Big Tech Dominance Despite Global Mistrust

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***Abstract*—The technological and online experiences of billions worldwide are 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 toward, 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 feels they lack control over the data collected about them, and one in four feels that Big Tech knows what they are thinking, knows more about them than their best friend, and may even be secretly listening to their conversations. Additionally, one in four feels addicted to Big Tech products, have no choice but to use them, and wishes 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 policymakers aiming to curb their dominance.**

***Index Terms*—Policy, technology, trust.**

I. 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, whichcontrols 65 to 70 percent of all U.S. online marketplace sales [4], also engages in self-preferencing behavior, 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 U.S. 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 antitrust investigations over the past decade. In the United States, the House Judiciary Subcommittee (HJC) on antitrust released a report titled "Investigation of Competition in Digital Markets" documenting anticompetitive conduct by Alphabet, Amazon, Apple, and Meta, and highlighting key limitations in current antitrust laws and their enforcement [4]. As of the writing of this article, 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.

II. Background and Related Work

Due to privacy violations, lack of transparency, and breaches of antitrust rules, many Big Tech companies incurred substantial fines. In December 2021, for example, Italy's antitrust regulators issued a $1.3 billion fine against Amazon for breaking antitrust 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

Manuscript received 17 May 2023; revised 1 September 2023 and 19 November 2023; accepted 24 November 2023. Date of publication 2 January 2024; date of current version 31 May 2024. *(Corresponding author: Yasir Zaki.)*

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This article has supplementary downloadable material available at https://doi.org/10.1109/TCSS.2023.3339183, provided by the authors.

Digital Object Identifier 10.1109/TCSS.2023.3339183

was subjected to a €2.42 billion fine by the European Commission due to self-preferencing behavior [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 antitrust 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 antitrust 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. While the impact of Big Tech's dominance on the economy has been a well studied area of research [22], [23], [24], [25], [26], [27], sentiments toward Big Tech has not yet been examined at scale. Nonetheless, a few studies have examined user sentiments toward 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 U.S.-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 [28]. Another study examined user attitudes toward 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 [29]. Finally, one study examined the relationship between awareness of privacy scandals and attitudes toward 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 [30].

Despite the above research, the literature still lacks a global study comparing user attitudes toward 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 antitrust 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.

III. Methods

This study included three distinct analyses, which, taken as a whole, aimed to portray the Big Tech's shared power despite the lack of trust individuals have in some of these companies. We first begin with an exploratory examination of the performance of Big Tech over time, particularly with regards to their number of acquisitions, shared weight in the stock market, as well as their number of users. Next, we portray the lack of effects that major scandals had on the stock price of both Meta and Apple namely Cambridge Analytica [31] and Batterygate [32]. 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 [31]. 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 [33]. Of the numerous scandals which Big Tech companies have faced, these two scandals were chosen due to their consumer facing nature, where users of these two companies were directly affected. Furthermore, these two scandals have both taken place over the last decade and have received significant media coverage. 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 Gardeazabal [34], and later extended by Abadie et al. [35]. We utilize this methodology to estimate the counterfactual stock price for Meta and Apple in the case where they did not face their respective scandals. This methodology allows for the construction of a counterfactual by selecting a weighted average of the outcome variable from a group of units similar to the treated unit. In our case, the treated unit is the stock price of Meta and Apple, respectively, while the group of units similar to the treated unit is a subset of similar tech companies listed in the NASDAQ-100 Tech index. The synthetic control methodology often relies of "domain experts" to identify the group of units similar to the treated unit. To simplify our search for the groups of similar units, we begin by looking at all companies listed in the NASDAQ-100 tech index, and then use principal component analysis to cluster companies based on the similarity of their performance in the two years before each scandal. We then employ the silhouette method to cluster these companies, leaving us with four clusters. Both Meta and Apple fall into the same cluster of 66 companies, which are listed in Table 35 in supplementary material. While the synthetic control methodology enables one to control for market-level changes that affect all companies in the control group, it would be less effective in controlling for specific events (other than the treatment event) that may have affected the target group in the duration surrounding the time of the treatment.

