Big Tech dominance despite global mistrust

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Abstract

The technological and online experiences of billions worldwide is dominated by a handful of companies known as "Big Tech". Despite this being a cause for concern in governmental, economic and ethical spheres, the literature lacks a study exploring the impact of public scandals on, and the global sentiment towards, Big Tech. Here, we quantify the power of Big Tech by analyzing their acquisitions, market capitalization, and number of monthly active users. Moreover, we utilize the synthetic control method to estimate the effect of public scandals on the stock price of two Big Tech companies, and find that they had no lasting effect. We also analyze the number of tweets mentioning these scandals, and find that they quickly fade from the spotlight. To explore public sentiment, we survey 5300 participants across 25 countries, and find that those from countries with lower digital literacy and more authoritarian regimes are more trusting of Big Tech. Furthermore, we find that one in three feel they lack control over the data collected about them, and one in four feel that Big Tech know what they are thinking, know more about them than their best friend, and may even be secretly listening to their conversations. Additionally, one in four feel addicted to Big Tech products, have no choice but to use them, and wish there were more companies to choose from. These findings highlight the adverse effect of the oligopolistic nature of Big Tech on consumer choice, and help inform policy-makers aiming to curb their dominance.

Significance Statement

Billions of people utilize the products and services of Big Tech companies. Big Tech's dominance and its subsequent privacy and anti-trust violations have prompted numerous investigations and fines, yet the impact of these measures in deterring Big Tech has been questionable. Furthermore, little is known regarding how public sentiment towards Big Tech varies worldwide. We study the impact of major global scandals on Big Tech companies, revealing the lack of long-term impact these scandals had on stock price and online public discourse. We also survey 5300 participants regarding Big Tech and find that those from countries with lower digital literacy and authoritarian regimes were more trusting of Big Tech. These findings help inform policymakers aiming to curb Big Tech's dominance.

Introduction

The Internet is dominated by a handful of "Big Tech" companies, each of which controls a particular sector of the online space [1]. In the context of mobile applications, for example, over 99% of smartphones are part of the app-ecosystem of either Apple or Alphabet (Google's parent company) [2], effectively giving app developers no choice but to abide by their policies, regardless of how unfair they may be [3]. Big Tech companies have also been accused of "self-preferencing", an act in which a company unfairly favors its own products on its platforms. For example, Apple has been accused of listing its own subscription-based apps at the top of search results. Google, on the other hand, routinely devotes a large portion of first-page results to its own services, such as YouTube, Google Flights, and Google Maps. Amazon, which controls 65 to 70 percent of all US online marketplace sales [4], also engages in self-preferencing behaviour, often listing itself as the default seller for numerous products and favoring third-party vendors who utilize its warehouse and delivery services. The massive amount of user-related data amassed by these companies enables them to dominate the digital ad market, with 64% of all US digital ad spending in 2021 ($128 billion) going to Alphabet, Amazon, and Meta (Facebook's parent company) [5].

It has been argued that certain characteristics of the digital market make them susceptible to a "winner-take-all" system, enabling major players in the technology space to seize power and act as gate-keepers over channels of distribution [6]. This trend has been the subject of multiple anti-trust investigations over the past decade. In the US, the House Judiciary Subcommittee (HJC) on Anti-Trust released a report titled "Investigation of Competition in Digital Markets" documenting anti-competitive conduct by Alphabet, Amazon, Apple, and Meta, and highlighting key limitations in current anti-trust laws and their enforcement [4]. As of the writing of this paper, two bills are before Congress, namely, the Open App Markets Act, and the American Choice and Innovation Online Act, addressing findings made by the HJC regarding predatory app store regulations and self-preferencing, respectively [7, 8]. Issues of data protection and regulation have also been a topic of discussion elsewhere around the world. In 2018, for example, the EU passed the General Data Protection Regulation (GDPR), which in turn has served as a model for laws passed globally in more than nine other countries.

Due to privacy violations, lack of transparency, and breaches of anti-trust rules, many Big Tech companies incurred substantial fines. In December 2021, for example, Italy's anti-trust regulators issued a $1.3 billion fine against Amazon for breaking anti-trust laws by preferencing third-party merchants who use the company's warehouse and delivery systems [9]. Amazon has also been subjected to a number of fines by the GDPR, including a €35 million fine in 2020 and a €746 million fine in 2021 regarding their failure to acquire cookie consent on the website [10, 11]. Similarly, Meta was issued a $5 billion fine by the Federal Trade Commission due to its failure to protect users' data from being harvested by Cambridge Analytica [12]. The GDPR also levied a €60 million fine on Meta due to Facebook's failure to obtain cookie consent [13], and a €255 million fine due to its failure to explain the legal basis of its data processing practices on WhatsApp [14]. As for Google, it was subjected to a €2.42 billion fine by the European Commission due to self-preferencing behaviour [15]. Moreover, the French data protection authority imposed a

€150 million fine on Google in 2022 due to cookie consent procedures [16]. This followed a €50 million fine against Google in 2019 for lack of information provided to users in their consent policies [17]. Lastly, Apple received multiple anti-trust fines by the Dutch consumer watchdog for failure to comply with an order to make it possible for app providers to use non-Apple payment channels [18]. In total, more than $30 billion worth of anti-trust fines have been imposed on Big Tech companies since 2015 [19]. Despite their magnitude, it is unclear whether these fines are sufficient to deter Big Tech companies from violating the various laws aimed at regulating digital markets.

Given the extensive media coverage of the above investigations [20, 21], it is only natural to question whether the misconduct of Big Tech companies influences the trust levels of their users. Indeed, a number of studies have examined user sentiments towards Big Tech, especially following the emergence of privacy and regulation as a topic of concern in the digital zeitgeist. One such study interviewed ten college students at a medium-sized US-based university regarding their Facebook usage following the Cambridge Analytica scandal, revealing that many of them had changed their frequency of usage but none had opted to leave the platform entirely [22]. Another study examined user attitudes towards institutional privacy before and after the Cambridge Analytica scandal through interviews with 50 young adults in Israel. The authors noted a shift in perspective on the notion of privacy, with participants moving away from considering privacy to be a human right, to accepting economic surveillance as being inherent in the digital world [23]. Finally, one study examined the relationship between awareness of privacy scandals and attitudes towards content reuse among 500 participants from Amazon Mechanical Turk, noting that those with the greatest awareness of the scandal exhibited a greater skepticism for algorithmically targeted advertising, and a heightened desire for data mobility and networked privacy rights [24].

Despite the above research, the literature still lacks a global study comparing user attitudes towards Big Tech across countries. Such a study is especially fitting given the global reach of these companies, with their user bases extending to virtually every corner of the globe. To fill this gap, we start off by examining the shared power of Big Tech with regards to their number of acquisitions, market cap, and number of users. Moreover, we explore the relationship between major privacy and anti-trust scandals and the companies' performance in the stock market, as well as the nature of public discourse surrounding these scandals on Twitter. We then survey 5300 participants, recruited from 25 countries spanning six continents, to obtain a global view of people's trust in Big Tech companies, and a better understanding of the country characteristics that are associated with mistrust.

Results

Throughout our analysis, we focus on the following tech giants: Alphabet (the parent company of Google), Amazon, Apple, ByteDance (the parent company of TikTok), Meta (the parent company of Facebook), Microsoft, and Tencent (the parent company of WeChat); these will be referred to as "Big Tech". We start our analysis by examining the performance of Big Tech over time. Figure 1a shows the cumulative number of acquisitions made by each company since their establishment. Microsoft stands out as the one

