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Mobile Leapfrogging and Digital Divide Policy

Assessing the limitations of mobile Internet access

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This paper examines the emerging global phenomenon of mobile leapfrogging in Internet access. Leapfrogging refers to the process in which new Internet users are obtaining access by mobile devices and are skipping the traditional means of access: personal computers. This leapfrogging of PC-based Internet access has been hailed in many quarters as an important means of rapidly and inexpensively reducing the gap in Internet access between developed and developing nations, thereby reducing the need for policy interventions to address this persistent digital divide. This paper offers a critical perspective on the process of mobile leapfrogging. Drawing upon data on Internet access and device penetration from 34 countries, this paper first shows that while greater access to mobile technologies suggests the possibility of a leapfrog effect, the lack of 3G adoption suggests that mobile phones are not yet acting as functionally equivalent substitutes for personal computers. Next, this paper puts forth a set of concerns regarding the limitations and potential shortcomings of mobile-based Internet access relative to traditional PC-based Internet access. This paper illustrates a number of important relative shortcomings in terms of memory and speed, content availability, network architecture, and patterns of information seeking and content creation amongst users. This paper concludes that policymakers should be cautions about promoting mobile access as a solution to the digital divide, and undertake policy reforms that ensure that communities that rely on mobile as their only gateway to the Internet do not get left further behind.

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Introduction

As Internet penetration rates continue to rise throughout the world, digital divides in Internet access persist as central public policy challenges of the digital age. In 2011, 70.2 percent of individuals in "developed" countries were using the Internet, whereas as 24.4 percent of those in "developing" countries were connected, suggesting that developing countries are lagging behind.[1] At the same time, within countries, societal stratifications due in part to divides in access and digital literacy also persist. For example, in the United States, African Americans and Hispanics have tended to have lower levels of Internet access than the rest of the population.[2] Such divides are generally a function of economic disparities that limit access to the necessary hardware (traditionally, personal computers), infrastructure, services, and training.[3]

These divides have attracted policy attention, in recognition of the substantial social and economic benefits (both at the individual and national levels) that are a function of Internet access and digital literacy.[4] High speed Internet access and usage are widely regarded as key mechanisms by which nations can enhance their economic development and individuals can improve their economic prospects, political efficacy, educational attainment, and social networks.[5] Policy interventions to address digital divides have been implemented at the local, state, national, and international levels, and have encompassed initiatives such as government subsidies to develop and maintain infrastructure; programs that improve the quality of computer facilities in schools, libraries and community centers; and digital literacy programs.[6] Despite such efforts, digital divides persist.[7]

The rapid diffusion of mobile handheld devices presents another possible solution to the digital divide, and a potential alternative to traditional policy interventions. In many developing nations, and in many lower-income demographic groups within more developed nations, populations that have previously lacked traditional PC-based Internet access are adopting Internet-enabled mobile devices, as the cost of these devices is lower than the cost of PCs.[8] This process has raised the possibility of what technology and development scholars call "technology leapfrogging," in which a population adopts a new technological innovation without ever having adopted the preceding technology.[9] This potential for mobile leapfrogging has led many observers to contend that mobile Internet access can act as a great leveler, closing gaps that exist between haves and have-nots, providing pragmatic solutions to digital divides that have challenged policymakers for more than two decades.[10]

However, largely absent from the policy discourse surrounding mobile leapfrogging and digital divides has been any in-depth discussion of how mobile Internet access compares to traditional PC-based Internet access across a variety of relevant performance and usage dimensions that reflect the extent to which mobile Internet users reap the full scope of benefits afforded to traditional PC-based Internet users. This paper seeks to provide a thorough examination of this issue and its implications for digital divide policymaking and policy research.

Technology Leapfrogging and the Digital Divide

Technology leapfrogging refers to "the adoption of advanced or state-of-the-art technology in an application area where immediate prior technology has not been adopted."[11] Technology leapfrogging is widely seen as a way to rapidly increase the pace of a country's economic development and thereby reduce the gap between developed and developing nations.[12] As Wijkman and Afifi state, "the benefits [of leapfrogging] can be financial, social, as well as environmental."[13] A key underlying requirement

for any leapfrogging scenario is that the leapfrogging technology be superior in terms of performance relative to established alternatives.[14] This point is of particular relevance to the issue being addressed here, in terms of trying to develop a more well rounded understanding of how mobile Internet access compares to PC-based access, and the extent to which mobile can alleviate digital divides.