For each scandal and its associated target company, we bootstrap a synthetic control model over 200 iterations to minimize the prescandal root mean square percentage error (RMSPE),

which gives us the model with the smallest difference between the counterfactual stock price, and the real stock price for a particular company before the scandal took place. To validate our results, we employ an in-space placebo test, which estimates the ratio of postscandal RMSPE to the prescandal RMSPE if each of the other companies in the control group was used as the treated unit. If Meta and Apple were the companies with the highest ratio, this would indicate that the scandal had a clear effect on Meta and Apple alone. The in-space placebo tests can be seen in Figs. 2 and 3 in supplementary material.

We also count the number of tweets mentioning each of the scandals in the two year periods before and after each scandal occurred. 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 [31]. As for Batterygate, we count the number of tweets that include the terms "#Batterygate," "Apple slows," and "Apple slowing." While this is clearly not a perfect representation of the corpus of language used regarding the two scandals, for practical reasons we selected these phrases which explicitly mention each scandal.

Finally, we perform a survey with 53 000 participants who were recruited from 25 countries (ranging between 203 and 291 participants per country) in order to estimate the levels of trust individuals have in different tech companies, and the levels of correlation between the responses to the questions on the survey and country level indices, including the country's democratic index, digital literacy, gross national income, income inequality, industrialization, internet penetration, linguistic diversity, population, and religious importance. These indices were chosen as descriptors which evaluate different characteristics of a country's population from political, economical, cultural, and religious perspectives (see Table I for the data sources of these indices). Several studies have investigated correlations between such country-level indicators and a variety of outcome variables. For instance, Yao et al. [36] investigate correlations between a country's democratic index and COVID-19 case fatality rate. Similarly, Wang and Hao [37] utilize national level indicators such as internet penetration, GDP per capita, and population density, in addition to several individual level factors to study sustainable consumption behavior. Note that we deliberately do not restrict our analysis to only those who indicated that they use these platforms, due to the assumption that some may not use these platforms specifically because they do not trust them, or are worried about data misuse.

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 [38], [39], [40], [41], [42]. 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: six from Africa, five from South America, five from Asia, five from Europe, three from North America, and one from Australia. These were chosen as the most populous countries on each continent out of the those available on Survey Monkey. While the cost of running the survey differed across countries, the total cost was approximately $33.000. The complete Survey instrument can be found in Note 1 in supplementary material, while the demographics and sample sizes of our survey respondents can be found in Note 2 in supplementary material. To maximize survey respondent awareness of the companies chosen in our analysis, in some cases we ask respondents about specific platforms produced by these companies rather than asking about the parent company itself which may be less known. For instance, in the case of Meta, we surveyed respondents on their opinions of Facebook, rather than Meta, since Facebook's rebranding to Meta was relatively new at the time of the study. Similarly, we asked respondents about Google rather than Alphabet, WeChat rather than Tencent, and TikTok rather than ByteDance, since these are more recognizable emblems of their parent companies. However, in the case of Amazon and Apple, we ask participants about the parent companies directly.

The research was approved by the Institutional Review Board of New York University Abu Dhabi (HRPP-2022-56) and was performed by a CITI-trained [43] person. All researches were performed in accordance with relevant guidelines and regulations. Informed consent was obtained from all participants.

IV. Results

A. Examining Big Tech's Acquisitions, Market Cap, and Monthly Active Users

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." Alphabet, Amazon, Apple, Meta, and Microsoft were selected due to their relevance in the technological zeitgeist. Indeed, these five companies are well known within the technology community as the "Big Five" or "Big Tech" colloquially [55]. While other companies, e.g., Tesla or NVIDIA, may currently hold a higher market capitalization than Meta, we focus on these five American companies due to the fact that they are used extensively by the general public (as opposed to Tesla, for instance). We include the Chinese companies Tencent and ByteDance to gain insight into public opinion on these companies worldwide, as there have been no inquiries in the literature on the public sentiments toward these companies. Note that, naturally, the level of awareness of these companies may vary across countries, and often there may be other technology companies that are more popular in a specific country than the ones included. However, we restrict our analysis to these seven companies due to their large global reach and number of users worldwide.