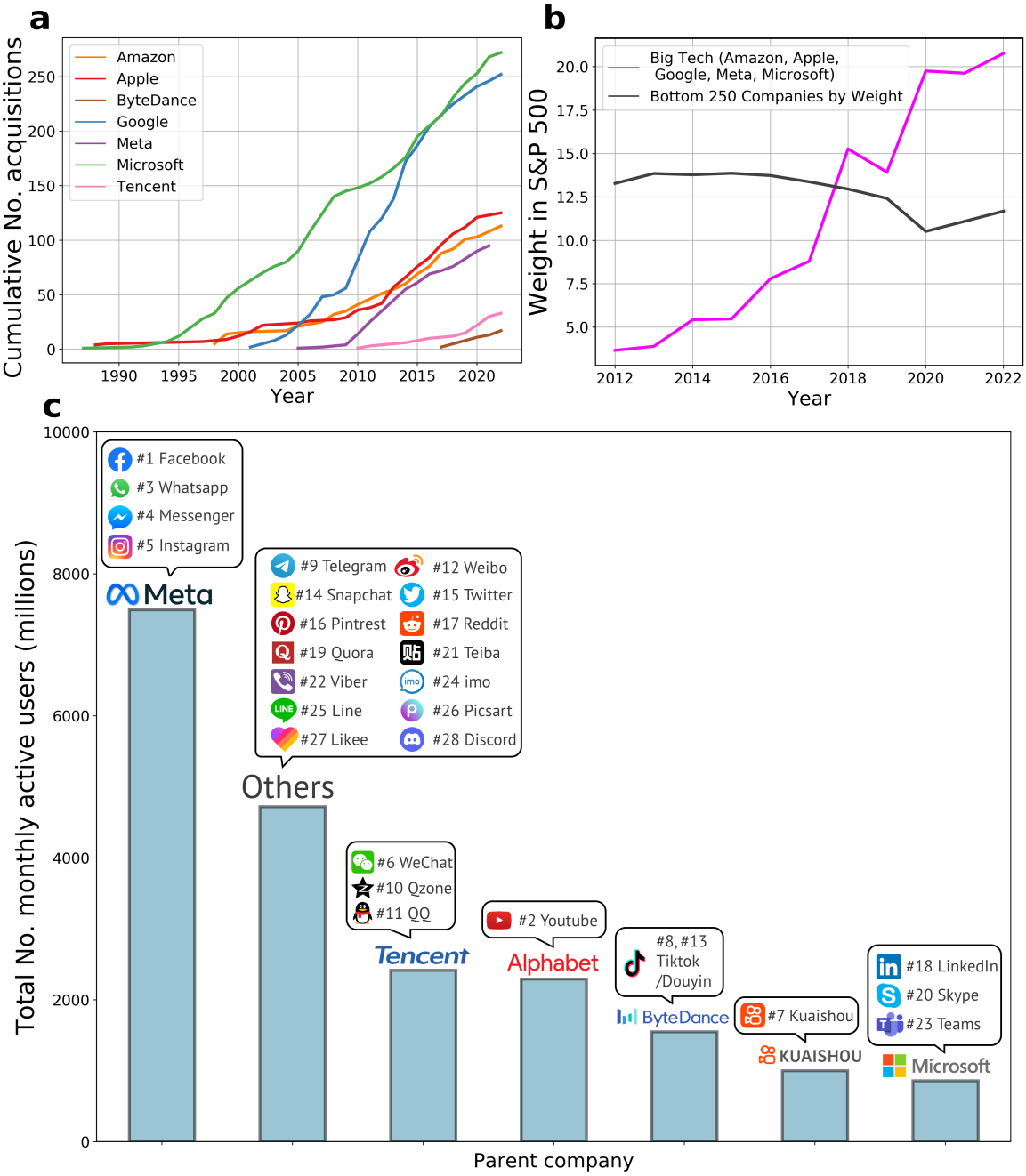

Figure 1: **Examining Big Tech's acquisitions, market cap, and monthly active users. a**, Cumulative number of acquisitions made by each Big Tech company over time. **b**, The magenta curve represents the weight of US-based Big Tech in the S&P 500 Index over time. The black curve is similar, except that it corresponds to the 250 companies with the lowest weight in the S&P 500 Index. The weight of each company equals its market capitalization divided by the total market capitalization of the S&P 500 [25]. Non-US based companies (Tencent and ByteDance) are excluded, since they are not listed on the S&P 500. **c**, The 28 social media platforms with the most monthly active users, grouped by their respective parent companies (x-axis), and the total number of users for each parent company (y-axis). Each platform's rank (based on monthly active users) is specified next to its logo. Platforms that do not have a parent company, or do not share one with another platform, are grouped under the parent "Others".

with the largest such number, amassing 272 acquisitions by 2022. However, when considering the average number of acquisitions made per year, we find that Google leads Big Tech in this regard, with about 11.5 acquisitions annually. In total, Big Tech has made 907 different acquisitions over the past 35 years. Figure 1b depicts the weight of US-based Big Tech in the S&P 500 Index, calculated as the aggregate market capitalization of US-based Big Tech companies divided by the total market capitalization of all 500 companies listed in this index. As shown in this figure, the weight of Big Tech has risen from 3.67% in 2012 to 20.67% in 2022, i.e., to a fifth of the total market capitalization of the S&P 500. To better understand the magnitude of this weight, we compare Big Tech to the 250 companies with the least weight in the index each year. As can be seen, in 2012, the weight of Big Tech was only about one fourth of that of the bottom 250 companies (3.67% vs. 13.5%). However, over the following years, the share of Big Tech increased almost steadily while the share of the bottom 250 companies decreased slightly, eventually leading to Big Tech surpassing the bottom 250 in 2018, and having almost double the weight in 2022 (20.67% vs. 11.65%). Having examined the performance of Big Tech in terms of acquisitions and market capitalization, we now turn our attention to the number of users of social media platforms; see Figure 1c. In particular, the figure lists the 28 platforms with the most monthly active users (MAUs), and specifies the rank of each such platform according to MAU. It also groups the platforms by parent company (x-axis), while specifying the total number of MAUs for each such company (y-axis). As for the platforms that do not have a parent company or do not share one with another platform, they are all grouped under the parent "Others" to facilitate the comparison. Out of the six remaining parent companies, five are among the Big Tech companies considered in our study, namely, Alphabet, ByteDance, Meta, Microsoft and Tencent. As the figure illustrates, Meta alone garners control almost 7.5 billion MAUs across its various platforms, and holds four out of the five most popular social media platforms. The remaining companies also control a very large number of MAUs. Specifically, Tencent has 2.4 billion across three platforms, Alphabet has 2.3 billion with YouTube, ByteDance has 1.5 billion under TikTok and it's Chinese version Douyin, and Microsoft has 860 million across its three business oriented social media platforms, namely LinkedIn, Skype and Microsoft Teams.

Given the dominance of Big Tech companies that we have seen in Figure 1, one cannot help but wonder whether major scandals would have a lasting effect on their performance. To find out, we focus on two Big Tech scandals, namely Cambridge Analytica [26] and Batterygate [27]. The former scandal relates to the harvesting of Facebook user data by a firm called Cambridge Analytica, which used this data to construct and sell psychological profiles of American voters to political campaigns [26]. The latter scandal faced by Apple was related to the company allegedly slowing down older iPhones so that consumers would purchase newer models, resulting in a $500 million settlement [28]. We will estimate the effect of these scandals on each company's stock price, and measure the public reaction to the scandal based on the number of tweets mentioning the topic. To estimate the scandal's effect on stock price, we employ the *synthetic control method* developed by Abadie and Gardezabal [29], and later extended by Abadie et al. [30]. Generally, this method is used to evaluate the effect of an intervention on a treatment group by constructing a weighted combination of groups used as control, to estimate what would have happened