There are a number of recognized challenges and difficulties associated with the process of technology leapfrogging. While leapfroggers "are not inhibited by entrenched intermediate technology,"[15] any new technology requires a process of learning and the acquisition of relevant skills.[16] Thus, one concern is that users who have leapfrogged to the new technology have not developed skills via experience with the previous technology that could significantly affect their ability to effectively use the new technology. The danger, then, is that "not only is the earlier technology bypassed, but many of the skills associated with it are bypassed, as well."[17] From this standpoint, the prospects for effective technology leapfrogging are best when the new technology requires a completely different skill set than the previous technology.

Information and communication technologies have been a focal point of technology leapfrogging initiatives and research over the past two decades.[18] The ongoing rapid diffusion of mobile devices represents one of the most visible and significant contexts in which technology leapfrogging is either already taking place or is a goal being pursued.[19]

Research has provided compelling evidence across a variety of contexts of how mobile Internet technologies can help reduce the gap in Internet access that has persisted in large part due to the costs associated with PC-based Internet access and can provide those previously excluded with opportunities to become better integrated into social, economic, and political life.[20] Research on marginalized communities has found that mobile Internet access has proven effective in strengthening social ties within these communities,[21] and has enabled many community members to improve their earning potential via the information and professional contacts accessible online.[22] A compelling example of the transformative potential of mobile Internet access can be seen in Schejter and Tirosh's recent analysis of technology adoption (including mobile devices) by a demolished Bedouin village in Israel named Al-'Arakeeb:

> As an unrecognized village, Al-'Arakeeb's disconnectedness from the national water, electricity, and telecommunications grid is a major component of the state's effort to delegitimize the traditional Bedouin way of life. [...] mobile and wireless technologies have enabled the rewriting of the rules to a certain extent. They have allowed 'Arakeebians to overcome the concerted effort to marginalize them and take part [...] in civil society. Batteries and generators brought electricity; broadcast technology brought radio and television; cellular technology, satellite television, and mobile Internet made "unrecognized Al-'Arakeeb a member of the international community.[23]

A convincing case can even be made that there are some ways in which mobile Internet access is superior to traditional Internet access, particularly in terms of the wider array of contexts in which access can be obtained, which facilitates different kinds of uses, as well as greater overall levels of usage.[24] The ability to immediately access and disseminate information and to utilize the ever-growing array of functionalities provided by mobile applications, regardless of location or context, provide many benefits that PCs and laptop computers cannot match.[25] The Al-'Arakeeb example illustrates how the limitations of forced transience and disconnectedness can be overcome

through the use of mobile devices. Reflecting the tremendous value seen in mobile Internet access, the World Wide Web Consortium has launched a subgroup of its Mobile Web Initiative devoted to the Mobile Web for Social Development.[26]

Status of Mobile Leapfrogging Around the World

Given the widespread enthusiasm regarding mobile's prospects for closing digital divides, it is important to try to establish a baseline understanding of where things stand globally with the process of mobile leapfrogging. At the general level, it is very clear that mobile Internet access is diffusing at a rate that far outpaces fixed Internet access. By the end of 2010, the number of broadband Internet subscriptions over mobile technologies eclipsed the number of subscriptions over fixed technologies.[27] Mobile subscriptions are expected to rise from 61 percent of all broadband connections in developing countries to 84 percent in 2016.[28] From a leapfrogging standpoint, an important aspect of these patterns is the extent to which "mobile only" subscribers account for a large percentage of the growth. According to one recent estimate, there were approximately 14 million mobile-only Internet users in the world in 2011, with the number expected to increase to 788 million by 2016.[29]

However, it is also important to recognize that many of those currently adopting mobile devices are not necessarily also obtaining broadband Internet access. Some mobile devices are not capable of supporting Internet access; and some mobile subscribers may not have a data plan as part of their subscription package, or may have such usage discouraged by wireless data caps.[30] A recent Nielsen study of smartphone adoption in the "emerging countries" of Brazil, Russia, India and China found that "feature phones" (phones without a touchscreen, QWERTY keypad, or operating system) account for between 33 percent (China) and 80 percent (India) of the mobile devices in use in these countries.[31] Along related lines, a recent *Financial Times* analysis suggests that the smartphone industry is already exiting its period of explosive growth.[32] This is due to indications that in the developed world, "people who don't have a smartphone are either making the choice not to have one, or can't afford one"; while in the developing world, lower-priced feature phones are proving more appealing than higher-priced smartphones.[33]

In order to get a more complete sense of the extent to which mobile leapfrogging in Internet access has been taking place, it is useful to look at 3G adoption. Comparing 3G adoption levels with mobile device penetration can serve as an indicator of the extent to which mobile users are experiencing broadband Internet access. One of the most comprehensive efforts to date to map ongoing patterns in Internet adoption and usage around the world has been the Open Society Foundation's Mapping Digital Media (MDM) initiative. This initiative is an effort to study the global and national opportunities and risks generated by the transition from traditional to digital media in 60 countries (34 of these studies have been completed thus far).[34]