We start our analysis with an exploratory examination of the performance of BigTech over time. Fig. 1(a) shows the

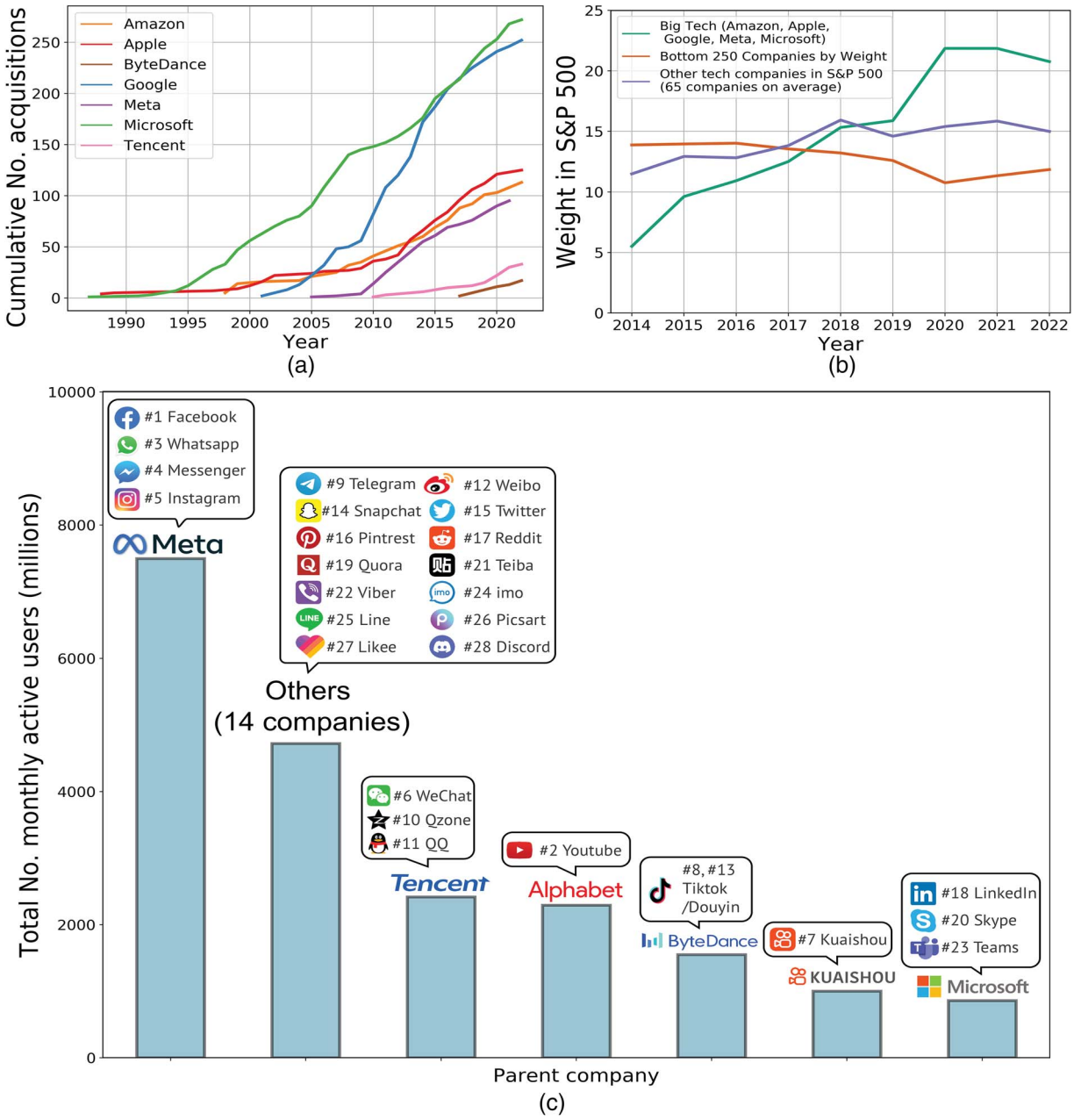

Fig. 1. Examining Big Tech's acquisitions, market cap, and monthly active users. (a) Cumulative number of acquisitions made by each Big Tech company over time. (b) The green curve represents the weight of U.S.-based Big Tech in the S&P 500 Index over time. The orange curve is similar, except that it corresponds to the 250 companies with the lowest weight in the S&P 500 Index. On the other hand, the magenta curve corresponds to the other tech companies in the S&P 500 which are not Big Tech. The weight of each company equals its market capitalization divided by the total market capitalization of the S&P 500 [54]. Non-U.S.-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. The 14 platforms that do not have a parent company, or do not share one with another platform, are grouped under the parent "Others."