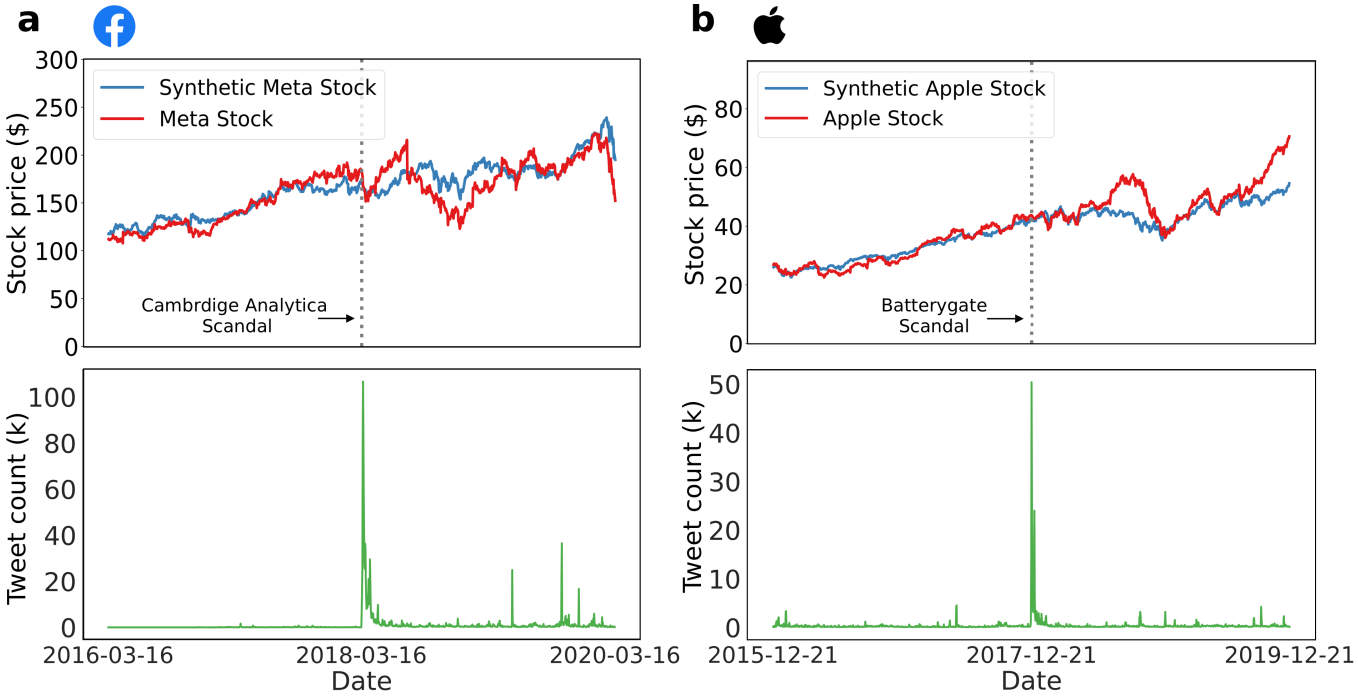

Figure 2: **Temporal analysis of Cambridge Analytica and Batterygate. a**, The upper row depicts Meta's stock price (red) and a synthetic model of Meta's stock price (blue) over time. The bottom row depicts the number of tweets mentioning Cambridge Analytica over time. **b**, The upper row depicts Apple's stock price (red) and a synthetic model of Apple's stock price (blue). The bottom row depicts the number of tweets mentioning Batterygate over time. The vertical dashed lines represent the dates on which the two scandals occurred.

to the treatment group had it not received the treatment. In our context, the treatment received by Meta is the Cambridge Analytica scandal while the treatment received by Apple is the Batterygate scandal. More details regarding our synthetic model can be found in the Methods section. To measure the public reaction to the scandal on Twitter, in the case of Cambridge Analytica, we count the number of tweets that include "Cambridge Analytica" or "#DeleteFacebook"—the trending hashtag soon after the New York Times published its article covering the scandal [26]. As for Batterygate, we count the number of tweets that include the terms "#Batterygate", "Apple slows" or "Apple slowing".

The results for the Cambridge Analytica and Batterygate scandals are depicted in Figures 2a and 2b, respectively. Starting with the former scandal, the figure depicts the temporal trend over the 4-year period centered around the date at which the scandal was first reported by news outlets, i.e., March 16th, 2018. As shown, while Meta's stock price did experience a dip below its expected performance, as represented by its synthetic stock, Meta's stock price rebounded to surpass its expected performance in the year following the scandal. The final dip in performance was due to the market crash at the start of the COVID-19 pandemic. This analysis suggests that the scandal did not have a lasting effect on Meta's stock performance. As for the public reaction to the scandal, the number of relevant tweets exhibited a steep rise on the day the article was published, reaching over 100 thousand tweets. This was followed by a secondary peak during the senate hearing of Meta's CEO Mark Zuckerburg in April 2018. Following the hearing, the number of tweets containing the keywords fell once again, taking the scandal out of the public limelight. Another short peak can be seen towards the end of 2019, which coincides with the SEC fining of Meta as a result of the scandal, reinvigorating public discourse on the scandal once again momentarily. This analysis portrays the ephemeral nature of public discourse surrounding the Cambridge Analytica scandal. As for Batterygate, Figure 2b depicts the temporal trend over the 4-year period centered around the start of the scandal, i.e., December 21st, 2017. As can be seen, the admittance of Apple to throttling the performance of older iPhone models did not have a negative impact on its stock price. In fact, Apple's stock price exceeded its expected performance over the duration of the two years following the scandal, showing a clear resilience to the public backlash regarding the incident. Furthermore, we see a similar trend in tweet counts, with a sharp peak on the day of the release of this information, with a subsequent sharp decline thereafter. These findings suggest that Big Tech companies are resilient to major scandals.

While Big Tech companies may be resilient to scandals in the stock market, we also sought to uncover global public sentiment towards each Big Tech company, and how these sentiments relate to various characteristics of the countries in which the participants reside. To that end, we surveyed 5300 participants from 25 different countries around the globe; see Methods for more details. We ask participants various questions, two of which are the focus of the next analysis; the first asks: "To which degree do you trust these companies?", while the second asks: "To which degree are you worried that these companies might use your private data in a way you consider to be inappropriate?". Participants answered the first question on a scale ranging from "Strongly Mistrust (-2)" to "Strongly Trust (2)", and answered the second question on a scale ranging from " Not at all worried (0)" to "Extremely Worried (4)". Figure 3a depicts the correlation between a country's average response to the first question vs. the country's rank according to various in-

