Title

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W(h)ither the Device Divide? Changing Relationships between PC or Mobile Device with Online Activities

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Abstract

The "device divide" occurs when uses of the Internet vary substantially by device. While the mobile phone was welcomed as a way to reduce the general digital divide, much early research presumed that mobile Internet was essentially inferior to PC-based Internet in terms of possible online activities and related benefits. Given ongoing developments in devices, online activities, and socio-demographic differences, we reassess the device divide. After reviewing the concept, and considering mobile phone capabilities that could influence activities, followed by summarizing changes in device usage and online activities in the U.S., we analyze the device divide from 2011-2019 in Armenia. Over time, use of mobile Internet separately and combined with PC Internet grew, and differences in online activity use withered, raising issues of whither device divide research. Nonetheless, in all years, there are continuing demographic-based digital divides after controlling for device divides.

W(h)ither the Device Divide? Changing Relationships between PC or Mobile Device with Online Activities

With the growth in adoption, functionality, power, and connectivity of smartphones, it is time to revisit the "device divide" – the extent to which the *means* of accessing the Internet influence the kinds of, and engagement with, online *activities*, which in turn can affect outcomes. Early mobile phone research argued that these devices could overcome technological, financial, and infrastructural divides associated with personal computers (PCs) and landlines, offering people in lower income countries and the rural and urban poor opportunities to improve their conditions. At the same time, there has been a presumption of PC superiority and mobile inferiority with respect to suitability for different kinds of online activities, dampening those expectations.

Yet devices, online activities, and social contexts continue to evolve and change, raising the question: Whither the device divide? First, we explain the device divide concept. Second, we respond to claims justifying the mobile inferiority argument with evidence from empirical studies. Third, we then discuss mobile device capabilities that influence the potential for mobile phones for online activities. Fourth, we summarize what U.S. Pew data say about the changing nature of device usage and online activities. Fifth, using over-time data from Armenia, we test whether engagement in a set of online activities has changed over time, whether PC or mobile device is associated with different engagement in Internet activities, and whether those activities are associated with socio-demographic differences, another form of the digital divide.

Literature Review

Device Divide

Research about digital divides and inequalities is wide-ranging (e.g., Helsper, 2021; van Dijk, 2020), and has extended its focus from access and adoption, to knowledge and skills, to usage and skills, and to outcomes. We focus on the *device divide*. As mobile phones and smartphones became more widespread, scholars considered the role that the device used to access the Internet plays in affecting inequalities (Chigona et al., 2009; Donner, 2015; Pearce & Rice, 2013). Early on, Rice and Katz (2003) analyzed the Internet/mobile phone divide, showing that distinctions among Internet and mobile phone usage/nonusage was primarily influenced by income and education.

In the early years of mobile Internet, PCs were expensive and required considerable infrastructure, while "dumb" mobile phones were fairly affordable, portable, and did not require an Internet connection. It appeared that smartphones could overcome some of the key barriers to accessing the Internet, such as by "leap-frogging" the challenges associated with of PCs and landlines, especially relevant in rural areas and lower income countries (Huang, 2011; Katz & Rice, 2003; Ranganathan, 2011). However, there were (and are) multiple challenges and costs associated with mobile phone use, especially in developing countries (e.g., Gitau et al., 2010), affected by varying national telecommunications policies and regulation (e.g., Howard & Mazaheri, 2009).

Different aspects of material Internet access (hardware, devices, peripherals, software, maintenance) provide different opportunities or requirements for skills, use and activities, and outcomes (Donner, 2015; Gonzales, 2016; Pearce & Rice, 2013; van Deursen & van Dijk, 2019; van Dijk, 2020). So while mobiles did decrease the access challenge of the digital divide for many, there remained a device divide, whereby engagement in, and thus potential outcomes from, a variety of online activities were considered significantly different for PC- versus mobile-

Internet users (Chigona et al., 2009; Correa et al., 2020; Marler, 2018; Pearce & Rice, 2013, 2017; Tsetsi & Rains, 2017).

Presumption of PC Superiority and Mobile Inferiority

Many of those device divide studies presumed PC superiority and mobile inferiority. In both earlier (Chigona et al., 2009; Donner, 2015; Pearce & Rice, 2013), and newer work (Correa et al., 2020; Lopez-Sintas et al., 2020; Reisdorf et al., 2020; Tsetsi & Rains, 2017), scholars discuss how PC-based Internet use provided access to resources and activities that were more likely to foster the capital needed for greater benefits than did mobile Internet access. Focusing on the drawbacks of mobile Internet (e.g., Ghose et al., 2013), some used the terms "mobile underclass" or "second class netizens" (Napoli & Obar, 2014, 2016a; Wang & Liu, 2018).

Napoli and Obar (2013; 2014; 2016a; 2016b) outlined six such aspects, discussed below. We provide responses based on empirical studies and the changing environment that now call into question some of those claims from that period. We then propose four other characteristics of mobiles that can influence activities. In doing so, we emphasize that the concept of the device divide is related to the changing features, capabilities, and affordances of devices that can affect the ways in which users engage with Internet activities.

Technological Capabilities

Claim. Napoli and Obar posited that technological capabilities, such memory, storage, processing, and speed, were worse for mobiles compared to PCs and that wireless connectivity would not catch up with fixed broadband.

Response. Mobiles are far more powerful than in the past, sometimes even more powerful than PCs (Samsung, 2020). Many users now have access to inexpensive storage and processing, and the difference between PC-based broadband and mobile broadband is less important than it was in the past, especially with 4G and 5G (Quaglione et al., 2020). However, this increased bandwidth is currently less available to rural or underserved than to urban populations (Crotty & Strover, 2020).

Screen Size and Content Viewing

Claim. Smaller screens limit the display of content (Ghose et al., 2013). Napoli and Obar further noted the lack of "mobile-ready" websites (less than 10% of the web in 2012).