cumulative number of acquisitions made by each company since their establishment. Microsoft stands out as the one 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. Fig. 1(b) depicts the weight of U.S.-based Big Tech in the S&P 500 Index, calculated as the aggregate market capitalization of U.S.-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 5.51% in 2014 to 20.76% 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.

TABLE I
DATA SOURCES

Dataset	Source
Stock Data	Yahoo Finance [44]
Democratic Index	Economist Intelligence Unit [45]
Digital Literacy	World Economic Forum Global Competitiveness Report [46]
Gross National Income in Purchasing Power Parity per capita	The World Bank [47]
Income Inequality	United Nations Human Development Report [48]
Industrialization	United Nations Industrial Development Report [49]
Internet Penetration	World Telecommunication/ICT Indicators Database [50]
Linguistic Diversity	Alesina et al. [51]
Population	U.S. Census Bureau [52]
Religious Importance	Pew Research Center [53]

As can be seen, in 2014, the weight of Big Tech was less than half of that of the bottom 250 companies (5.51% versus 13.88%). However, over the following years, the Big Tech's weight increased almost steadily while the weight of the bottom 250 companies decreased slightly, eventually leading to Big Tech surpassing the bottom 250 in 2018, and having almost double the weight of the bottom 250 in 2022. We also compare Big Tech to the weight of all technology companies listed in the S&P 500 which are not a part of Big Tech. As depicted in the figure, the weight of Big Tech companies surpassed that of the remaining technology companies in the S&P 500 in 2019, and held 1.38x more weight in comparison to other technology companies in 2022 (20.76% versus 14.99%), a noteworthy difference considering that Big Tech comprises of only five U.S.-based companies, while there were 65 other technology companies listed on the index in 2022.

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 Fig. 1(c). 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. Specifically, we consider standalone applications that can be downloaded and installed on any device in the world. Thus, an application such as iMessage is not considered since it cannot be downloaded by non-Apple devices. Fig. 1(c) 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. Indeed, Meta alone holds more MAUs than the platforms created by 14 other non-Big Tech companies combined. Importantly, these platforms are considerably well-used, considering they are among the 28 platforms with the most MAUs worldwide. The remaining Big Tech 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.

B. Effects of Major Scandals on Stock Performance and Public Discourse

Given the dominance of Big Tech companies that we have seen in Fig. 1, one cannot help but wonder whether major scandals would have a lasting effect on their performance. The results for the Cambridge Analytica and Batterygate scandals are depicted in Fig. 2(a) and 2(b), 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., 16 March 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 tweets mentioning the Cambridge Analytical scandal, the number of relevant tweets exhibited a steep rise on the day the article was published, reaching over 100 000 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 toward the end of 2019, which coincides with the SEC fining of Meta as a result of the scandal, reinvigorating discourse on the scandal on Twitter once again momentarily. This analysis portrays the ephemeral nature of Twitter discourse surrounding the Cambridge Analytica scandal. As for Batterygate, Fig. 2(b) depicts the temporal trend over the four-year period centered around the start of the scandal, i.e., 21 December 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

