Search | Search Non-Brand | Display Click | Conversion |
|--------------------------------|--------------|--------------|----------------|------------------|---------------|------------|
| Time                           | -0.0551***   | -0.0547***   | -0.0501***     | -0.0418***       | -0.0246***    | 0.0131***  |
|                                | (0.0002)     | (0.0002)     | (0.0002)       | (0.0002)         | (0.0001)      | (0.0001)   |
| Treat                          | -0.0017***   | -0.0016***   | -0.0009***     | -0.0007***       | -0.0009***    | -0.0011*** |
|                                | (0.0002)     | (0.0002)     | (0.0002)       | (0.0002)         | (0.0002)      | (0.0001)   |
| ATE                            | 0.0072***    | 0.0101***    | 0.0054***      | 0.0031***        | 0.0037***     | 0.0022***  |
|                                | (0.0003)     | (0.0003)     | (0.0003)       | (0.0003)         | (0.0002)      | (0.0001)   |
| Weekly Trends                  | 0.0027***    | 0.0031***    | 0.0015***      | 0.0010***        | 0.0021***     | 0.0000     |
|                                | (0.0002)     | (0.0002)     | (0.0002)       | (0.0002)         | (0.0001)      | (0.0001)   |
| Weekly Trends Sq.              | -0.0001***   | -0.0001***   | -0.0000*       | -0.0000***       | -0.0001***    | -0.0000    |
|                                | (0.0000)     | (0.0000)     | (0.0000)       | (0.0000)         | (0.0000)      | (0.0000)   |
| Constant                       | 0.0453***    | 0.0448***    | 0.0443***      | 0.0386***        | 0.0181***     | 0.0243***  |
|                                | (0.0007)     | (0.0007)     | (0.0007)       | (0.0006)         | (0.0005)      | (0.0003)   |
| Individual-level Heterogeneity | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| Ad-level Heterogeneity         | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| R <sup>2</sup>                 | 0.0477       | 0.0446       | 0.0438         | 0.0385           | 0.0194        | 0.0141     |
| F-statistic                    | 2971.4985    | 2766.0181    | 2716.6661      | 2373.4887        | 1173.8197     | 850.9569   |
| No. of observ.                 | 3,000,000    | 3,000,000    | 3,000,000      | 3,000,000        | 3,000,000     | 3,000,000  |

Notes: Controlling for average time-varying unobserved confounders with nonlinear weekly time trend. Significance levels defined as \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001; robust standard errors are in parentheses.

|                                | Search Brand | Direct Visit | Organic Search | Search Non-Brand | Display Click | Conversion |
|--------------------------------|--------------|--------------|----------------|------------------|---------------|------------|
| Time                           | -0.0551***   | -0.0547***   | -0.0501***     | -0.0418***       | -0.0246***    | 0.0131***  |
|                                | (0.0002)     | (0.0002)     | (0.0002)       | (0.0002)         | (0.0001)      | (0.0001)   |
| Treat                          | -0.0017***   | -0.0015***   | -0.0009***     | -0.0007***       | -0.0009***    | -0.0011*** |
|                                | (0.0002)     | (0.0002)     | (0.0002)       | (0.0002)         | (0.0002)      | (0.0001)   |
| ATE                            | 0.0072***    | 0.0101***    | 0.0054***      | 0.0031***        | 0.0037***     | 0.0022***  |
|                                | (0.0003)     | (0.0003)     | (0.0003)       | (0.0003)         | (0.0002)      | (0.0001)   |
| Daily Trend                    | 0.0004***    | 0.0005***    | 0.0003***      | 0.0001           | 0.0003***     | 0.0000     |
|                                | (0.0001)     | (0.0001)     | (0.0001)       | (0.0001)         | (0.0000)      | (0.0000)   |
| Constant                       | 0.0461***    | 0.0443***    | 0.0428***      | 0.0390***        | 0.0175***     | 0.0243***  |
|                                | (0.0007)     | (0.0007)     | (0.0007)       | (0.0006)         | (0.0005)      | (0.0004)   |
| Individual-level Heterogeneity | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| Ad-level Heterogeneity         | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| Weekly Time Dummies            | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| R <sup>2</sup>                 | 0.0478       | 0.0446       | 0.0439         | 0.0385           | 0.0195        | 0.0141     |
| F-statistic                    | 1953.5120    | 1819.5246    | 1786.4447      | 1559.1672        | 772.9866      | 558.8325   |
| No. of observ.                 | 3,000,000    | 3,000,000    | 3,000,000      | 3,000,000        | 3,000,000     | 3,000,000  |