Response. Al Ghamdi et al. (2016) showed that size had no impact on comprehension of health information, although it did affect reading time and clarity of organization. While Elliott et al. (2020) indicated no effect on reading speed, Hsieh et al. (2016) reported that individuals read faster on smaller screens. Hilbert and Aravindakshan (2018) showed that larger screens were associated with more extensive sessions, while smaller screens were associated with more frequent intensive use. Moreover, current mobile web pages and apps have far greater usability than in the past (Kortum & Sorber, 2015).

Network/Platform Architecture

Claim. Napoli and Obar argued that the network and platform architecture of mobiles was less open than PCs. An example from that time was how Apple controlled access to and validation of apps through their online store (Wortham, 2009).

Response. The Apple App Store and the Google Play Store currently offer millions of apps, and Apple says that 90% are reviewed in 48 hours (App Store, 2021).

Usage Patterns

Claim. Napoli and Obar seemed to treat PC- and mobile-based use and usage contexts as the same phenomenon, making it easier to conclude that PCs were superior for some activities, such as search tasks.

Response. Different usage environments as well as device capabilities may help explain some of the differences in their usage (Tsiaousis & Giaglis, 2014). The advantages or disadvantages of mobile- versus PC-based activities are contextual or socially constructed (e.g., Newlands & Lutz, 2020; Willems, 2020). Also, as Harrison et al. (2013) explain, mobiles are often used under circumstances where there is greater cognitive load, such as walking or interacting with others, and this may affect activities such as searching or typing.

Information. Information seeking is an important aspect of mobile use. Verma et al. (2018) found no significant difference between mobile and PC users in their ability to judge the relevance and usefulness of information.

Entertainment. While not discussed by Napoli and Obar, entertainment possibilities on mobiles are pervasive. Adepu and Adler (2016) showed that many users preferred gaming on mobiles versus PCs, although game performance was better on PCs. Sundar et al. (2017) highlight a number of different entertainment options that are enhanced by the use of mobiles, including mobile-only location-based games such as Pokémon Go.

Shopping. Shopping via mobiles is popular and growing (Groß, 2015) and has created new ways of shopping (Fuentes & Svingstedt, 2017).

News Consumption. People now consume more news on mobiles than on PCs (Nelson, 2020). However, users do tend to devote less cognitive engagement to video news on smartphones (Dunaway & Soroka, 2021), and mobile-based news viewing can be shallower and shorter (Molyneux, 2018).

Social Uses. Scholars have discussed the central importance of mobiles in social interaction and coordination (Campbell, 2019; Ling, 2004) and have highlighted social uses as an important digital inequality consideration (Helsper, 2021). For younger people particularly, the presumption of availability due to mobiles is integral to social identity and relational maintenance.

Political Participation. Considerable research investigates the role and consequences of mobile Internet for political participation and civic engagement (Lopez-Sintas et al., 2020; Martin, 2014; Wang & Liu, 2018).

General Usage. Wang and Liu's (2018) analysis of Chinese telecom usage data argued against mobile inferiority or the "mobile underclass." Mobile-only Internet users generated more data traffic, used apps more frequently, visited more web pages, and used the same types of apps, compared to PC-based Internet users.

Content Creation

Claim. Content creation is an important, albeit newer, digital inequality consideration (Hargittai & Micheli, 2019; Helsper, 2021). Creating some kinds of content is presumed to be more difficult on mobiles, especially because of the small keyboard, storage, and screen size. Having PCs allows for easier engagement in crowdwork (Newlands & Lutz, 2020).

Response. Yet, as Sundar et al. (2017) explain, text entry interfaces on mobiles are not inherently inferior to a PC physical keyboard. One rigorous analysis showed that smartphone typing speed could be as high as 70% of PC speed (Dhakal et al., 2018). There may be advantages to mobile touchscreen keyboards, especially for stroke-based languages (Sundar et al., 2017). Adepu and Adler (2016) and Sundar et al. (2017) argue that haptics, specifically touchscreens, and voice input and transcription, allow for many additional benefits for mobile usage and can provide improved accessibility. The integration of a camera, Internet, screen, keyboard, microphone, and GPS, allows for many activities, including content creation, promotion, distribution, and consumption, to be done more easily on smartphones than with PCs

(Hilbert & Aravindakshar, 2018; Schrock, 2015).

Skill Sets across Platforms

Claim. Napoli and Obar stated that PC users need, have, and develop greater skills because of the capabilities and requirements of the PC.

Response. Perhaps the least empirically supported, this claim did not consider the decades of research demonstrating demographic differences in skills (Hargittai & Micheli, 2019; Scheerder et al., 2017). That is, differences in skill levels across devices may be less once demographics are considered. Moreover, even when skill levels are lower, mobile-only Internet users often find ways to circumvent that lack (Pavez & Correa, 2020).

Other Mobile Device Characteristics or Capabilities

Here we consider four additional aspects not raised by Napoli and Obar.

Cost. Accessing the Internet via mobiles is "a cost-effective opportunity to reduce digital access gaps" (Correa et al., 2020, p. 1075), compared to PC-based access, although mobiles have high purchase and contract costs, as well as ongoing data, maintenance, upgrade, and replacement costs (Gonzales, 2016; Silver et al., 2019).

Voice. Sundar et al. (2017) note that speech and voice recognition abilities in mobiles are superior to that of most PCs. Smartphones are the most popular voice recognition devices, with nearly half of U.S. adults using them (Fox Rubin, 2019). Voice recognition can allow for safer driving (Albert et al., 2016) (while also creating more driving distractions) and greater accessibility (Pradhan et al., 2020).

Portability. Napoli and Obar (2013) noted the importance of portability, especially for seeking information (Ghose et al., 2013; Kortum & Sorber, 2015), and Schrock (2015) highlighted portability as the key affordance of mobiles. The "perpetual contact" associated with mobiles is partially due to portability (Katz & Aakhus, 2002). As a consequence, mobile availability can have a greater or at least different effect on social capital than PC-based access (Schrock, 2016). However, decreasing size and weight of laptops and tablets make them highly portable too.