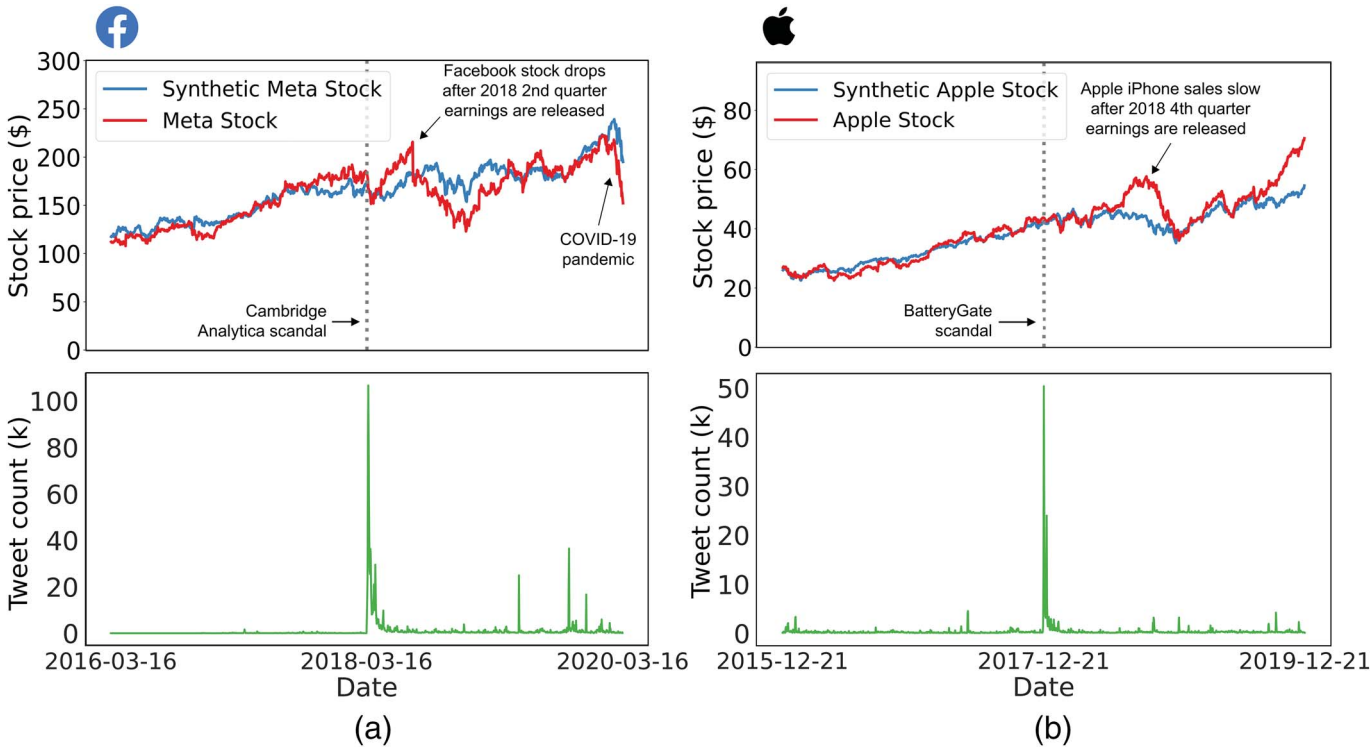

Fig. 2. Temporal analysis of Cambridge Analytica and Batterygate. (a) The upper row depicts Meta's stock price (red) and a synthetic model of Meta's stock price (blue) over time. The bottom row depicts the number of tweets mentioning Cambridge Analytica over time. (b) The upper row depicts Apple's stock 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. Major dips in stock performance in relating to instances other than the scandals in question are highlighted using arrows are shown in (a).

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.

C. Survey

While Big Tech companies may be resilient to scandals in the stock market, we also sought to uncover global public sentiment toward 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 Section III for more details. We ask participants various questions, one of which is the focus of the next analysis, namely, "To which degree do you trust these companies?" 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)." Fig. 3(a) depicts the correlation between a country's average response to the first question across all companies vs. the country's rank according to various indices. More specifically, the indices include the country's democratic index (DI), internet penetration (IP), digital literacy (DL), income equality (INE), gross net income at purchasing power parity per capita (GNI), population (POP), industrialization (IND), linguistic diversity (LD), and religious importance (RI). 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 INE 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. Fig. 3(b) illustrates the coefficient estimates and standard errors of 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. Next, we model trust in Big Tech has a function of participant-level characteristics, which includes both demographic information (their age and gender), as well as responses to other questions in the survey. The results can be seen in Fig. 3(c). As shown in the figure, we find that as a participant uses the products of a Big Tech company less, they are less likely to trust said Big Tech company, with those who had never used a product being the least likely to trust it. Further, we find that those who feel