The MDM initiative provides data on mobile and 3G adoption for 22 of the 34 countries studied (mobile statistics refer to the percentage of the population and 3G statistics refer to the perentage of mobile users). In 2009, Italy had 147 percent mobile penetration and 36 percent 3G penetration; Serbia had 132 percent mobile (2010) and 11.5 percent 3G (2009); Argentina had 120 percent mobile and 9.1 percent 3G in 2010; Mexico had 80.2 percent mobile (2010) and 6.5 percent 3G (2009); and South Africa had 100 percent mobile (2010) and only 1 percent 3G penetration (2009). By comparison, the United States had 90 percent mobile penetration and 51 percent 3G penetration in 2010, and Japan had very high levels of both

mobile (91 percent) and 3G (94 percent) penetration in 2010.

These patterns suggest that while consumers in these countries are using mobile phones, in most they have not moved as quickly in terms of adopting fully functional smartphones, and/or in terms of using the mobile Internet data services that would allow them to access the Internet with

Table 1. Mobile vs. 3G Penetration Rates Across 34 Countries

Country	Mobile 2010	3G 2005	3G 2010
Russia	163.6**	n/a	n/a
Lithuania	149.0	n/a	n/a
Italy	147.0**	13.9	36.2**
China	144.4	1.7*	45.4
Croatia	144.4	1.7*	45.4
Albania	139.0	n/a	n/a
Germany	132.0**	2.9	20.1**
Serbia	132.0	0.0	11.5**
UK	130.1	11.4*	40.9
Netherlands	128.0**	2.0	22.0**
Hungary	120.0	0.4	22.9**
Argentina	120.0	0.0	9.1
Romania	118.2**	n/a	22.0**
Poland	117.0**	0.2	25.8**
Chile	116.0	n/a	8.5
Slovenia	103.5	n/a	n/a
South Africa	100.0	0.4	1.0**
Sweden	97.0**	n/a	n/a
Peru	95.5	n/a	2.5**
Colombia	95.4	n/a	n/a
Macedonia	95.4	n/a	16.2
Latvia	92.5	n/a	n/a
Turkey	91.9	0.0	12.6
Japan	91.0	33.2	93.7
US	90.0	9.6*	51.0
Montenegro	83.0**	n/a	n/a
Bosnia/Herz	83.0**	n/a	n/a
Morocco	81.1**	n/a	59.5**
Mexico	80.2	0.0	6.5**
Moldova	80.1	n/a	3.7
Georgia	73.0	n/a	n/a
Lebanon	68.0	n/a	n/a
Thailand	56.8**	0.0	0.0
Nigeria	54.0	n/a	n/a

*Note. 3G is percentage of mobile subscribers, not of entire population. *2006 data; **2009 data.*

capabilities similar to wireline. In this regard, then, when we consider the process of mobile leapfrogging from a global perspective, it is more appropriate to suggest that the rapid diffusion of mobile devices is facilitating the *possibility* of mobile leapfrogging in Internet access. However, this possibility can only be fully realized when the mobile devices being adopted possess the necessary capabilities for Internet access, and when broadband access and usage via mobile catch up with mobile device penetration.

Nonetheless, the rapid rate at which Internet-enabled mobile devices are diffusing has led many to proclaim that these devices may represent the long-sought solution to the digital divide.[35] And more recent data than the data presented here (which are from 2010) may show that over the past three years the process of genuine mobile leapfrogging in Internet access has accelerated substantially.

A Comparative Assessment of Mobile- and PC-Based Internet Access

While mobile-based Internet access may indeed represent the most viable solution to the digital divide, policy deliberations on this issue have thus far assumed too high degree of equivalence between mobile and PC-based Internet access. If we look, for instance, at the discussions that have taken place within the Internet Governance Forum, which is perhaps the most prominent and inclusive multi-national context in which digital divide issues are discussed, the baseline that has been established for discussions about the mobile Internet is not *if* it is an adequate substitute for addressing the digital divide that has developed in the PC context, but *how* to promote and preserve the rapid rates of mobile adoption that are increasingly common in developing nations. For instance, the Chair's Summary of the 2011 Internet Governance Forum stated that "the dramatic rise in mobile Internet access is bringing into sharp focus key policy areas, most notably access to spectrum and how it is managed and allocated into bands that optimize network investments. Other areas of concern include the capacity and quality of core network transport networks as well as the availability of sustainable and reliable power sources."[36] The question of whether mobile Internet access is a fully adequate solution to the digital divide problem was largely disregarded in order to focus on questions related to how to maximize access, investment, and diffusion.