Location awareness. Another capability is location awareness (Martin, 2014; Schrock, 2015; Sundar et al., 2017; van Deursen & van Dijk, 2019). Individuals can easily navigate with GPS, and many applications like security systems, childcare check-in authorizations, government services, and contact tracing require location awareness (Rice et al., 2021).

General Trends in Device Adoption, Use, and Activities in the U.S.

In addition to the above characteristics and capabilities, changes in the adoption and use of various devices, the types of activities available, and engagement in those activities, also help explain some of the apparent variations in the device divide. Further, while this study only considers individual use contexts, of course those become embedded in broader networks of other users and wider social network, organizational, and institutional (government, health, media, etc.) contexts. For example, PCs, laptops (and now tablets), and smartphones (as well as other devices) have become ubiquitous in institutional, industry, market, social, and organizational settings, enabling and requiring a wider array of online activities and usage contexts (e.g., Bouwman et al., 2005; Rice & Leonardi, 2013; Rice, 2017).

For a general context, this section summarizes U.S. trends of individual PC and mobile use from the Pew Research Center (2022). As Figure 1 shows, from 2008 through 2019, PC ownership was flat (around 75%); tablet growth increased, and then flattened around 2017 at 50%. Cell phone use flattened out in 2016-2018, possibly due to saturation adoption in some groups (e.g., college graduates and household income over USD75K). By 2019, percentages of

media use were cell phone 96%, smartphone 84%, desktop or laptop 74%, and tablet 52%. In 2019, 46% of U.S. adults used the Internet mostly via mobile, 30% mostly by another device (desktop, laptop, tablet), and 21% both equally. At that time there were still clear demographic differences (especially income) in use of smartphone, PC, home broadband, or tablet.

–Figure 1–

2013 survey responses showed the following percentages of using cell phones for online activities: text messaging (81%), accessing Internet (60%), email (52%), downloading apps (50%), directions, recommendations, or location-related services (49%), music (48%), video calling (21%), location sharing/checking in (8%). All of these except the last increased from the earlier surveys (2009). A mid-2015 survey reported growth from 2012 to 2015 in percent of smartphone owners using smartphone for directions, recommendations or location-related services (7% to 90%), music (53% to 67%), video calls or chat (33% to 47%), and watching movies or TV (15% to 33%). 2015-2016 Pew Research Center (2022) data indicated that 55% of smartphone owners used them for news, 28% job search, 9% dating, 13% e-books, and 51% for online purchases, and 59% for discussing purchases while in a store. Using mobiles often for getting news increased from 21% in 2013 to 57% in 2019, while doing so via PC dropped from 35% to 30%. In Pew surveys between Oct 2019 and June 2020, 18% said they got their political news mostly from social media, second only to news websites (25%).

Finally, we note the vast literature on digital divides in general and socio-demographic influences on usage and online activities in particular, well beyond the scope of this empirical study. For paragraph summaries of socio-demographic influences, see Pearce and Rice (2017); for comprehensive reviews see e.g., Helsper (2021) and Van Dijk (2020), among others.

Research Questions

The preceding review sets the foundation for the overall question, W(h)ither the device divide? in the form of three research questions:

RQ1. To what extent has engagement in online activities changed over time?

RQ2. How are those online activities associated with different device access?

RQ3. How are those online activities associated with socio-demographic differences, after controlling for device divides?

Methods

Data Sources and Sampling

This study responds to these questions by looking at changes within the case of Armenia. Doyar et al. (2022) provide a succinct history of the development of ICTs and the Internet in the USSR and these Southern Caucasus (Armenia, Azerbaijan, and Georgia), and their economic, political, military/war, telecommunications policy, infrastructure, service providers, and technological contexts. Armenia is an interesting context, as it has high literacy and education but low economic levels (UNESCO, 2021). Armenia has the lowest per capita GDP, and economic growth, and highest unemployment of the Southern Caucasus countries (Doyar et al., 2022). Armenia's GINI index was .29 in 2011, .32 in 2015, and .30 in 2019 (World Bank, 2021a; 0 is maximum equality, 1 maximum inequality). (For context, Organization for Economic Co-operation and Development (OECD) countries range between .24-.49, while African countries range between .6-.7). Moreover, both Internet and mobile phone adoption in Armenia was rapid (Pearce & Rice, 2013, 2017; Rice & Pearce, 2015; World Bank, 2021b, c). Mobile cell subscribers rose very quickly beginning in 2005, while Internet users did not begin to take off until 2009 (Doyar et al, 2022). By 2020, Internet use and mobile phone use reached 76%-77% of Armenian adults. In 2017, 86% of that Internet use occurred through mobile networks, while in

2020 64% of households accessed the Internet via computer. In general, access and service quality is lower in rural areas (Doyar et al., 2022). Early home *broadband* Internet in Armenia required a plan and pre-payment, whereas dial up Internet and mobile Internet could be bought in smaller affordable parcels (Pearce et al., 2013). However, few Armenian households owned PCs with which to use broadband Internet, with only 38% of households in 2011, growing to 58% in 2019 (Caucasus Barometer, 2020).

We obtained data from the *Caucasus Barometer* (https://www.crrc.am/en/barometer/; https://caucasusbarometer.org/en/datasets/), an ongoing set of surveys about socio-economic issues and political attitudes conducted by the NGO Caucasus Research Resource Centers (CRRC) in Armenia, Azerbaijan, and Georgia. These data are relevant for our questions because of the multiple years of surveys, the nationally representative sampling, the large sample sizes, the rigor and trustworthiness of the research organization, the crucial role of Internet access, and the consistent (if limited) measures of access devices, Internet activities, and demographics. We analyze data from Armenia over four periods: one (2011) was a special survey focusing on media (called "Media"), and three surveys (2011, 2015, 2019) were from the regular Barometer series (called "Barometer") (we do not report on 2013 or 2017 for parsimony, but those tables are available from the authors). Sampling was multi-stage cluster sampling with stratification of adults 18+. Overall sample sizes and response rates for the surveys were 2011 Media: N=1,420, 75.4%; 2011 Barometer: N=2,365, 70%; 2015 Barometer: N=1,863, 66%; and 2019 Barometer: N=1491, 37%. Responses were collected through in-person interviews at the respondent's house, by trained personnel.