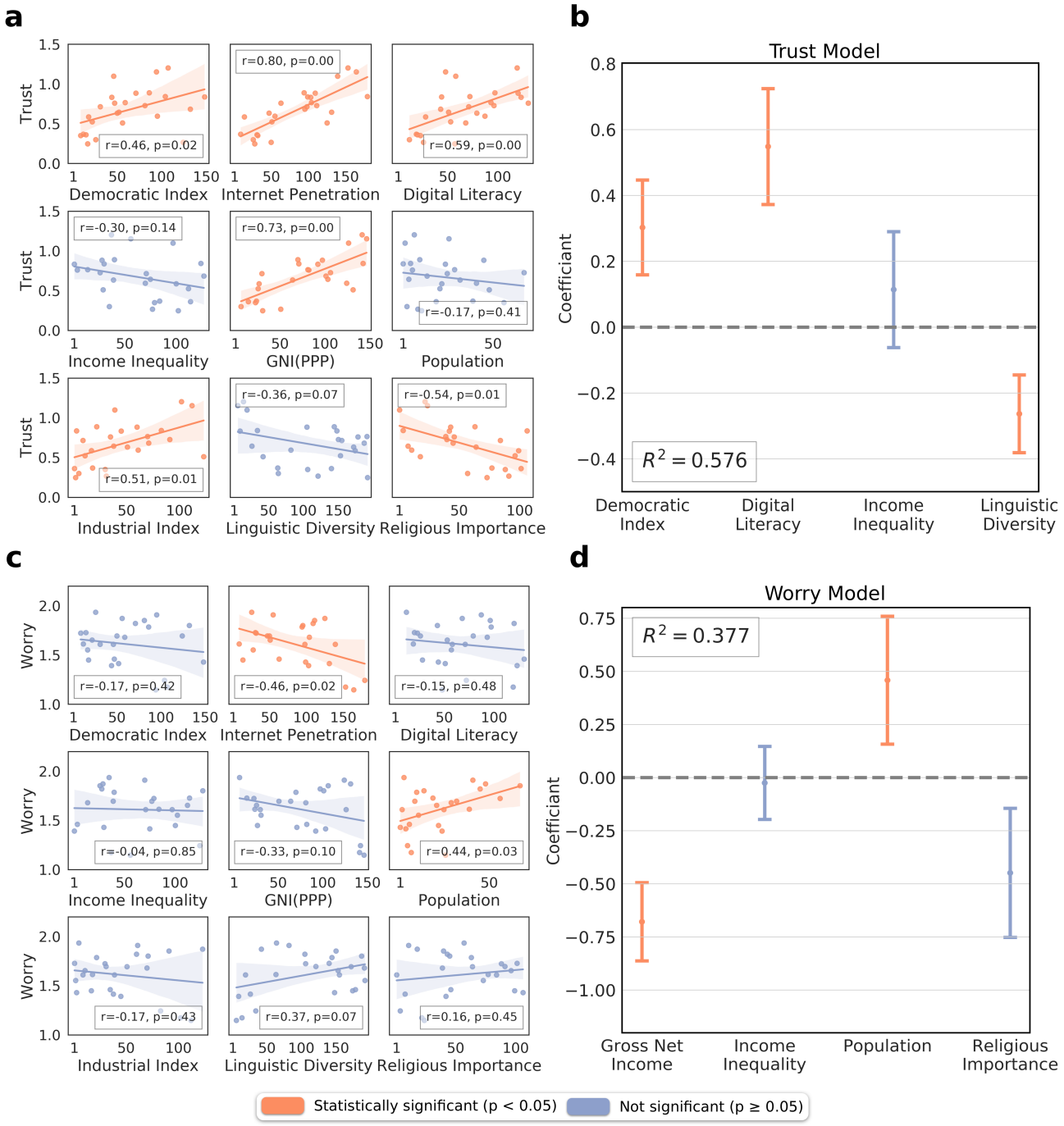

Figure 3: **The relationship between country characteristics and the level of trust and worry in Big Tech companies.** **a**, Correlation between various country characteristics and trust in Big Tech. **b**, Regression results of trust as a function of democratic index rank, digital literacy rank, income inequality rank, and linguistic diversity rank. **c**, Correlation between various country characteristics and worry regarding data misuse by Big Tech. **d**, Regression results of worry as a function of gross national income at purchasing power parity per capita rank, income inequality rank, population rank, and religious importance rank. Correlations and control variables highlighted in orange were statistically significant, while those highlighted in purple were not.

dices. More specifically, the indices include the country's democratic index (DI), internet penetration (IP), digital literacy (DL), income inequality (II), gross net income at purchasing power parity per capita (GNI), population (POP), industrialization (IND), linguistic diversity (LD) and religious importance (RI). These indices were chosen as descriptors which evaluate different characteristics of a country's population from political, economical, cultural and religious perspectives. As can be seen, the degree to which people trust Big Tech companies is negatively correlated with a country's RI rank, meaning that countries with a greater RI are more trusting of Big Tech (note that the country with the lowest rank, i.e., 1, has the highest index value). On the other hand, the degree to which people trust Big Tech companies is positively correlated with a country's DI, IP, DL, GNI, and II rank, meaning that countries with greater such indices are less trusting of Big Tech. Next, we model trust in Big Tech as a function of multiple indices. To do so, we take the power set of the indices and compute the variance inflation factors of each set. All sets with a maximum variance inflation factor < 5 were then used as a potential control variable set. Out of these, we chose the set which produced the highest R^2 value, i.e., the one that explains the most variance in a country's trust. Figure 3b illustrates the coefficient estimates and standard errors of the terms of the resulting model excluding the intercept; this model achieves an R^2 value of 0.576. As can be seen, trust is positively correlated with a country's DI and DL ranks and negatively correlated with the LD rank. Figure 3c and 3d are similar to 3a and 3b except that they focus on participant responses to the second question rather than the first. As shown, there are far less indices that are significantly correlated with participant responses, with only IP and POP having a positive and negative correlation, respectively. Figure 3d shows the coefficient estimates of the model with the highest R^2, which was 0.377. A reflection on these findings can be found in the Discussion section. Moreover, Supplementary Note 2 provides a comparison of responses to the aforementioned two questions in developed vs. developing countries, as well as a comparison of responses based on participants' gender and age. Finally, Supplementary Note 3 details the regression results of the two models used in the above analysis.

Figure 4a summarizes participants' responses to the first question for each Big Tech company, with the orange box plots showing the percentage of participants whose answer was either "Strongly Mistrust (-2)" or "Somewhat Mistrust (-1)", and red box plots showing the percentage of participants who answered "Strongly Mistrust (-2)". As can be seen, participants tend to trust traditional tech companies (Amazon, Apple, Google, and Microsoft) more than social media platforms (Facebook, TikTok, and WeChat). Figure 4b is similar to 4a, except it focuses on the answers to the second question instead of the first. Again, we find that people are more worried about data misuse from social media platforms than traditional tech companies. Having analyzed participant responses to the first and second questions, we now focus on eight remaining questions, labeled Q1 to Q8, all of which are True or False questions. These are listed in Figures 4c to 4j, respectively, along with the proportion of participants who selected "True" in each country. These questions can be grouped into different themes surrounding technology usage. In particular, Q3 and Q7 address issues surrounding the oligopolistic nature of Big Tech, while Q2, Q6, and Q8 discuss issues related to privacy invasion. Q1, on the other hand, addresses the lack of agency that people have on the data being collected about them, while Q4 discusses addiction to technology. Finally, Q5 asks whether partici-

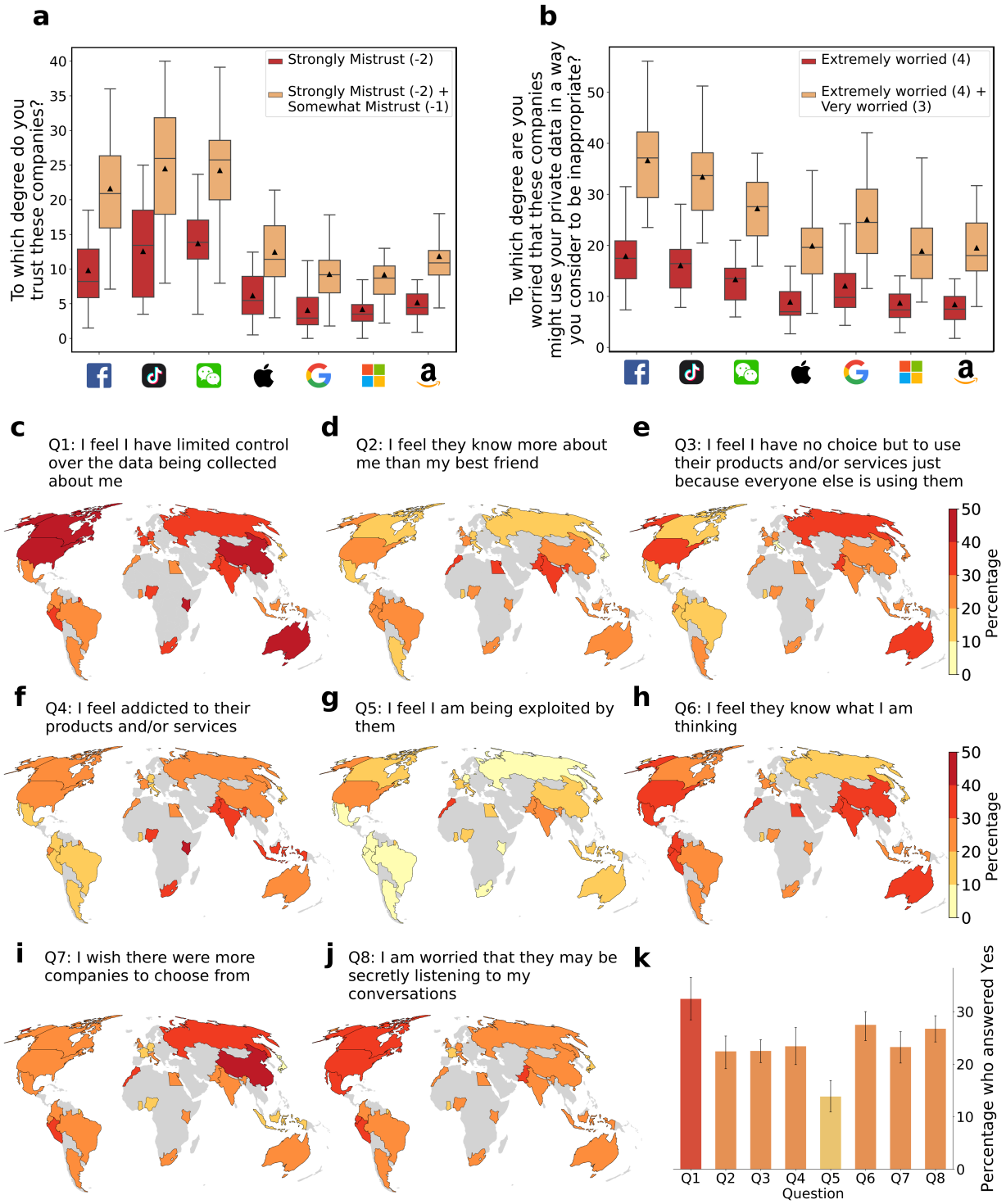

Figure 4: **Summary of survey responses. a**, Box plots corresponding to those who selected "−2" (red) and those who selected either "−1" or "−2" (orange) on the scale (−2, −1, 0, 1, 2) when answering: "*To which degree do you trust these companies?*"; **b**, Box plots corresponding to those who selected "4" (red) and those who selected either "3" or "4" (orange) on the scale (0, 1, 2, 3, 4) when answering: "*To which degree are you worried that these companies might use your private data in a way you consider to be inappropriate?*". **c - k**, Percentage of participants who answered "Yes" to questions Q1 to Q8 in each country, and overall. Error bars represent 95% CI intervals.