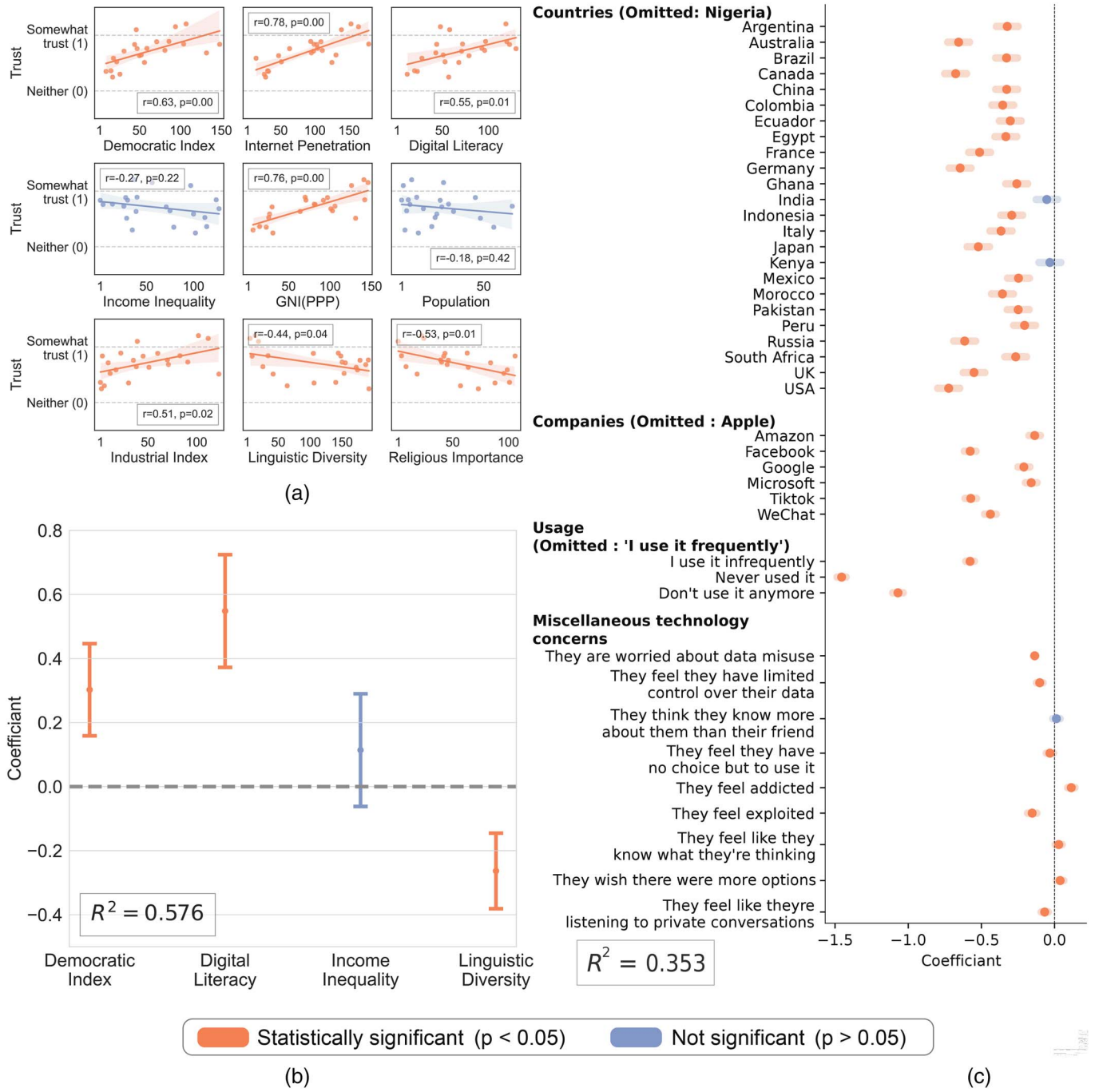

Fig. 3. Relationship between participant and country characteristics and the level of trust in Big Tech companies. (a) Correlation between various country characteristics and trust in Big Tech. (b) OLS-estimated coefficients and 95% confidence intervals of selected independent variables predicting trust in Big Tech as a function of country characteristics, namely, democratic index rank, digital literacy rank, income inequality rank, and linguistic diversity rank. (c) OLS-estimated coefficients and 95% confidence intervals of trust as a function of participant-level characteristics. Note that in (a), we zoom in to better highlight differences along the y-axis. Correlations and control variables highlighted in orange were statistically significant, while those highlighted in purple were not.