The 2019 nationally representative survey in Armenia provides this profile: Gender (M=35.8%, F=64.2%); age (M=50.7, SD=17.8); location (33.5% rural, 30.7% urban, 35.7% capital); education (45.7% ranged from no primary education to completed secondary education, 29.2% had some higher education, 24.2% completed higher education .9% had a post-graduate degree); Internet use frequency (27.3% never, 14.3 from less often to at least once a week, and 57% every day); current household economic situation (15.7% not enough for food, 26.5% enough for food but not clothes, 45.2% enough for food and clothes but not expensive durables, 10.3% can afford some expensive durables; 2.2% can afford anything we need); household own a cell phone (97.2%); personally own a cell phone (76.5%); mean PCs in household (1.14, SD-.41).

Measures

2011 Media Internet Access Device and Activities

Respondents were asked: Have you used the Internet in the past 12 months (0 No, 1 Yes)? Only users were analyzed. They were also asked, Which device do you use the most for Internet access? (none, mobile phone, PC, both). However, to be consistent with the Barometer data and analyses, we increment both mobile and PC if the respondent indicated "both", and then do not include "both" as a separate category in the analyses. For activities: When you access the Internet, which of the listed below do you usually do? (each 0 No, 1 Yes) Internet for work, Email, Search engine [Google, Yahoo], Play games, Download music or applications, IM [Skype, ICQ, MSN, etc.], SNS [Odnoklassniki, Facebook, Twitter, etc.], Blog, Watch videos [YouTube, Vimeo], Online news.

2011-2019 Caucasus Barometer Internet Access Device and Activities

Again, only Internet users were analyzed. The two device measures were: Have you activated Internet access from your personal cell phone? Do you have Internet access from your home computer? (both 0 No, 1 Yes). Concerning activities, respondents selected from a list the

three most frequently engaged in. The total number of mentions for each activity were tallied. We analyzed only activities with at least 10% of respondents mentioning them, and which were measured in at least two of the three selected Barometer years (2011, 2015, 2019): Receive/send emails, Search for information, Play online games, Download/listen/watch music/videos, Use Facebook (not asked in 2015), and Read/listen to/watch the news.

Demographics

Gender. Interviewers noted if the interviewee was a man or a woman. ***Age***. Respondents' birth year was subtracted from the survey year. ***Education***. 2011 media respondents reported their education (Primary, Incomplete secondary, Completed secondary, Secondary technical, Incomplete higher, Completed higher, Post-graduate); the three Barometer surveys also included No primary. ***Economic Wellbeing***. Because income is not a complete measure of economic wellbeing, especially in poorer countries (Ringen, 1998), the survey used a respondent's assessment of their satisfaction of basic needs (Boarini & Mira, 2006). Respondents were asked, What phrase best describes your family's financial situation? and given six levels: We don't have enough money even for food; We have enough money for food but not for clothes; We can buy food and clothes, but not more expensive things; We can buy some expensive things like a TV or washing machine; We can buy expensive goods and car, have a vacation, but not buy an apartment; We can also buy an apartment. ***Urban Location***. Interviewers determined if the household was located in a rural area (1), an urban region (2), or the country's capital (3). Urban regions in post-Soviet countries are defined as a settlement with more than 10,000 residents and the majority must not be employed in agriculture (Buckley, 1998). Location is particularly relevant because of typical concentration of broadband and wider adoption of communication technologies in more urban areas (Hollman et al., 2021; Vogels, 2021). ***English Knowledge***. Much Internet content and search engines use English, creating challenges for those speaking/writing particularly linguistically isolated languages such as Armenian (Pearce & Rice, 2014). "Those who can read some English face fewer language-related issues with mobile phones in most countries, including difficulties finding online content in their preferred language or feeling there were no apps or websites in their native language" (Silver et al., 2019, p 9). What is your English language knowledge? (No basic knowledge, Beginner, Intermediate, or Advanced).

Analyses

For each year, we first summarized the mean differences in activities across the devices (those descriptives and t-test tables are available from the authors, but are summarized for 2011 Media). Then we conducted binary logistic hierarchical regressions for each activity, with device or access type entered in the first block (device divide), and demographics in the second block (digital divide).

Results

2011 Media: Activities, Device Access, and Socio-Demographics

Overall, for the 420 who reported using the Internet and either mobile or PC for Internet access, the most frequent activities were SNSs (62%), search engines (45%), IM (37%), and news (35%), followed by watch videos (30%), email (29%), play games (23%) and working purposes (24%), with lower levels of download music or other applications (16%), and blogs (6%). Half of these (work, search engine, IM, SNSs, and online news) differed significantly across mobile or PC access. PCs were used more than mobile for work (28% vs 5%), search engines (48% vs 32%), IM (42% vs 9%), and online news (40% vs 8%), but less for SNSs (57% vs 85%). All the socio-demographics differed across devices significantly. PC users were more

males (60% vs 47%), had higher education (4.9 vs 3.8), were older (35.0 vs 26.2), had slightly less bad economic wellbeing (2.9 vs 2.3), were more urban (2.4 vs 2.1), and had greater English language skill (3.4 vs 2.8).

Table 1 shows results from the logistic regressions, which explained from .02 to .22 variance. PC-based access was associated with more Internet for work, IM, videos, and online news, but less SNS use. Controlling for device access, socio-demographics played little role, except primarily for age (in most cases, younger) and location (more urban). English skill was significant only for using the Internet at work, and email, and slightly for online news.

–Table 1–

2011, 2015, 2019 Barometer: Activities, Device Access, and Socio-Demographics

As Figure 2 shows, from 2011 to 2019, use of the devices for email declined (25% to 11%), games declined (from 16% to 2%), music/videos stayed the same (19%, though with increases in the middle years), news increased (19% to 36%), information searching declined (49% to 28%), and Facebook use increased (16% to 51%).