In a rare counterpoint to this perspective, at a session of the 2012 Internet Governance Forum, one participant raised the provocative question, "should [developing countries] accept Internet access from mobile phones [as] sufficient? Should developing countries be demanding more?"[37] Those panelists who addressed the question answered with little elaboration that mobile access was sufficient and the issue received no further discussion, as attention quickly turned back to the issue of how best to accelerate mobile diffusion and access.

The goal of this section is to give these very important, though largely neglected, questions more expansive and comprehensive treatment than they have received at the Internet Governance Forum or in other policymaking contexts, with a particular emphasis on providing reasons to reconsider the common assumption that mobile Internet access represents a comparable form of Internet access to PC-based access.

Most research on mobile Internet access and usage to date has lacked comparative analyses of any type in which the characteristics or usage patterns of mobile platforms are assessed relative to PC-based platforms. And, when such analyses are conducted, any policy implications of the findings are largely neglected, given that these studies generally are not motivated by policy concerns. There are, however, a number of findings scattered across different

fields of study that can begin to inform the question of how mobile Internet access compares to PC-based access in terms of criteria relevant to the digital divide. It should be emphasized that the goal here is to focus on those aspects of the differences between PC and mobile Internet access that represent the fundamental, and perhaps difficult to change, differences between the two platforms. Thus, certain technological and economic disparities that could diminish rapidly over time (e.g., bandwidth and pricing differences) will not be a point of focus here, though these too have been raised in the few extant discussions about the possible shortcomings of mobile Internet access,[38] and so should be taken into consideration as well (see above).

Technological Capabilities

At the most basic level, it is important to consider the technological capabilities of mobile Internet devices relative to PCs. While both devices provide gateways to the Internet (although, as discussed below, not always the exact same Internet), the mechanisms by which a user engages with the Internet are fundamentally different in a number of significant ways—ways that in many cases have a direct bearing on whether the two platforms represent equivalent opportunities for users to take full advantage of the opportunities for social, political, and economic development that the Internet provides. As Rice and Katz noted in an early comparative analysis of PC and mobile device usage, an important dimension of the digital divide is the potential gap between those who have advanced functionality and services and those who have technologies with lesser capabilities.[39] As this section illustrates, this challenge persists as an important dimension of the digital divide when we compare many aspects of the functionality of PCs and mobile devices.

Memory, Speed, and Storage Capacity

Mobile devices differ from PCs across fundamental characteristics as basic as available memory and storage capacity. Mobile devices simply cannot store or process as much data as a PC.[40] Their capacity relative to PCs has thus been described as "intrinsically limited."[41] Such differences impact how the various platforms that users access online function. For example, a recent comparative analysis of YouTube's functionality across mobile and PC platforms found that YouTube performs far better on the PC than on mobile devices. These performance differences were due largely to the challenges associated with coping with "the tighter constraints in terms of storage availability for mobile devices."[42]

In an analysis of South African Internet users' attitudes and behaviors in relation to the mobile platform, Hyde-Clark and Van Tonder found that the limitations of mobile devices in regards to memory and storage were among the most frequently articulated reasons why those studied felt that mobile devices could not effectively replace PCs.[43] These same respondents expressed the sense that while mobile devices could replace PCs for various online "social" activities, they could not replace PCs for a range of more rigorous "business" activities.[44] These sentiments were reflected in the usage patterns revealed in the study, in which usage of mobile devices for accessing news Web sites and business services lagged far behind usage for social and entertainment services. In this way, the differences in capabilities lead to differences in usage patterns in ways that have a direct bearing on digital divide concerns. Specifically, if only the gap in access to and usage of entertainment-related content and services is being significantly closed, then fundamental digital divide concerns related to individuals' access to, and usage of, the kinds of information that can enhance their economic

prospects, political efficacy, and social networks persist.

Content Availability

Certainly some of these shortcomings related to memory, speed, and storage impact the availability and display of mobile Internet content. And so, in considering the technological capabilities of PCs versus mobile devices, it is important to also take into account how content is delivered on each platform.[45]

Of course, the smaller screens of mobile devices place limits on how much information can be displayed on a screen and how that information is displayed. Consequently, the history of the mobile Internet has been one in which two different approaches to displaying and accessing Web content have been employed. The first involves accessing full Web sites (those designed for PC interface) via Internet-enabled mobile devices. The second involves the development of "mobile tailored" Web sites which are parallel versions of traditional Web sites that are designed to better operate within the display limitations of mobile devices.[46] A third option, the use of mobile apps as a means of providing content and services to mobile devices via bypassing the Web is discussed under a separate heading below.