Notes: Controlling for average time-varying unobserved confounders with weekly time dummies and daily time trend. Significance levels defined as \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001; robust standard errors are in parentheses.

| <b>Table A23. DID Non-Binary Treatment (Duration Normalized)</b> |                     |                     |                       |                         |                      |                   |
|--|---------------------|---------------------|-----------------------|-------------------------|----------------------|-------------------|
|  | <b>Search Brand</b> | <b>Direct Visit</b> | <b>Organic Search</b> | <b>Search Non-Brand</b> | <b>Display Click</b> | <b>Conversion</b> |
| <b>Time</b>  | -0.0526***          | -0.0506***          | -0.0486***            | -0.0411***              | -0.0236***           | 0.0140***         |
|  | (0.0002)            | (0.0002)            | (0.0002)              | (0.0002)                | (0.0001)             | (0.0001)          |
| <b>Treated</b>   | 0.0018***           | 0.0000              | 0.0016***             | 0.0010***               | 0.0005**             | -0.0004**         |
|  | (0.0002)            | (0.0002)            | (0.0002)              | (0.0002)                | (0.0002)             | (0.0001)          |
| <b>ATE Duration</b>  | -0.0034             | 0.1452***           | 0.0045                | -0.0088                 | 0.0162***            | 0.0154***         |
|  | (0.0056)            | (0.0055)            | (0.0054)              | (0.0049)                | (0.0039)             | (0.0028)          |
| <b>Constant</b>  | 0.0542***           | 0.0520***           | 0.0498***             | 0.0418***               | 0.0247***            | 0.0244***         |
|  | (0.0005)            | (0.0005)            | (0.0005)              | (0.0004)                | (0.0003)             | (0.0002)          |
| <b>Individual-level Heterogeneity</b>                            | ✓                   | ✓                   | ✓                     | ✓                       | ✓                    | ✓                 |
| <b>Ad-level Heterogeneity</b>                                    | ✓                   | ✓                   | ✓                     | ✓                       | ✓                    | ✓                 |
| <b>R<sup>2</sup></b>   | 0.0480              | 0.0418              | 0.0444                | 0.0392                  | 0.0195               | 0.0143            |
| <b>F-statistic</b>   | 2937.7869           | 2541.6991           | 2702.6603             | 2376.6326               | 1157.6243            | 845.0611          |
| <b>No. of observ.</b>  | 2,820,934           | 2,820,934           | 2,820,934             | 2,820,934               | 2,820,934            | 2,820,934         |

Notes: Effects of display advertising (Duration of Treatment Normalized). Significance levels defined as \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001; robust standard errors are in parentheses.