–Figure 2–

Concerning the logistic regressions, for 2011, Table 2 shows that mobile access is marginally associated with less music or videos, and more news. Home computer access was marginally associated only with more email. Socio-demographics play an infrequent role, though each has at least one marginally significant association with activities, and age the most (less email, downloading, and Facebook, but marginally more news).

–Table 2–

By 2015, Table 3 shows little device influence, with only marginally more email by phone access. Again, socio-demographics played some scattered role, here primarily via higher education (more email, information, and news, with marginally less gaming).

–Table 3–

In 2019, the regressions show that there were significant effects for mobile phone access (marginally less downloading of music and videos, but significantly more Facebook and news), but no effects of PC access (Table 4). Demographics also had some varied influences, primarily due to age (less email, downloading, and Facebook, but marginally more news), and to urban location (more information searching, gaming, and downloading, but less Facebook and news).

–Table 4–

Discussion

Summary

RQ1. To What Extent Has Engagement in Online Activities Changed over Time?

Of frequent activities in the Barometer datasets, there is less searching for information but more news. Armenia experienced a revolution in the spring of 2018 which likely increased interest in news. SNS also had already begun to take off as a primary activity, and given that much news now comes through SNSs, this is not surprising. There is less emailing but more Facebook; other data sources indicate tremendous growth in Facebook use during this period (Pearce, 2021). The growth in mobile and messaging apps probably also contributed to email's decline.

RQ2. How Are Those Online Activities Associated with Different Device Access?

While the Media 2011 results clearly showed the avowed device divide, with different activities associated with access via PC compared to mobile, the Barometer data showed less influence of device access on activities. There were few clear differences in activities with use of mobile Internet or not, or the use of PCs or not, except for significantly higher levels for three

activities for mobile access in 2015. For all analyzed years, most of the differences were between using or not using mobiles, with few and even then only marginally significant differences by using or not using PCs. For 2011, PC access was slightly negatively associated with email, and mobile phone slightly negatively with music/videos and positively with online news; for 2015 mobile phone was slightly positively associated with email; and by 2019 mobile phone was again slightly negatively associated with music/videos, significantly negatively with Facebook, and significantly positively with online news.

RQ3. How Are Those Online Activities Associated with Socio-Demographic Differences, Controlling for Any Device Divides*?*

After controlling for device type, some socio-demographics are still associated with use of online activities, in line with the general digital divide literature. Early on, age was the primary difference, though with some influence by gender and education. By 2019, age still had significant, but weak, influence on activities, while gender and education influenced several activities. However, urbanness and English knowledge emerged as stronger influences, supporting previous findings and clearly relevant to the Armenian context (Pearce & Rice, 2014), generally positively associated with email, information searching, games, and downloading, and online news. By 2019, the device used to access the Internet (esp. PC) has little substantive effect on use of most of the activities. While some demographic divides or inequalities remain, the device divide for online activities seems to have withered.

Limitations

The current study uses a representative national sample from Armenia. While this is useful and adds to the little research not conducted in North America or Western Europe, the specific findings are not generalizable to other countries, due to Armenia's unique context and language. However, the Armenian case is empirically valuable because it allows us to assess a device divide in a very different context than usual, in a very poor but highly educated developing country, with rare over-time data, and with consistent measures.

Using secondary data also is a limitation, as the operationalizations may not provide ideal measures, such as the PC and mobile indicators in the Barometer surveys, or cover all relevant online activities. Nonetheless, the stability of the measure operationalizations provide an opportunity to assess changes over time. These data do not allow us to analyze different usage contexts of any given activity, nor whether those online activities contribute positively or negatively to social capital or other outcomes, central to both digital and device divide research.

We note that although mobile- and PC-based Internet access were quite distinct early on, over time more respondents reported using mobile as well as "both". Thus to some extent the device divide has "withered" due to using multiple devices, each facilitating both similar and different activities. So in terms of "whither" device divide research, an additional approach would be to separate out and compare online activities for mobile, PC, and both (such analyses, not reported here, show no significant differences in activities across those three categories in the Barometer data).

While we used the early Napoli and Obar discussion of the mobile- or PC-based Internet divide, a fuller approach would consider common and distinct affordances of the devices, and how those have changed over time. An affordances approach allows for greater understanding of the relationship between technology, context, and individual (Evans et al., 2017; Rice et al., 2017; Willems, 2020). However, not all of the capabilities discussed above are easily (or at all) associated with an affordance, and we have no measures of affordances of these devices at each time period.

Conclusion

Digital inequality is not going away. As resources become even more digitized, technologies become more capable, and available activities evolve, issues of access, skills, contexts, use and outcomes of technologies will continue (Helsper, 2021; Reisdorf et al., 2020; van Dijk, 2020). However, the device divide (at least between PC and mobile) seems to be *withering*. PC- and mobile-based Internet are both useful, for similar and different times, contexts, and activities. For example, the percent reporting use of both devices for Internet access rose in the Barometer surveys from 29.5% in 2011, to 41.2% in 2015, to 80.8% in 2019. Although our results reject the presumption of PC as superior and mobile as inferior access devices for activities, a more nuanced consideration of the role that devices, play is essential for better theorizing and understandings of digital inequality. So as far as *whither* device divide research, capabilities or affordances of digital devices that can affect the ways in which users engage with, and benefit from, online activities are more important than simple binary device distinctions. Research may study how such features correspond with current and new online activities, and also focus more on combinations of digital devices in various use contexts.