Within this context, there are two issues that need to be taken into consideration. First, for many of the Web sites that do not have an accompanying mobile version, mobile-based interaction with these sites can prove difficult; and, in some cases, impossible,[47] putting mobile users at a distinct disadvantage relative to their PC-based counterparts. This issue is of particular relevance when we take into consideration the less sophisticated mobile devices being adopted in developing nations and amongst low-income populations, which have a lower capacity than more technologically advanced smartphones in terms of displaying standard Web pages. According to one recent estimate, less than ten percent of the Web is "mobile-ready."[48]

This disparity in terms of mobile-ready content can be magnified further when the patterns of availability of mobile ready content are taken into consideration. For instance, a study of mobile device usage in Kenya found that users had very little access to locally-produced mobile ready content. As a result, they tended to spend the bulk of their time with international platforms such as Facebook, Wikipedia, and YouTube.[49]

Thus, even as users in developing nations gain access to the Internet via mobile devices, another form of digital divide persists in the form of a relative lack of mobile-ready content that directly addresses the populations' needs and interests. As Napoli and Karppinen illustrate, Internet governance discourse has increasingly acknowledged that disparities in available content may ultimately become a more significant element of the digital divide than disparities in technology access.[50]

Second, mobile-ready Web sites often represent streamlined or watered down versions of the standard Web site. Thus, mobile users often find themselves with access to less information and less functionality than PC-based users when forced to rely on mobile-tailored Web sites. Specialized search engines designed specifically for mobile devices have recently been introduced. These search engines essentially offer a more streamlined (one might say less information-rich) user experience than traditional search engines, reflecting the designers' assessment that in the mobile context "'the use case is more for messing around,'" rather than focused and directed information-seeking.[51] A common theme in the Web trade literature is the need for mobile-tailored Web sites to be designed in ways that allow them to be easily readable and navigable, given the smaller screen size available to users.[52] As one

assessment of the difference between content provision of the PC and the mobile device noted, "On the desktop, the question of how much copy is too much can feel very subjective. . . . In the mobile space . . . the need for brevity becomes more significant, and hard to argue against."[53] The end result is less information being presented to mobile users than to PC users.

Some research has uncovered significant dissatisfaction amongst Internet users with the scaled back versions of traditional Web sites that are accessible via mobile platforms.[54] As this research illustrates, this dissatisfaction arises from the more limited availability of content and the more limited array of functionalities and features that can be accessed on mobile sites. Subjects in this study were able to compare the mobile Internet to their traditional Internet experience. Mobile natives, on the other hand, would not even be aware of the degree to which their online experience falls short of a PC-based online experience.

Network/Platform Architecture

In considering the technological capabilities and characteristics across both platforms, it is also important to consider the structure and operation of the different networks and platforms on which the technologies operate. As Southwood has emphasized, "the very nature of the networks over which the Internet and mobile Internet are delivered differs."[55] This issue of the relative openness of mobile versus PC-based Internet access is reflected in the re-emergence of the "walled garden" model in relation to mobile Internet access.[56] The "walled garden" metaphor characterized the early days of dial-up Internet access, when ISPs such as America Online (AOL) sought to contain users within their own proprietary content, rather than having those users use the ISP as a gateway to the full expanse of the Web.[57] As Isomursu, et al. note:

> Mobile access service providers may set up 'walled gardens' providing custom content for their own clients, but at the same time building walls (intentional or unintentional) that prevent or hinder the access outside the garden. The walls can be, for example, payment regulations that make accessing external services expensive or make it difficult or unpredictable for the user to estimate the cost of leaving the garden.[58]

This issue of openness also arose more recently in a session of the 2011 Internet Governance forum devoted to the impact of the mobile Internet on Internet governance in Africa. This panel discussion began with the recognition that "the Internet in general is open, transparent and accessible. However, in contrast [the] mobile Internet... is relatively limited from that perspective of open [and] transparent [sic]."[59]

An additional force pushing toward the predominance of the walled garden model in the mobile Internet context is the explosion of mobile application production and usage as an alternative to accessing Web sites. Apps are designed and used specifically to compensate for the various shortcomings of mobile-based Web access relative to PC-based Web access.[60] And although apps certainly can provide an efficient and user-friendly experience, within the context of assessing mobile Internet access and usage against PC-based access and usage, it is important to recognize that the mobile apps model represents a much less open and much more constricted model of Internet access than traditional Internet access.[61] From a digital divide perspective, this would seem to represent another important criterion by which mobile device users could be perceived as receiving a "lesser" form of Internet access than their PC-based counterparts.