| <b>Table A24. DID Binary Exposure (Controlling for Dynamic Ads)</b> |                     |                     |                       |                         |                      |                   |
|---|---------------------|---------------------|-----------------------|-------------------------|----------------------|-------------------|
|   | <b>Search Brand</b> | <b>Direct Visit</b> | <b>Organic Search</b> | <b>Search Non-Brand</b> | <b>Display Click</b> | <b>Conversion</b> |
| <b>Time</b>   | -0.0551***          | -0.0547***          | -0.0501***            | -0.0418***              | -0.0246***           | 0.0131***         |
|   | (0.0002)            | (0.0002)            | (0.0002)              | (0.0002)                | (0.0001)             | (0.0001)          |
| <b>Treated</b>  | -0.0020***          | -0.0018***          | -0.0011***            | -0.0008***              | -0.0010***           | -0.0011***        |
|   | (0.0002)            | (0.0002)            | (0.0002)              | (0.0002)                | (0.0002)             | (0.0001)          |
| <b>ATE</b>  | 0.0072***           | 0.0101***           | 0.0054***             | 0.0031***               | 0.0037***            | 0.0022***         |
|   | (0.0003)            | (0.0003)            | (0.0003)              | (0.0003)                | (0.0002)             | (0.0001)          |
| <b>Dynamic Ad</b>   | 0.0008**            | 0.0010**            | 0.0006*               | 0.0003                  | 0.0004               | 0.0000            |
|   | (0.0003)            | (0.0003)            | (0.0003)              | (0.0003)                | (0.0002)             | (0.0002)          |
| <b>Constant</b>   | 0.0542***           | 0.0542***           | 0.0495***             | 0.0415***               | 0.0248***            | 0.0243***         |
|   | (0.0006)            | (0.0006)            | (0.0006)              | (0.0005)                | (0.0004)             | (0.0003)          |
| <b>Individual-level Heterogeneity</b>                               | ✓                   | ✓                   | ✓                     | ✓                       | ✓                    | ✓                 |
| <b>Ad-level Heterogeneity</b>                                       | ✓                   | ✓                   | ✓                     | ✓                       | ✓                    | ✓                 |
| <b>R<sup>2</sup></b>  | 0.0474              | 0.0443              | 0.0436                | 0.0384                  | 0.0192               | 0.0141            |
| <b>F-statistic</b>  | 3022.5313           | 2813.3556           | 2770.0085             | 2426.4775               | 1187.4175            | 870.7620          |
| <b>No. of observ.</b>   | 3,000,000           | 3,000,000           | 3,000,000             | 3,000,000               | 3,000,000            | 3,000,000         |

Notes: Effects of display advertising . Significance levels defined as \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001; robust standard errors are in parentheses.



**Table A25. DID Non-Binary Exposure (Controlling for Dynamic Ads)**

|                                | Search Brand | Direct Visit | Organic Search | Search Non-Brand | Display Click | Conversion |
|--------------------------------|--------------|--------------|----------------|------------------|---------------|------------|
| Time                           | -0.0526***   | -0.0506***   | -0.0486***     | -0.0411***       | -0.0236***    | 0.0140***  |
|                                | (0.0002)     | (0.0002)     | (0.0002)       | (0.0002)         | (0.0001)      | (0.0001)   |
| Treated                        | 0.0019***    | 0.0000       | 0.0016***      | 0.0010***        | 0.0005**      | -0.0004**  |
|                                | (0.0002)     | (0.0002)     | (0.0002)       | (0.0002)         | (0.0002)      | (0.0001)   |
| ATE Duration                   | -0.0001      | 0.0026***    | 0.0001         | -0.0002          | 0.0003***     | 0.0003***  |
|                                | (0.0001)     | (0.0001)     | (0.0001)       | (0.0001)         | (0.0001)      | (0.0001)   |
| Dynamic Ad                     | 0.0009**     | 0.0011***    | 0.0007*        | 0.0003           | 0.0004        | -0.0000    |
|                                | (0.0003)     | (0.0003)     | (0.0003)       | (0.0003)         | (0.0002)      | (0.0002)   |
| Constant                       | 0.0533***    | 0.0509***    | 0.0491***      | 0.0415***        | 0.0244***     | 0.0245***  |
|                                | (0.0006)     | (0.0006)     | (0.0006)       | (0.0005)         | (0.0004)      | (0.0003)   |
| Individual-level Heterogeneity | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| Ad-level Heterogeneity         | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| R <sup>2</sup>                 | 0.0480       | 0.0418       | 0.0444         | 0.0392           | 0.0195        | 0.0143     |
| F-statistic                    | 2869.6362    | 2482.8912    | 2639.9218      | 2321.3889        | 1130.7659     | 825.4082   |
| No. of observ.                 | 2,820,934    | 2,820,934    | 2,820,934      | 2,820,934        | 2,820,934     | 2,820,934  |

Notes: Significance levels defined as \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001; robust standard errors are in parentheses.