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Table 1

Logistic Binary Regressions of Device and Demographics on Activities, 2011 Media (Internet Users)

	Internet for work	Email	Search engine	Games	Music	IM	SNS	Blog	Videos	News
Device	1.47	-.24	.47	.12	.01	2.23	-1.46	.32	.92	1.48
Mobile (0)	(.63)* /	(.35) /	(.33) /	(.39) /	(.42) /	(.48)**	(.40)**	(.72) /	(.38)* /	(.51)**
PC (1)	4.37	.79	1.6	1.13	1.01	* / 9.3	* / .23	1.4	2.5	/ 4.4
Gender	-.36	-.15	-.27	.40	-.04	.04	-.17	.28	-.40	-.05
	(.27)	(.25) /	(.23) /	(.28) /	(.32) /	(.24) /	(.25) /	(.51) /	(.26) /	(.25) /
	/ .70	.86	.76	1.49	.96	1.04	.85	1.32	.67	.95
Education	.18	.07	.07	-.16	.16	.02	-.08	.17	-.11	.37
	(.12) /	(.11) /	(.10) /	(.11) /	(.14) /	(.10) /	(.10) /	(.23) /	(.11) /	(.11)**
	1.20	1.08	1.07	.85	1.17	1.02	.93	1.18	.90	* / 1.44
Age	.03	.01	-.01	-.001	-.05	-.003	-.04	-.06	-.05	.01
	(.01)*** /	(.01) /	(.01) /	(.01) /	(.02)**	(.01) /	(.01)**	(.03)* /	(.01)**	(.01) /
	1.04	1.01	.99	.99	* / .95	1.0	* / .96	.94	* / .95	1.01
Economic	.05	.04	-.04	.12	-.21	-.04	.03	.04	.05	.14
wellbeing	(.12) /	(.11) /	(.10) /	(.12) /	(.14) /	(.10) /	(.10) /	(.22) /	(.11) /	(.11) /
	1.05	1.04	.96	1.12	.81	.67	1.03	1.04	1.05	1.15
Urban	.06	.16	.39	.11	.27	-.20	.44	-.07	.38	.06
	(.21) /	(.19) /	(.17)* /	(.20) /	(.24) /	(.18) /	(.18)* /	(.38) /	(.20)* /	(.19) /
	.94	1.18	.68	.89	.77	.82	1.56	.94	1.47	1.06
English	.49	.30	.16	.08	.18	-.19	.16	.10	.12	.23
	(.15)*** /	(.13)* /	(.12) /	(.15) /	(.17) /	(.13) /	(.13) /	(.28) /	(.14) /	(.14)+ /
	1.64	1.35	1.17	1.08	1.2	.83	1.18	1.11	1.13	1.25
Intercept	-6.23	-2.2	-1.72	-1.67	-1.48	-1.3	1.69	-2.5	-.66	-5.4
	(.96)*** /	(.81)**	(.62) /	(.89)+ /	(.88) /	(.71)+	(.67)**	(1.4)+ /	(.70) /	(.84)**
	.002	* / .11	.18	.19	.23	.28	/ 5.4	.08	.52	* / .004
X^2 (7 *d.f.)*	53.7 ***	12.15+	20.6**	5.6	23.9**	36.5**	59.8***	10.5	45.2**	60.9**
					*	*			*	*
Nagel. R^2	.21	.05	.08	.02	.11	.13	.21	.09	.17	.22
N activity users	93	105	155	75	55	131	208	19	105	124

Ns: Internet user/ Cell & PC sample = 356; Mobile = 93 (22.1%); PC = 263 (62.6%); Both = 64 (15.2%); but analyses use Mobile and PC with "both" allocated to each.

Cell values for explanatory variables: B(S.E) sig. / Exp(B)

+ $p <$ .10. * $p <$ .05. ** $p <$ .01. *** $p <$ .001.

Table 2
Logistic Binary Regressions of Device and Demographics on Activities, 2011 Barometer (Internet Users)

	Email	Search info	Games	Music/ videos	Facebook	News
Mobile phone access (0,1)	.13 (.20) / 1.14	.03 (.18) / 1.03	.16 (.25) / 1.18	-.45 (.24)+ / .64	-.23 (.24) / .80	.39 (.21)+ / 1.47
Home computer access (0,1)	-.77 (.43)+ / .47	.10 (.40) / 1.10	.34 (.64) / 1.41	-.21 (.49) / .81	.95 (.77) / 2.59	-.04 (.48) / .96
Gender	-.06 (.19) / .95	-.38 (.17)* / .69	-1.1 (.25)*** / .34	.50 (.23)* / 1.65	-.29 (.24) / .75	.05 (.20) / 1.05
Education	.06 (.08) / 1.06	.19 (.07)** 1.21	-.15 (.09) / .86	-.14 (.09) / .87	.23 (.10)* / 1.25	.18 (.09)* / 1.19
Age	-.02 (.01)** / .98	-.01 (.01) / .99	-.00 (.01) / 1.0	-.04 (.01)*** / .97	-.06 (.01)*** / .94	.01 (.01)+ / 1.29
Economic wellbeing	.09 (.11) / 1.09	-.00 (.09) / 1.0	-.04 (.14) / .96	.07 (.12) / 1.07	-.01 (.13) / .99	.26 (.11)* / 1.29
Urban	.80 (.16)*** / 2.21	.08 (.12) / 1.09	-.11 (.17) / .90	.26 (.16) / 1.3	.53 (.19)** / 1.69	.00 (.11) / 1.16
English	.20 (.10)+ / 1.22	.09 (.09) / 1.10	-.06 (.14) / .94	.02 (.12) / 1.02	.21 (.13) / 1.23	.15 (.11) / 1.16
Intercept	-2.48 (.81) ** / .08	-.66 (.69) / .52	.91 (.98) / 2.49	-.69 (.89) / .50	-2.95 (1.15)** / .05	-3.98 (.86) / 1.16
X^2 (8 *d.f.*)	58.0***	21.5**	28.4***	32.9***	75.0***	24.6***
Nagel. R^2	.13	.05	.08	.08	.19	.06
N activity out of 626-628	157	329	91	116	107	144

Ns: Internet user/ Cell & PC sample = 912; Cell phone: No = 617, Yes = 295; PC: No = 114, Yes = 798
Neither = 9.6%; Cell No/ PC Yes = 58.0%; Cell Yes/ PC No = 2.9%; Both = 29.5%
Cell and PC access r=.08, p< .05 (2-sided)
Activities: mentioned as 1 of top 3 most frequent activities
Cell values for explanatory variables are B(S.E) sig. / Exp(B)
+ p < .10. * p < .05. ** p < .01. *** p < .001.