The devices themselves are also fundamentally different in terms of openness. Mobile devices are

a much less open platform for accessing the Internet than the PC.[62] As Horner notes, "unlike personal computers (PC), mobile handsets are primarily closed, proprietary technologies that are difficult for people to adapt and programme for different uses."[63] The opportunities, therefore, for mobile users to tap into the full economic potential of the Internet are much more limited. Consider, for instance, the dramatic entrepreneurial opportunities that have been facilitated by PC-based Internet access to develop and launch new online applications, platforms, and services that simply can not be approximated if a user is limited to access via a mobile device.

These disparities may ultimately be reinforced—and perhaps exacerbated—by differences in the regulatory parameters applied to the different platforms. In the U.S., for example, wireless providers have been exempted from some of the network neutrality regulations that have been imposed on wireline Internet service providers.[64] The FCC adopted this position due to a number of factors, including the rapid rate at which technologies and services are evolving on the mobile platform; greater competition in mobile Internet access provision than has historically been the case in the provision of fixed Internet access; and greater operational constraints faced by mobile Internet service providers.[65]

These justifications remain highly questionable.[66] The point here, however, is to emphasize that the perpetuation of such different network neutrality requirements across platforms would ultimately mean that mobile-only Internet users will access a very different Internet from PC-based Internet users, one in which the degree of openness and accessibility that has traditionally characterized the Internet could be significantly scaled back.

At this point, this bifurcated network neutrality regulatory model has only been instituted in the U.S. However, if—like the network neutrality issue itself[67]—this regulatory approach diffuses from the U.S. into other national contexts, then this issue becomes of greater significance in relation to the role that mobile devices play in addressing the digital divide.

Usage Patterns

The different technological characteristics of different communications platforms inevitably lead to different behavioral patterns and tendencies amongst users. Consequently, assessing the extent to which mobile devices represent an effective substitute to PC-based Internet access should be grounded in a detailed understanding of the usage patterns associated with the newer technology, and if and how these patterns differ in significant ways from the old technology. And, more specifically, do any of these differences in usage patterns relate to the concerns about disparities in the ability to access, produce, and disseminate information that are at the core of policy concerns about the digital divide?

A comprehensive understanding of the behavioral differences between PC-based and mobile Internet users is lacking at this point. This assessment is reflected in the fact that a fairly recent, comprehensive review of the literature on mobile use in the developing world, which organized the extant literature into a variety of subject categories, contained no subject category addressing comparative analyses of mobile and PC-based access.[68] At this point, research on the "traditional" and mobile Internet have been somewhat siloed lines of inquiry, with little comparative or integrated analysis,[69] and even fewer efforts to design studies that seek to compare these platforms in relation to the digital divide. As Hargittai and Kim note, "Despite the pervasiveness of mobile phones in everyday life and the potential benefits derived from various features of mobile services, there has been little attention given to cell and smartphone use patterns in relation to the digital divide."[70] Similarly, Hyde-Clark and Van

Tonder have noted that, within the specific context of mobile diffusion in developing countries, little research exists to illustrate how individuals are using the Internet once they go online.[71]

It is, however, possible to pull together some findings from disparate strands of research that, together, suggest that PCs and mobile devices may be "neither simply substitutes nor complements" in terms of Internet access and use.[72] These findings raise legitimate concerns about whether mobile Internet users are able to use the Internet in ways that effectively eclipse the digital divide between them and their PC-based counterparts.

Information Seeking

At the most basic level, it seems reasonable to question whether the depth of a user's engagement with the Internet is comparable across PC and mobile platforms. Are mobile Internet users engaging in as rigorous and engaged information-seeking, production, and dissemination as those who have PC-based access? This issue arises in research by Isomursu, et al., who explored the predominant metaphors for the mobile Internet that emerged from a series of user studies.[73] In terms of how users engage with information, the authors contend that an appropriate metaphor for PC-based Internet access is scuba diving, in which individuals can "dive deep into their areas of interest and be totally immersed with the experience."[74] Mobile Internet access, on the other hand, is considered by the authors as analogous to snorkeling, because "Environmental factors and equipment are optimized for 'skimming the surface' or 'dipping in and out.'"[75] As a result, the authors conclude that "*Passive forms of content consumption*... often work better in this kind of situation because they take up less cognitive energy."[76]

One usage study of mobile users in six countries concluded that information gathering was not a common task among mobile device users.[77] Another usage study that examined the nature of mobile Internet users' information-seeking activities found that PC-based users habitually access an average of 8.64 categories of Web sites, whereas mobile-based users habitually access an average of 3.58 categories of Web sites.[78] Along related lines, the average number of characters in mobile search queries is significantly lower than the average number of characters in PC-based search queries, and mobile searches utilize a significantly more limited search vocabulary than PC-based searches.[79] Mobile searches are also significantly less likely to utilize advanced search features such as Boolean operators or query modifiers.[80] Such tendencies may help explain why the rate of "unsuccessful" search queries (as measured by no click-throughs of the search results) is significantly higher for mobile queries than for PC-based queries.[81] Finally, mobile searchers exhibit a significantly greater tendency to rely on the first few search returns than PC-based searchers.[82]