pants feel exploited by Big Tech companies. Figure 4k depicts the proportion of participants who selected "True" to each question globally. As can be seen, on a global level, participants were most concerned with the lack of control they had over the data being collected about them (Q1); this concern persists across countries as shown in Figure 4c. The United States, Australia, and Canada were the three most concerned countries, with 53%, 47%, and 46% of participants therein agreeing with the statement, respectively. The second most concerning theme to our participants was privacy invasion, with 1 in 4 participants agreeing with Q6 and Q8, and 1 in 5 agreeing with Q2. The geographic distribution of responses to Q8 in Figure 4j reveals that people in North America are more concerned with being secretly listened to than other regions. Many participants were also concerned with the lack of alternative options available to them, with 23% of participants agreeing with Q3 and 24% agreeing with Q7, highlighting the adverse effect of the oligopolistic nature of Big Tech on consumer choice. Looking at the geographic distribution of responses to Q7 in Figure 4i, we find that participants in China were the most to agree with Q7. This may be related to the fact that many popular online services such as Facebook, Instagram, Google, and Twitter are banned in China. Finally, the question with which participants agreed the least was Q5, with only 1 in 10 people agreeing with the fact that they feel exploited by Big Tech. Supplementary Note 1 specifies the numeric values corresponding to each country, and compares participants' responses to Q1-Q8 based on age and gender.

Discussion

Our study highlighted the growing dominance of Big Tech through a look at a number of key metrics, including their acquisitions, market capitalization, and number of users at their disposal. However, this level of power has not come without engaging in predatory acquisitions. While such acquisitions may be of benefit to budding start-ups, enabling their creators to reap the benefits of their creations quickly, this is ultimately detrimental to overall market innovation. In particular, the characteristics of many tech start-ups do not meet the current turnover thresholds for merger investigation, as many do not monetize their products until acquiring a large user base [31]. These start-ups, if not acquired, may have otherwise boosted the competitive functioning of the market and offered consumers an alternative option for online services, a sentiment which many of our participants have echoed. As users do not typically pay for services offered by technology companies, these companies must balance an increase in advertising—the primary method by which they generate revenue—with the associated loss in viewership by the consumer. With a decrease in market competitiveness, consumers may be subjected to an increase in ad load if no suitable competitors are available. Furthermore, tech monopolies are characterized as part of a growing trend of *intellectual monopoly capitalism*—the economic concentration of intangible assets, mainly data—which is increasingly raising concerns in academic circles [32, 33, 34, 35, 36, 37]. Due to these characteristics, some scholars have argued that all acquisitions made by Big Tech firms should be notified to anti-trust authorities, not necessarily to block such acquisitions, but to monitor anti-competitive practices effectively [38]. Indeed, the European Council has approved such legislation, namely the Digital Markets Act, labelling companies

as "gatekeepers" that are capable of stifling competition; this legislation is expected to take effect in January 2023. With regards to Meta, many have criticized the acquisition strategy adopted by the company. Most notably, Meta co-founder and CEO, Mark Zuckerburg, stated that the company could "always just buy any competitive startups" according to emails obtained by Congress [39]. Indeed, Facebook's acquisitions of Instagram and WhatsApp have been argued to exemplify the use of a merger to limit competition.

This predatory acquisition behaviour, in addition to the breaching of numerous anti-trust and privacy regulations, have subjected Big Tech companies to a number of significant fines. Yet, the efficacy of these fines in deterring Big Tech from violating the law has come into question. Our study investigated these claims, proving scientifically the resilience exhibited by Big Tech in the face of large public scandals with regards to their stock price performance. This was done by utilizing the synthetic control method to estimate the stock price of Meta and Apple in a counterfactual world in which they did not face their respective scandals. Furthermore, we have shown the ephemeral nature of these scandals in the public eye, with online discourse on the matter quickly fading shortly after the scandal was revealed to the public. These findings clearly indicate that massive public scandals alone do not seem to have a lasting detrimental effect on the performance of Big Tech companies. Many policy-makers have voiced their concerns regarding the efficacy of the fines levied on Big Tech. Margrethe Vestager, the European Union's head of digital policy stated that companies such as Apple would rather periodically be fined than comply with the law [40]. Alphabet, for instance, has listed fines from the European Commission under "costs and expenses" in a recent financial report, an unsurprising fact given that the fine of 4.3 billion euros levied by the European Commission in 2018 only amounted to 3.7% of Alphabet's revenue that year. These opinions, coupled with our findings, indicate that more stringent regulation is needed to curb the power of Big Tech.

Considerations made by international policy-makers and anti-trust authorities must consider the relationships and sentiments of those who live in a particular country as they relate to their interactions with the services of Big Tech companies. Our study sheds light on such sentiments by examining trust in Big Tech and worry regarding data misuse in relation to a country's characteristics. We have shown that "trust" is negatively correlated with a country's democratic index and digital literacy, suggesting that those living in more authoritarian regimes or those with lower digital literacy may be more easily exploited into giving unnecessary data or permissions. Indeed, some scholars have argued that this may be already taking place in the form of "digital colonialism" by which Big Tech corporations control online experiences in the Global South, giving them power over various domains of life from politics to culture [41, 42, 43]. As of yet, African and Asian countries have the lowest adoption rates of some form of data privacy legislation, with only 61% and 57%, respectively. Moreover, out of the least developed countries, only 48% have adopted or drafted data protection legislation [44]. As mentioned previously, these laws are only as effective as their ability to deter Big Tech from violations, which is currently under scrutiny.

The results of our study have also revealed the key concerns participants face with regards to technology usage, with over 30% of them mentioning the lack of control they have over the data being collected about them, despite many of our participants coming from countries with data-protection legislation. In addition, many were concerned that Big Tech platforms seem to know what they are thinking; this could be

related to recent breakthroughs in machine learning and big data analysis, which allow companies to infer an individual's opinion on topics without their explicit statement [45]. Many participants also indicated that they are worried Big Tech companies may be secretly listening to their conversations, although this sentiment seems to be mostly concentrated in North America, where the documents leaked by former NSA contractor Edward Snowden garnered significant media attention in the region [46]. Finally, 25% of our participants indicated that they wish there were more companies to choose from, highlighting the adverse effects of the Big Tech oligopoly on consumer choice. These findings, taken as a whole, offer insights to policy-makers and regulators on the power of Big Tech, the lack of impact current regulations have had on their performance, and the characteristics and concerns of those directly affected by Big Tech's violations.

Methods

With regards to the synthetic control method, stock data for each of the companies listed in the NASDAQ-100 Technology Sector Index were collected from the years 2015 to 2022. To select the companies which would act as a control group within the experiment, we compute the functional principal component scores for each company's stock price, and apply K-means clustering to identify companies which best fit the target company, which is either Meta or Apple, depending on the scandal under consideration. The number of clusters chosen was four, which was determined using the silhouette method, dropping the number of companies in the cluster to 66 in total. For each scandal and its associated target company, we bootstrap a synthetic control model over 200 iterations to estimate the effect of the scandal on the company's stock price. Validation tests were performed to determine the validity of the models, which can be seen in Supplementary Note 4.

With regards to the survey, participants (N = 5300) were recruited from 25 countries (ranging between 203 and 291 participants per country). The study was conducted by a CITI-trained [47] person following Institutional Review Board (IRB) approval (HRPP-2022-56) from New York University Abu Dhabi. The survey was conducted online and did not request any identifiable or personal information. Participants in the survey were recruited via the Survey Monkey online platform, which collects responses from participants within the designated countries chosen by the surveyor. Studies have shown the validity of using Survey Monkey for conducting market research surveys, in addition to the numerous studies which use such platforms for conducting surveys globally [48, 49, 50, 51, 52]. The platform utilizes email and location verification to detect fraud and ID exclusions, thereby preventing duplicate and bot-submitted responses to a survey. The 25 countries included in this survey are distributed across continents as follows: 6 from Africa, 5 from South America, 5 from Asia, 5 from Europe, 3 from North America, and 1 from Australia. These were chosen as the most populous countries on each continent out of the those available on Survey Monkey. The list of countries can be seen in Supplementary Note 1.