exploited by Big Tech companies are least likely to trust them. In contrast, those who feel addicted to Big Tech products were more positively associated with trusting Big Tech. A similar analysis was completed for the question "To which degree are you worried that these companies might use your private data in a way you consider to be inappropriate?," which can be found in Fig. 8 in supplementary material. Response rates to both questions can be in Notes 4 and 5 in supplementary material, respectively. Comprehensive regression details, including the ranks of all of the countries in each of the country-level indexes, can be found in Note 7 in supplementary material.

Fig. 4(a) 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

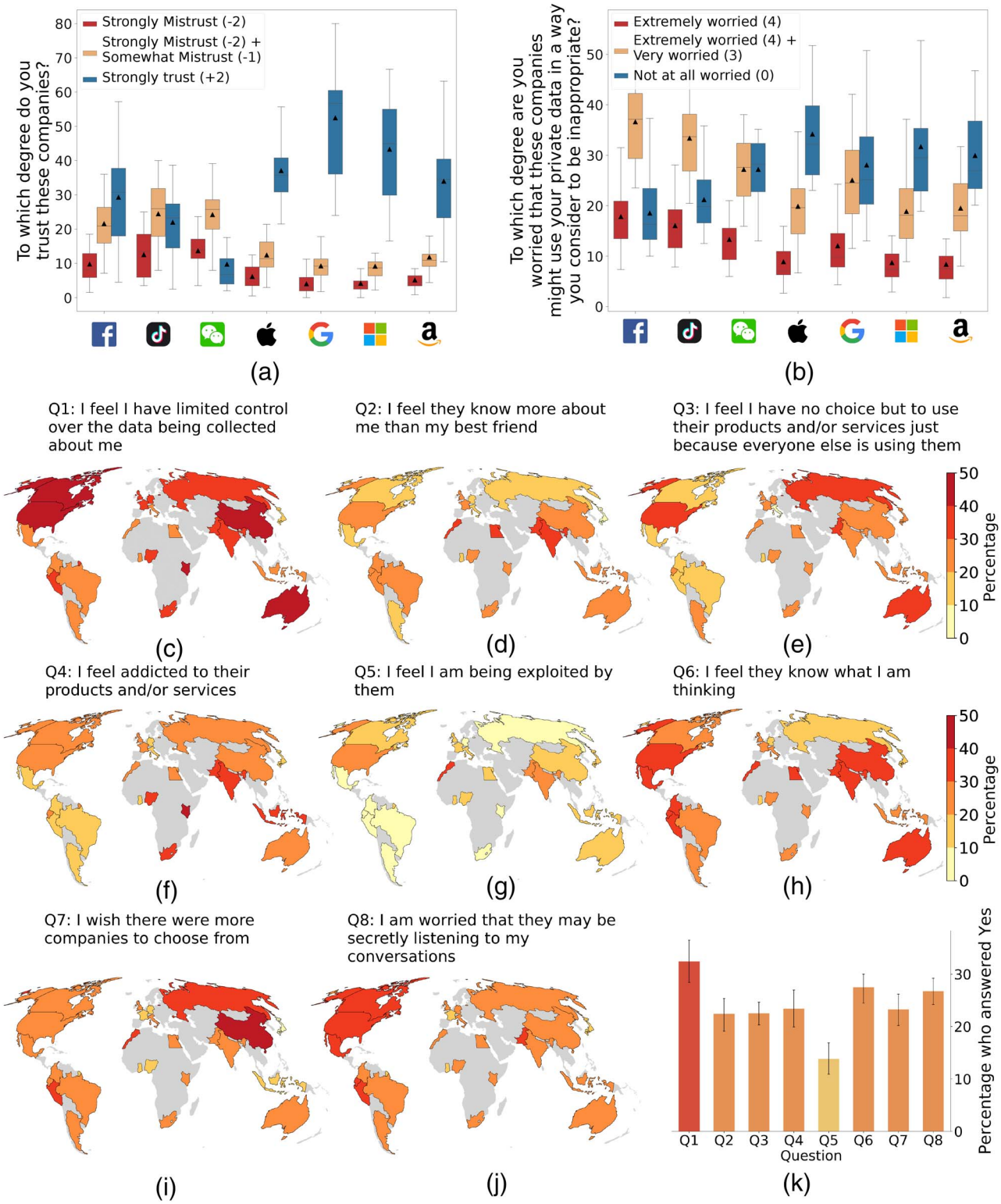

Fig. 4. Summary of survey responses. (a) Box plots corresponding to those who selected "−2" (red), those who selected either "−1" or "−2" (orange), or those who selected "2" (blue) on the scale (−2, −1, 0, 1, 2) when answering: "To which degree do you trust these companies?" (b) Box plots corresponding to those who selected "4" (red), those who selected either "3" or "4" (orange), or those who selected "0" (blue) 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.

"strongly mistrust (−2)" or "somewhat mistrust (−1)," red box plots showing the percentage of participants who answered "strongly mistrust (−2)," and blue box plots showing the percentage of participants who answered "strongly trust (+2)." As can be seen, there was a clear distinction in the responses of participants, where they tend to trust Amazon, Apple, Google, and Microsoft more than Facebook, TikTok, or WeChat. Fig. 4(b) is similar to Fig. 4(a), 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 Facebook, TikTok, and WeChat than the remaining 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 Fig. 4(c)–4(j), 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 participants feel exploited by Big Tech companies. Fig. 4(k) 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 Fig. 4(c). 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 Fig. 4(j) 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 Fig. 4(i), 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. Note 6 in supplementary material specifies the numeric values corresponding to each country and compares participants' responses to Q1–Q8 based on age and gender.

V. 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 [27]. 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 [56], [57], [58], [59], [60], [61]. Due to these characteristics, some scholars have argued that all acquisitions made by Big Tech firms should be notified to antitrust authorities, not necessarily to block such acquisitions, but to monitor anticompetitive practices effectively [62]. Indeed, the European Council has approved such legislation, namely the Digital Markets Act, labeling 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 cofounder and CEO, Mark Zuckerburg, stated that the company could "always just buy any competitive startups" according to emails obtained by Congress [63]. Indeed, Facebook's acquisitions of Instagram and WhatsApp have been argued to exemplify the use of a merger to limit competition.