Though some of these findings are somewhat dated (at least by Internet research standards), they do suggest that mobile Web usage patterns related to finding and accessing information are significantly more constrained than PC-based Web usage patterns. And, of course, when we consider the process of mobile device adoption in developing nations or under-served populations in order to effectuate leapfrogging, it is important to remember that these populations are not likely to possess the most advanced devices for some time.[83] As a result, findings that are reflective of the technological features and capabilities from the past five or so years are still likely to reflect the technological features and capabilities accessible by a significant proportion of the mobile-only population.

Some computer scientists have described accessing information and services on mobile devices as "inherently difficult."[84] Certainly, as devices and

services improve, such a blanket statement may become more difficult to support. However, it does seem reasonable to assume that mobile Web access and usage will remain inherently *more* difficult than PC-based access and usage.

Perhaps this is why a number of studies have indicated that mobile usage tends to be weighted much more heavily toward entertainment and leisure than is the case with PC usage.[85] For instance, a study of mobile users in Kenya found that "non-recreational uses of the internet, in particular professional activities, rank more highly in PC use… than on mobile phones, while the opposite is true for pure leisure uses such as playing games."[86] To the extent that a key underlying objective of any policy intended to eliminate the digital divide is to provide equivalent access to information to all members of the population, findings such as these would seem to represent an important consideration for any policymakers looking to the diffusion of mobile Internet access to comprehensively address the digital divide.

Content Creation

It is also important to emphasize that the digital divide is not only related to the ability to search for and access information, but also the ability to produce and disseminate information.[87] On this front there are also a number of ways in which mobile access likely falls short of PC-based access. Despite celebrated examples of best-selling novels being written on smartphones,[88] it is still the case that entering significant amounts of information is easier to accomplish on a PC-sized keyboard than it is on a mobile device's keypad.[89] This is an important point of distinction on a number of fronts. For example, this difference ultimately casts the mobile device as more of an information retrieval device and less of an information creation and dissemination device than the PC. This is not to say that substantial amounts content can not be created and distributed via mobile devices;[90] only that the creation of content of significant scope, complexity, and depth is much more easily accomplished via PCs than it is via mobile devices. This needs to be taken into account in relation to any contemporary conceptualization of the digital divide, which recognizes that the value of Internet access is a function of the abilities to both retrieve *and* create/disseminate information.[91]

This perspective receives support in findings that the creation of large and complex documents is a very uncommon activity on mobile devices.[92] Recent research that has compared mobile versus PC findings across two time periods (2007 and 2010) has found that a number of significant differences persist, particularly in terms of production and dissemination-oriented activities such as writing emails and participating in online discussions.[93] For instance, in 2010, 35 percent of mobile subjects reported writing emails on their devices, compared with 57 percent of PC users. Similarly, 24 percent of mobile users reported participating in online discussions, compared with 51 percent of PC users.[94] Similar patterns emerged in a PC deprivation study in which PC users were allowed only mobile Internet access for four days.[95] Participants used the device to access their email, but significantly cut back on composing and sending emails due to the difficulties associated with composing emails on a mobile device.[96]

Such findings appear reflective of broader patterns that have emerged in more macro-level multi-national research that indicates that "as new users get online, fewer and fewer of them appear to be content producers."[97] While this pattern may be a reflection of intrinsic differences between earlier and later Internet adopters, and may diminish over time, it also seems reasonable to ask whether such patterns might be a reflection of the differences between earlier and later adopters in terms of the characteristics of the device they are using to access the Internet. Perhaps the extent to which mobile devices are less conducive to substantive

content creation and dissemination is contributing to the fact that more recent Internet adopters (who are predominantly mobile users) are producing less content than previous waves of Internet adopters. This would seem to be a fundamental behavioral distinction that, if accurate, should factor prominently into any discussions about the extent to which mobile devices are eradicating the digital divide and creating an even playing field for users to take full advantage of the opportunities for social, economic, and political advancement afforded by the Internet.