Data Availability

The data collected for the synthetic control model, the regression models, and the survey that ran across 25 countries can be found at the following repository: https://github.com/comnetsAD/oligopoly. Information regarding the data sources for both the synthetic control model as well as the regression models can be found in Table 1.

Dataset	**Source**
Stock Data	Yahoo Finance [53]
Democratic Index	Economist Intelligence Unit [54]
Digital Literacy	World Economic Forum Global Competitiveness Report [55]
Gross National Income in Purchasing Power Parity per capita	The World Bank [56]
Income Inequality	United Nations Human Development Report [57]
Industrialization	United Nations Industrial Development Report [58]
Internet Penetration	World Telecommunication/ICT Indicators Database [59]
Linguistic Diversity	Alesina et. al. [60]
Population	U.S. Census Bureau [61]
Religious Importance	Pew Research Center [62]

Table 1: Data sources.

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Author Contributions

T.R., and Y.Z. conceived the study; H.I., T.R., and Y.Z. designed the experiments and wrote the manuscript; M.D., T.R., and Y.Z. designed and ran the survey; H.I performed the analysis and produced the figures.

Competing Interests

The authors declare no competing interests.

Supplementary Information for

Big Tech dominance despite global mistrust

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This document is structured as follows:

- **Supplementary Note 1** (*page 2*) Miscellaneous concerns with technology usage
- **Supplementary Note 2** (*page 5*) Mistrust and worry in Big Tech
- **Supplementary Note 3** (*page 7*) Regression results
- **Supplementary Note 4** (*page 9*) Synthetic control model validation

Supplementary Note 1. Miscellaneous Concerns with Technology Usage

Question	Text
Q1	I feel I have limited control over the data being collected about me
Q2	I feel they know more about me than my best friend
Q3	I feel I have no choice but to use their products and/or services just because everyone else is using them
Q4	I feel addicted to their products and/or services
Q5	I feel I am being exploited by them
Q6	I feel they know what I am thinking
Q7	I wish there were more companies to choose from
Q8	I am worried that they may be secretly listening to my conversations

Supplementary Table 1: Question number and the wording used in each question.

Question	Kenya	Egypt	Nigeria	South Africa	India	Pakistan	Indonesia	Ghana	Morocco
Q1	42.0	24.0	36.0	38.0	38.0	36.0	23.0	21.0	29.0
Q2	26.0	31.0	21.0	27.0	35.0	34.0	20.0	15.0	37.0
Q3	23.0	25.0	24.0	27.0	25.0	31.0	20.0	16.0	25.0
Q4	46.0	21.0	34.0	34.0	33.0	38.0	34.0	16.0	22.0
Q5	8.0	17.0	14.0	9.0	29.0	20.0	15.0	14.0	30.0
Q6	23.0	31.0	23.0	25.0	36.0	34.0	28.0	14.0	31.0
Q7	24.0	24.0	15.0	27.0	28.0	29.0	16.0	19.0	33.0
Q8	23.0	26.0	26.0	26.0	24.0	30.0	25.0	18.0	29.0

Question	Argentina	Peru	Ecuador	Colombia	Mexico	China	Brazil	Average
Q1	25.0	30.0	28.0	24.0	23.0	43.0	24.0	30.2
Q2	18.0	21.0	26.0	20.0	15.0	25.0	24.0	24.7
Q3	21.0	16.0	24.0	16.0	17.0	29.0	17.0	22.2
Q4	17.0	12.0	24.0	17.0	13.0	22.0	19.0	25.1
Q5	6.0	4.0	7.0	3.0	4.0	11.0	8.0	12.4
Q6	29.0	32.0	32.0	35.0	32.0	35.0	29.0	29.3
Q7	23.0	32.0	27.0	20.0	21.0	45.0	28.0	25.7
Q8	29.0	39.0	37.0	27.0	38.0	24.0	27.0	28.0

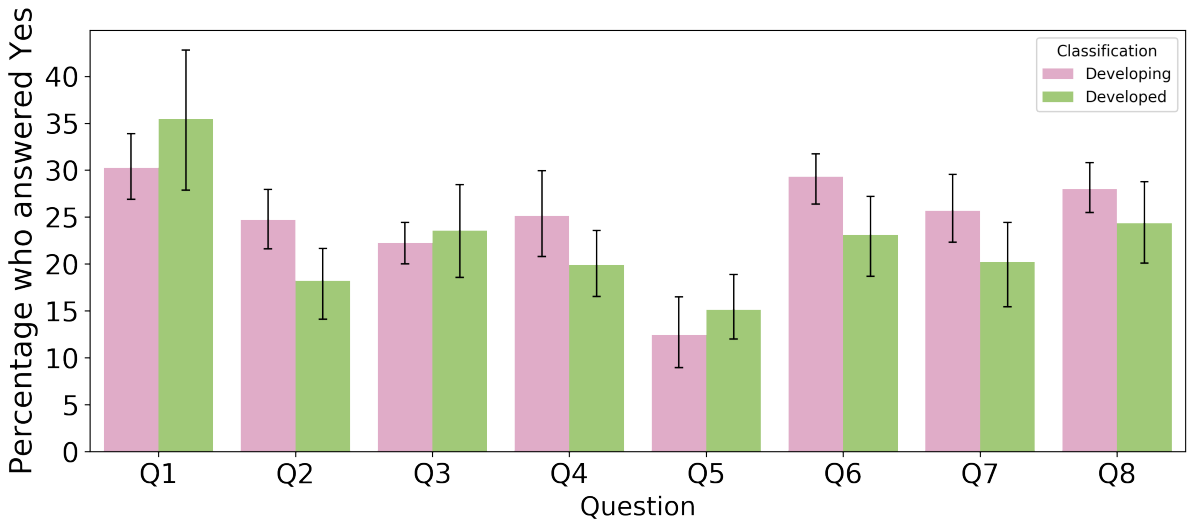
Supplementary Table 2: Distribution of responses to Q1-Q8 across developing countries.

Question	Canada	Australia	UK	USA	France
Q1	46.0	47.0	39.0	53.0	30.0
Q2	19.0	20.0	20.0	27.0	23.0
Q3	17.0	31.0	23.0	34.0	21.0
Q4	23.0	29.0	20.0	24.0	21.0
Q5	16.0	17.0	15.0	28.0	16.0
Q6	26.0	32.0	23.0	30.0	24.0
Q7	26.0	23.0	20.0	26.0	10.0
Q8	30.0	24.0	28.0	38.0	16.0
Question	Japan	Italy	Germany	Russia	Average
Q1	13.0	24.0	34.0	33.0	35.4
Q2	4.0	15.0	17.0	19.0	18.2
Q3	21.0	9.0	23.0	33.0	23.6
Q4	12.0	13.0	13.0	24.0	19.9
Q5	15.0	11.0	9.0	9.0	15.1
Q6	12.0	28.0	17.0	16.0	23.1
Q7	9.0	21.0	17.0	30.0	20.2
Q8	14.0	23.0	21.0	25.0	24.3

Supplementary Table 3: Distribution of responses to Q1-Q8 across developed countries.