**Table A26. DID Binary Exposure (Absolute Position Controls)**

|                                | Search Brand | Direct Visit | Organic Search | Search Non-Brand | Display Click | Conversion |
|--------------------------------|--------------|--------------|----------------|------------------|---------------|------------|
| Time                           | -0.0551***   | -0.0547***   | -0.0501***     | -0.0418***       | -0.0246***    | 0.0131***  |
|                                | (0.0002)     | (0.0002)     | (0.0002)       | (0.0002)         | (0.0001)      | (0.0001)   |
| Treated                        | -0.0020***   | -0.0018***   | -0.0011***     | -0.0008***       | -0.0010***    | -0.0011*** |
|                                | (0.0002)     | (0.0002)     | (0.0002)       | (0.0002)         | (0.0002)      | (0.0001)   |
| ATE                            | 0.0072***    | 0.0101***    | 0.0054***      | 0.0031***        | 0.0037***     | 0.0022***  |
|                                | (0.0003)     | (0.0003)     | (0.0003)       | (0.0003)         | (0.0002)      | (0.0001)   |
| Constant                       | 0.1181       | -0.0363      | 0.1975         | 0.0416           | 0.0823        | 0.0243     |
|                                | (0.1271)     | (0.1275)     | (0.1217)       | (0.1103)         | (0.0897)      | (0.0641)   |
| Individual-level Heterogeneity | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| Ad-level Heterogeneity         | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| Controls for Position          | ✓            | ✓            | ✓              | ✓                | ✓             | ✓          |
| R <sup>2</sup>                 | 0.0478       | 0.0453       | 0.0441         | 0.0385           | 0.0208        | 0.0141     |
| F-statistic                    | 728.1813     | 687.7421     | 672.9900       | 583.4672         | 309.1202      | 209.1666   |
| No. of observ.                 | 3,000,000    | 3,000,000    | 3,000,000      | 3,000,000        | 3,000,000     | 3,000,000  |

Notes: ATE of Display Advertising Exposure (Absolute Position Controls). Significance levels defined as \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001; robust standard errors are in parentheses.

| <b>Table A27. DID Non-Binary Exposure (Absolute Position Controls)</b> |                        |                        |                        |                         |                        |                       |
|--|------------------------|------------------------|------------------------|-------------------------|------------------------|-----------------------|
|  | <b>Search Brand</b>    | <b>Direct Visit</b>    | <b>Organic Search</b>  | <b>Search Non-Brand</b> | <b>Display Click</b>   | <b>Conversion</b>     |
| <b>Time</b>  | -0.0526***<br>(0.0002) | -0.0506***<br>(0.0002) | -0.0486***<br>(0.0002) | -0.0411***<br>(0.0002)  | -0.0236***<br>(0.0001) | 0.0140***<br>(0.0001) |
| <b>Treated</b>   | 0.0018***<br>(0.0002)  | 0.0000<br>(0.0002)     | 0.0017***<br>(0.0002)  | 0.0010***<br>(0.0002)   | 0.0005**<br>(0.0002)   | -0.0004**<br>(0.0001) |
| <b>ATE Duration</b>  | -0.0001<br>(0.0001)    | 0.0026***<br>(0.0001)  | 0.0001<br>(0.0001)     | -0.0002<br>(0.0001)     | 0.0003***<br>(0.0001)  | 0.0003***<br>(0.0001) |
| <b>Constant</b>  | 0.1187<br>(0.1281)     | -0.0409<br>(0.1252)    | 0.1983<br>(0.1229)     | 0.0413<br>(0.1115)      | 0.0821<br>(0.0901)     | 0.0244<br>(0.0648)    |
| <b>Individual-level Heterogeneity</b>                                  | ✓                      | ✓                      | ✓                      | ✓                       | ✓                      | ✓                     |
| <b>Ad-level Heterogeneity</b>  | ✓                      | ✓                      | ✓                      | ✓                       | ✓                      | ✓                     |
| <b>Controls for Position</b>   | ✓                      | ✓                      | ✓                      | ✓                       | ✓                      | ✓                     |
| <b>R<sup>2</sup></b>   | 0.0484                 | 0.0429                 | 0.0448                 | 0.0393                  | 0.0210                 | 0.0143                |
| <b>F-statistic</b>   | 710.8314               | 625.7401               | 655.8840               | 570.9528                | 300.1428               | 202.8036              |
| <b>No. of observ.</b>  | 2,820,934              | 2,820,934              | 2,820,934              | 2,820,934               | 2,820,934              | 2,820,934             |

Notes: ATE of Display Advertising Exposure (Absolute Position Controls). Significance levels defined as \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001; robust standard errors are in parentheses.