Table 3
Logistic Binary Regressions of Device and Demographics on Activities, 2015 Barometer (Internet Users)

	Email	Search info	Games	Music/ videos	Facebook	News
Mobile phone access (0,1)	.48 (.25)+ / 1.61	.07 (.16) / 1.07	-.30 (.29) / .74	.00 (.21) / 1.00	--	.11 (.17) / 1.12
Home computer access (0,1)	.89 (1.05) / 2.43	-.33 (.45) / .72	.92 (1.05) / 2.5	.36 (.64) / 1.43	--	-.09 (.46) / .92
Gender	-.41 (.24)+ / 67	-.29 (.16)+ / .75	-.96 (.26)*** / .38	-.17 (.20) / .85	--	-.25 (.17) / .78
Education	.30 (.10)** / 1.35	.25 (.07)*** / 1.29	-.22 (.12)+ / .81	-.24 (.09)** / .78	--	.15 (.07)* / 1.17
Age	-.02 (.01)* / .98	-.01 (.01)+ / .99	.01 (.01) / 1.01	-.03 (.01)*** / .97	--	-.01 (.01) / .99
Economic wellbeing	.16 (.14) / 1.17	.03 (.09) / 1.03	-.17 (.15) / .85	.03 (.11) 1.03	--	-.18 (.10)+ / .83
Urban	.19 (.16) / 1.21	.10 (.20)/ 1.11	.33 (.17)* / 1.39	-.14 (.13) / 87	--	-.16 (.11) / .85
English	.46 (.14)*** / 1.59	.17 (.10)+ / 1.19	-.25 (.20) / .77	.01 (.13) / 1.01	--	-.04 (.22) / .96
Intercept	-5.15 (1.29)*** / .01	-1.42 (.65)* / .24	-.79 (1.31) / .45	1.02 (.88) 2.76	--	-.25 (.68) / .78
X^2 (8 *d.f.*)	84.2***	48.9***	31.6***	40.2***	--	11.4
Nagel. R^2	.19	.08	.09	.08	--	.02
N activity out of 823	100	281	68	136	--	216

Ns: Internet user/ Cell & PC sample = 1009; Cell phone: No = 576, Yes = 433; PC: No = 45, Yes = 964
Neither = 2.8%; Cell No/ PC Yes = 54.3%; Cell Yes/ PC No = 1.7%; Both = 41.2%
Cell and PC r = .02 ns.
Activities: mentioned as 1 of top 3 most frequent activities
Cell values for explanatory variables are B(S.E) sig. / Exp(B)
+ $p <$ .10. * $p <$ .05. ** $p <$ .01. *** $p <$ .001.

Table 4

Logistic Binary Regressions of Device and Demographics on Activities, 2019 Barometer (Internet Users)

	Email	Search info	Games	Music/ videos	Facebook	News
Mobile phone access (0,1)	.52 (.56) / 1.68	.27 (.28) / 1.30	-.14 (.65) / .87	-.51 (.28)+ / .60	-.49 (.25)* / .61	.78 (.26)** / 2.18
Home computer access (0,1)	-.29 (.59) / .75	-.14 (.41) / .87	.18 (1.05) / 1.20	-.17 (.43) / .85	.33 (.36) / 1.39	.12 (.36) / 1.13
Gender	0.37 (.27) / .69	-.37 (.18)* / .69	-1.03 (.44)* / .36	.07 (.20) / 1.07	.37 (.16)* / 1.45	-.46 (.16)** / .63
Education	.32 (.11)** / 1.38	.23 (.07)*** / 1.26	-.29 (.18)+ / .75	-.10 (.08) / .90	.11 (.07) / 1.12	-.03 (.07) / .98
Age	-.03 (.01)** / .97	.00 (.01) / 1.00	.01 (.02) / 1.01	-.02 (.01)* /.98	-.01 (.01)* / .99	.01 (.01)+ / 1.01
Economic wellbeing	.28 (.16)+ / 1.32	-.14 (.10) / .87	.35 (.25) / 1.44	.01 (.11) / 1.01	.30 (.10)** / 1.35	-.24 (.10)* / .79
Urban	-.04 (.17) / .96	.40 (.12)*** / 1.50	.56 (.20)+ / 1.75	.59 (.13)*** / 1.81	-.36 (.10)*** / .70	-.21 (.10)* / .81
English	.45 (.17)** / 1.57	.38 (.12) ** / 1.46	-.07 (.32) / .94	.02 (.13) / 1.02	-.33 (.12)** / .72	-.01 (.12) / .99
Intercept	-3.9 (1.20)*** / .02	-3.00 (.76)*** / .05	-2.88 (1.82) / .06	-.92 (.80) / .40	-.06 (.68) / .94	.36 (.68) / 1.43
X^2 (8 *d.f.*)	70.4***	67.5***	14.5+	29.5***	41.8***	30.0***
Nagel. R^2	.19	.13	.08	.06	.08	.06
N activity out of 682-692	79	215	24	156	342	281

Ns: Internet user/ Cell & PC sample = 840; Cell phone: No = 126, Yes = 714;PC: No = 52, Yes = 679