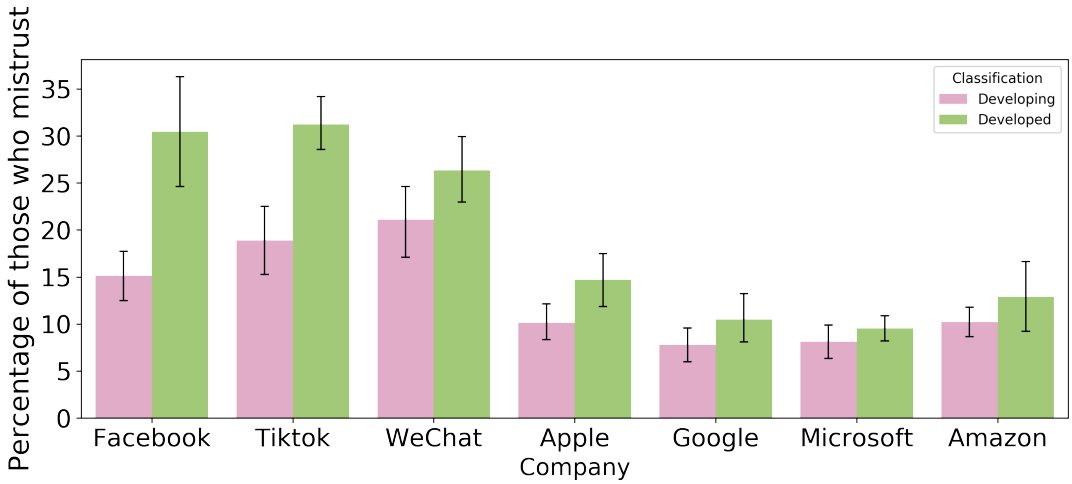
Question	18-29	30-44	45-60	≥ 60	Female	Male
Q1	34.0	32.0	33.0	33.0	32.0	34.0
Q2	24.0	22.0	25.0	16.0	21.0	24.0
Q3	23.0	24.0	24.0	24.0	21.0	26.0
Q4	29.0	23.0	16.0	11.0	22.0	26.0
Q5	14.0	13.0	15.0	16.0	12.0	16.0
Q6	30.0	31.0	19.0	14.0	27.0	29.0
Q7	24.0	27.0	22.0	18.0	22.0	27.0
Q8	30.0	29.0	21.0	16.0	27.0	28.0

Supplementary Table 4: Distribution of responses to Q1-Q8 across different genders and ages.

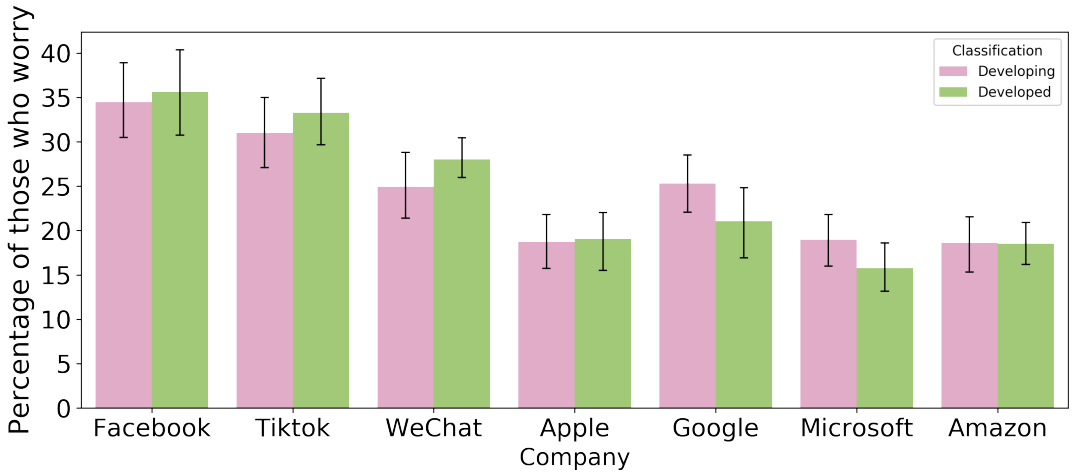


Supplementary Figure 1: **Miscellaneous concerns vs. country classification.** With regards to questions Q1-Q8, we plot the percentage of those who answered "Yes" to each of the questions, split by country classification as designated by the United Nations.

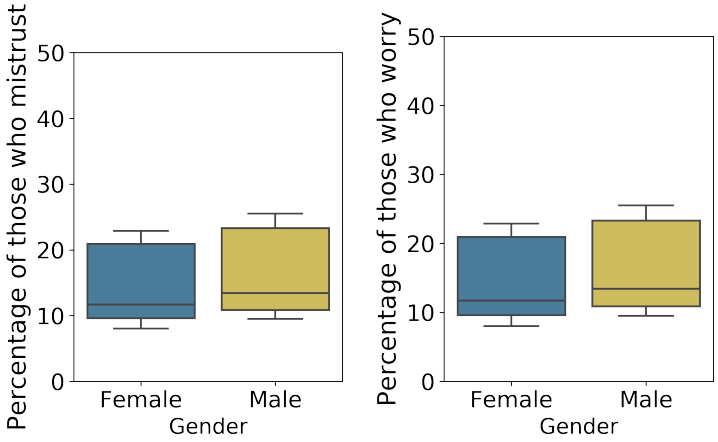
Supplementary Note 2. Mistrust and Worry in Tech Companies



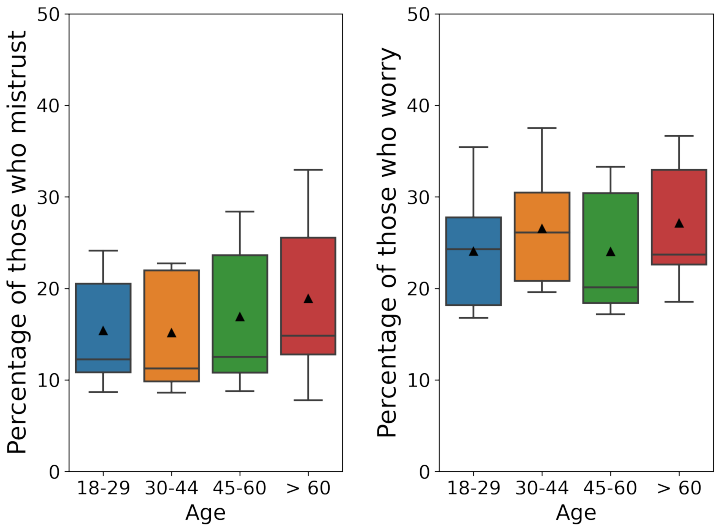
Supplementary Figure 2: **Mistrust vs. country classification.** For the question about the level of trust in Big Tech companies, we plot the percentage of those who answered "Strongly Mistrust (-2)" or "Slightly Mistrust (-1)" for each company, split by country classification as designated by the United Nations.



Supplementary Figure 3: **Worry vs. country classification.** For the question about the level of worry regarding data misuse by Big Tech companies, we plot the percentage of those who answered "Extremely Worried (4)" or "Very Worried (3)" for each company, split by country classification as designated by the United Nations.



Supplementary Figure 4: **Responses to survey questions divided by gender.** **a**, For the question about the level of trust in Big Tech companies, we plot the percentage of those who answered "Strongly Mistrust (-2)" or "Slightly Mistrust (-1)" for each company, split by gender. **b**, For the question about the level of worry regarding data misuse by Big Tech companies, we plot the percentage of those who answered "Extremely Worried (4)" or "Very Worried (3)" for each company, split by gender.



Supplementary Figure 5: **Responses to survey questions divided by age.** **a**, For the question about the level of trust in Big Tech companies, we plot the percentage of those who answered "Strongly Mistrust (-2)" or "Slightly Mistrust (-1)" for each company, split by age. **b**, For the question about the level of worry regarding data misuse by Big Tech companies, we plot the percentage of those who answered "Extremely Worried (4)" or "Very Worried (3)" for each company, split by age.

Supplementary Note 3. Regression Results

	Trust
Democratic Index Rank	0.30*
	(0.14)
Digital Literacy Rank	0.55**
	(0.18)
Income Inequality Rank	0.11
	(0.17)
Linguistic Diversity Rank	-0.26*
	(0.12)
N	25
R^2	0.58

Supplementary Table 5: Trust regression results.

	Variance Inflation Factor (VIF)
Democratic Index Rank	2.74
Digital Literacy Rank	2.79
Income Inequality Rank	2.56
Linguistic Diversity Rank	3.10

Supplementary Table 6: Variance inflation factors of control variables in trust model.