Skill Sets Across Platforms

It is also important to emphasize that in mobile leapfrogging contexts, users are accessing the Internet for the first time via mobile devices. This stands in stark contrast to the earlier pattern, in which an individual first accessed the Internet via the PC, only to later migrate to the mobile device (either exclusively or in conjunction with the PC). As the literature on technology leapfrogging reminds us, there are potentially important implications in these different processes, as the PC-initiated Internet user may have developed certain types of knowledge and skills that transfer to the mobile context, thereby allowing a PC-initiated user of a mobile device to make more effective use of the platform than a "mobile native."[98] Hargittai and Kim, for instance, found consistent evidence that the amount of prior Internet experience and the range of Internet-related skills sets that individuals have developed in the context of PC-based Internet access is positively related to the range of functionalities that these individuals utilize on their mobile devices.[99] On the basis of these findings, they raise the concern that the spread of mobile devices could exacerbate existing digital inequalities.

In a rare study of the challenges that "mobile natives" face in using mobile devices to go online, Gitau, Marsden, and Donner found that a sample of low-income residents of Cape Town, South Africa faced a variety of technical challenges, related to issues such as device set-up, security settings, menu navigation, and the dearth of mobile-ready online content in their native language.[100] These challenges led the authors to conclude that "many elements of the mobile internet have been deployed with the assumption that would-be users would have access to a PC, and/or previous experience with the PC-based internet."[101] Similarly, a study of novice and low-literate mobile users in India, the Philippines, and Kenya found a wide range of usage barriers related to "understanding or utilizing hierarchical structures, soft keys, scroll bars, nonnumeric inputs, and specialized terminology."[102] Of course, PC usage would pose similar challenges to novice and low literacy users; nonetheless, the extent to which policymakers should assume that mobile access represents a complete leapfrogging opportunity should be tempered by such findings. As was noted earlier, instances such as this, in which the skill sets associated with the previous technology are relevant to the effective use of the new technology, pose particular challenges from a technology leapfrogging standpoint.[103]

Findings such as these are reflective of the increasing recognition amongst scholars and policy advocates (and, to a lesser extent, policymakers) of what has been termed the second-level digital divide.[104] The second level digital divide refers to the gaps in relevant technology usage skill sets that can persist even after disparities in technology access have been addressed. As Campbell and Kwak warn, "the rapid evolution of mobile communication technology creates new affordances for people to be connected and informed, however it also poses new challenges for those with lower levels of technological fluency, and this can have a detrimental effect on one's ability to maximize benefits of mobile communication technology."[105] Any such patterns are of increasing significance, given, as Horrigan

has argued, "lower levels of engagement with online resources among those who are online are more consequential than a few years ago."[106]

If mobile-only Internet users are unlikely to develop and utilize skill sets that are as extensive as those possessed by PC-based Internet users, then policymakers should be concerned about whether mobile leapfrogging is simply replacing one form of digital divide with another. One could argue that this second-level digital divide is of a lesser magnitude than the initial digital divide, but it is still a divide whose causes and consequences should inform any digital divide policy deliberations.

Conclusion

This paper has illustrated the current status of mobile leapfrogging as a global phenomenon and explored a range of fundamental differences between mobile and PC-based Internet access and usage, in an effort to illustrate some important ways in which mobile Internet access may fall short in terms of bridging the digital divide between those with and those without PC-based Internet access. This analysis has highlighted the more limited functionality of mobile Internet devices and networks across some key dimensions that bear directly on the extent to which the gaps in information access and usage that are an outgrowth of the digital divide can be alleviated.

Although this analysis has pulled together relevant findings across the computer and information science and communications literatures, it has also identified a lack of systematic comparative research that is grounded in – and informed by – digital divide research and policy deliberations. As policymakers consider the various technological platforms and policy options at their disposal to address the digital divide, their deliberations need to be informed by a more detailed understanding of how the technological, content, and network characteristics of different platforms impact patterns in information seeking, access, usage, creation, and dissemination that are at the core of why the digital divide matters.

It is important to emphasize that the goal here is not to oppose digital divide-motivated efforts to support mobile adoption and usage. Rather, the goal here is to try to inject into the policy conversation a more thorough understanding of how effective such efforts can really be in terms of providing mobile users with the same kind of opportunities to access, produce, and disseminate information as PC users; and to raise a note of caution about the implications of abandoning efforts to promote PC diffusion in the light of the potential for mobile leapfrogging. It is important to recognize the potentially significant compromises and shortcomings that come from a policy approach to the digital divide that emphasizes mobile access and largely abandons any emphasis on PC-based access, particularly in light of the fundamental requirement for technology leapfrogging discussed at the outset – that the leapfrogging technology be clearly superior to available alternatives.[107] In the case of mobile and PC-based Internet access, it seems that there are reasonable grounds to question whether this is indeed the case.

In the end, the digital divide is a complex, multi-layered phenemonon. Effectively addressing it requires a rigorous understanding of the fundamental differences between the platforms used to get online, as well as the variations in usage patterns that are exhibited across these different platforms.

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