Neither = 2.0%; Cell No/ PC Yes = 13.0%; Cell Yes/ PC No = 4.2%; Both = 80.8%

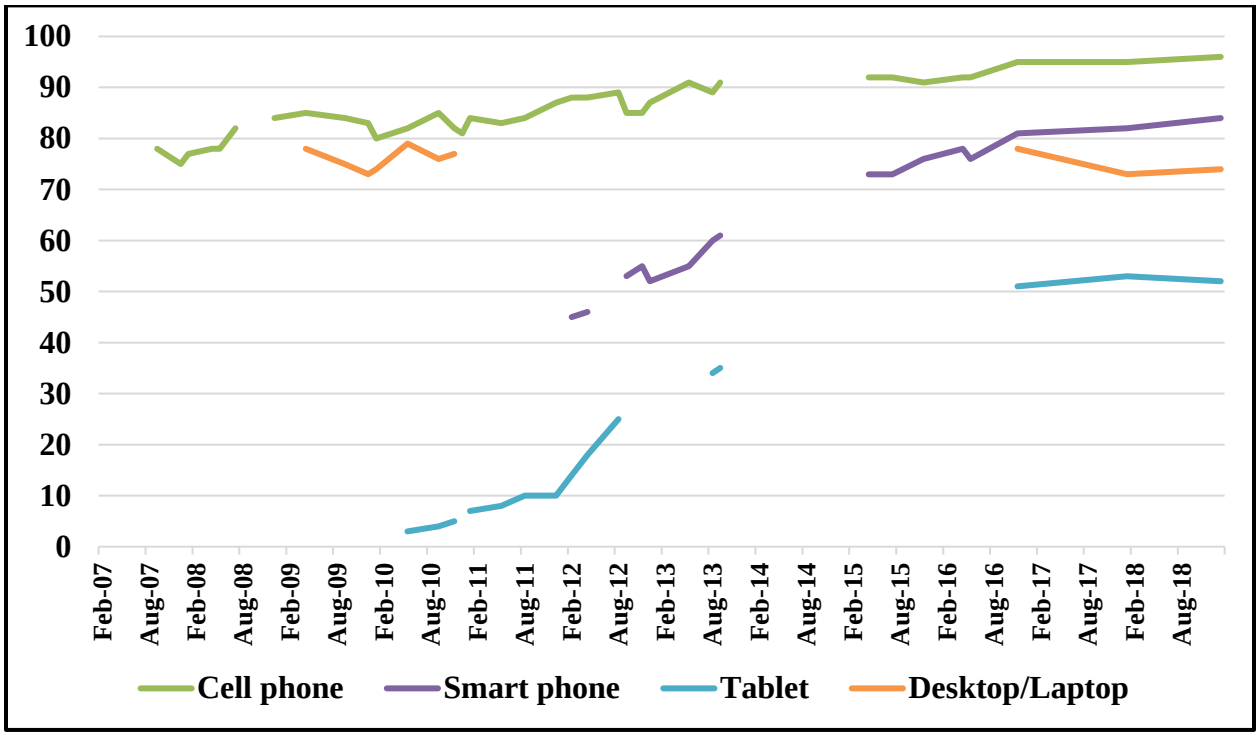
Cell and PC $r = .13$, $p < .001$

Activities: mentioned as 1 of top 3 most frequent activities

Cell values for explanatory variables are B(S.E) sig. / Exp(B)

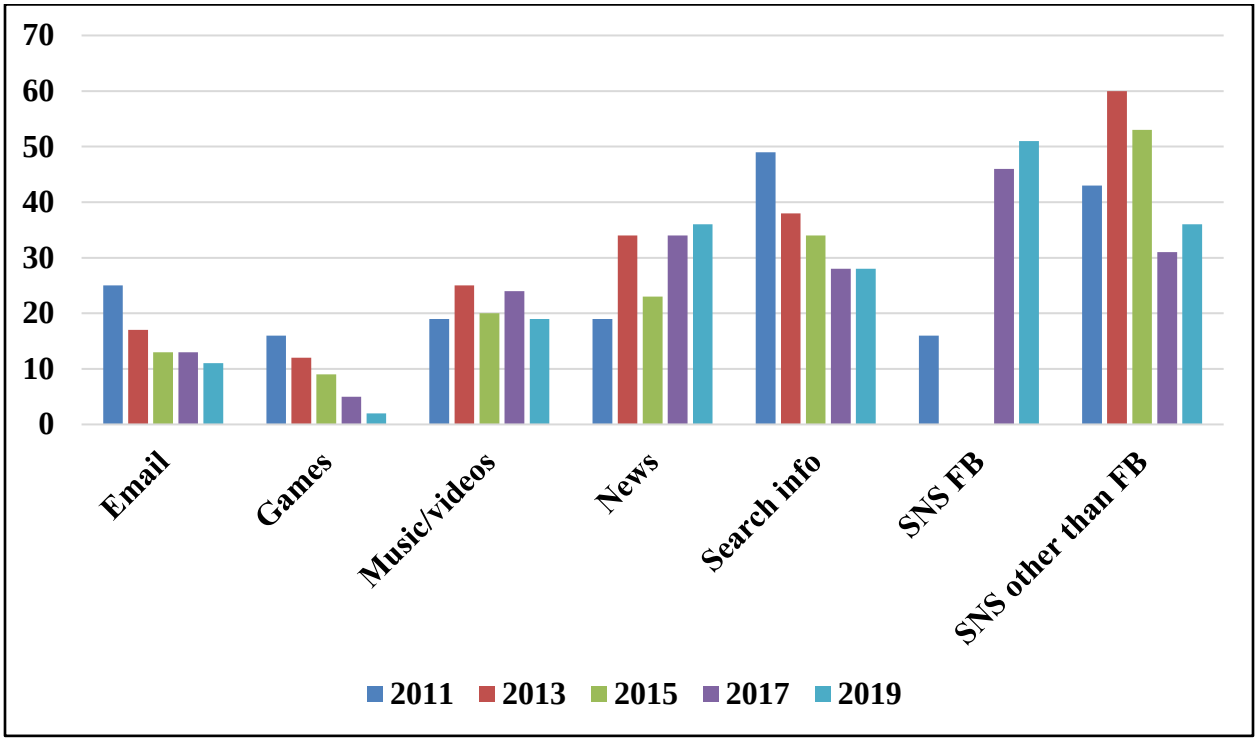
+ $p <$ .10. * $p < .05$. ** $p < .01$. *** $p < .001$.

Figure 1
Adoption of Digital Media in U.S., 2005 – 2019



Source: Pew 2019 January 8 – February 7 Core Trends Survey

Figure 2
Percent Mentioning Internet Activities, 2011 – 2019 Barometer



MMC-22-0029 Final
W(h)ither the Device Divide? Changing Relationships between PC or Mobile Device with Online Activities

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