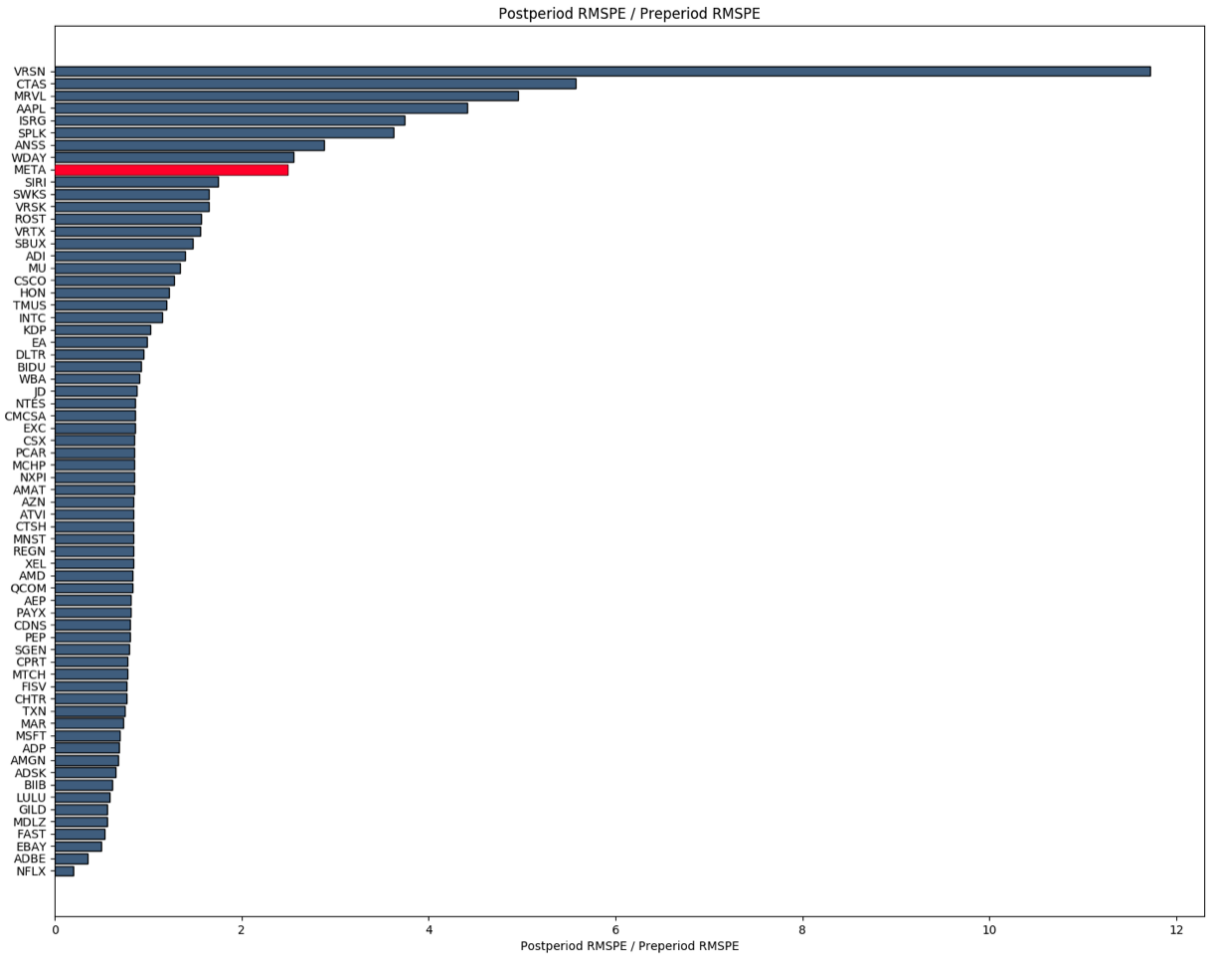
	Worry
Population Rank	0.46*
	(0.18)
Income Inequality Rank	-0.02
	(0.17)
GNI PPP Rank	-0.68*
	(0.30)
Religious Importance Rank	-0.45
	(0.30)
N	25
R^2	0.38

Supplementary Table 7: Worry regression results

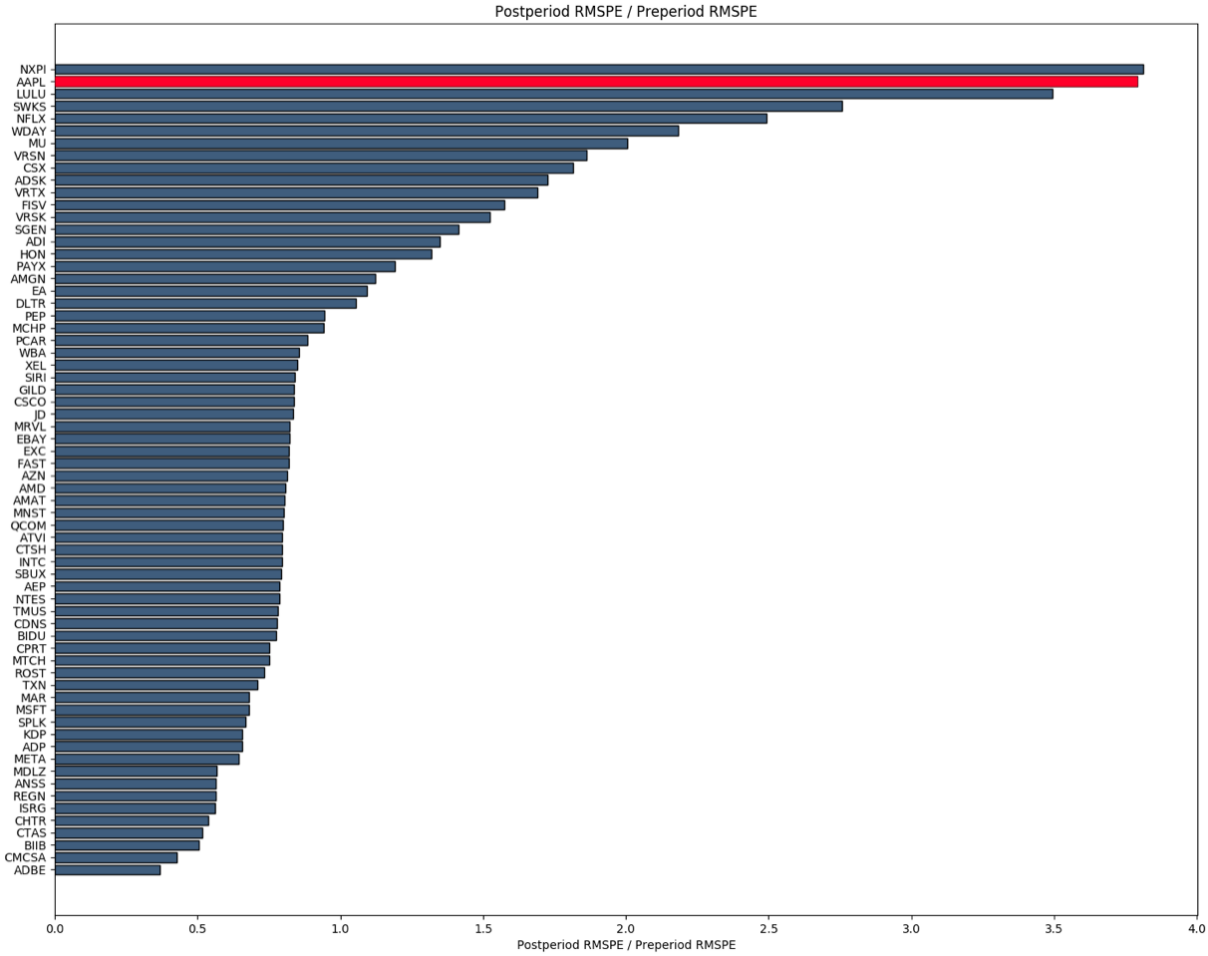
	Variance Inflation Factor (VIF)
Population Rank	2.45
Income Inequality Rank	3.52
GNI PPP Rank	2.42
Religious Importance Rank	3.23

Supplementary Table 8: Variance inflation factors of control variables in worry model.

Supplementary Note 4. Synthetic Control Model Validation



Supplementary Figure 6: **In-space placebo test for synthetic Meta stock model.** For each of the companies included in the control group, we plot the ratio of the post-treatment RMSPE vs. the pre-treatment RMSPE. Considering that Meta (highlighted in red) is not the company with the highest error ratio, we can not conclusively say that the Cambridge Analytica scandal had a significant impact on the stock price of the company.



Supplementary Figure 7: **In-space placebo test for synthetic Apple stock model.** For each of the companies included in the control group, we plot the ratio of the post-treatment RMSPE vs. the pre-treatment RMSPE. Considering that Apple (highlighted in red) is not the company with the highest error ratio, we can not conclusively say that the Batterygate scandal had a significant impact on the stock price of the company.