This predatory acquisition behavior, in addition to the breaching of numerous antitrust and privacy regulations, has 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 on Twitter, with the number of tweets on the matter quickly fading shortly after the scandal was revealed to the public. These findings suggest that massive public scandals alone do not seem to have a lasting detrimental effect on the performance of Big Tech companies. This analysis is not without its limitations. While we use the number of tweets as a simplified proxy for online public attention, future work may examine the sentiment exhibited in these tweets to better map the temporal public opinion toward a given scandal or company

[64]. Tangentially, with regards to the fines levied on Big Tech companies, many policy-makers have voiced their concerns regarding the efficacy of these fines 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 [65]. 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 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 antitrust 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 [66], [67], [68]. 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 [69]. 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. While 30% may seem insignificant, if generalized to all users of Big Tech companies, this would reflect the opinion of hundreds of millions of people. 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 [70]. 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 [71]. 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.

VI. Conclusion

In this study, we demonstrated the collective power of Big Tech companies through an analysis of their acquisitions, market capitalization and monthly active users, showing that, in terms of market capitalization, Big Tech companies collectively share over a fifth of the total market capitalization of the largest 500 U.S. companies. Furthermore, we show that Meta's stock price did not suffer lasting effects due to the Cambridge Analytica scandal, and that public reaction to the scandal on Twitter was ephemeral. We also highlight country-level factors that exhibit correlations with the level of trust one has in Big Tech companies. For instance, those living in countries with lower average digital literacy were more likely to trust Big Tech companies. Lastly, we identify key concerns of Big Tech user with regards to technology usage, most pressing of which was that they feel a lack of control over the data being collected about them. 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.

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