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Research Topics for Informing Broadband Internet Policy

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INTRODUCTION

This issue paper presents a set of candidate broadband research topics prepared by the RAND Science and Technology Policy Institute (S&TPI) to assist the President's Council of Advisors on Science and Technology (PCAST) Panel on 21st Century Infrastructure. The PCAST Panel is examining broadband Internet infrastructure with the goal of developing policy advice on speeding broadband deployment by addressing demand-related issues.

As part of this process, OSTP staff has requested that S&TPI develop and briefly describe examples of research whose results would inform broadband Internet policy choices. They exemplify research that might best be done at a national level, independent of particular stakeholders in the policy debate. They are representative of projects that could be undertaken by creating and privately funding an independent, nonprofit organization focusing on broadband research.

These candidate research topics were derived from a review of the policy ideas being considered by PCAST. Our review examined the assumptions made by advocates of such policies, the evidence supporting those assumptions, and the uncertainties and gaps in knowledge surrounding them. The research topics were then synthesized to help clarify the underlying assumptions of various policies and to suggest approaches for obtaining better information and insights that can inform policy recommendations and choices.

The list of six research topics that follows is neither complete nor prioritized. It is not complete in the sense that other research topics could readily be added for consideration and in the sense that not every research idea is articulated to the same level of detail.

These research topics recognize PCAST's primary interest in Internet access technologies that deliver 10–100 megabits per second (Mb/s) of bandwidth to a customer. Technologies providing this kind of performance follow the deployment of earlier access technologies for both telecommunications and broadcast services. Experience with these prior technology deployments can provide insights and lessons to apply to digital broadband access in the range of 10–100 Mb/s. In this document the term broadband refers to both contemporary (e.g., Digital Subscriber Line [DSL] and Cable Modem) and future, higher-performance access technologies.

The set of candidate research topics is intended to stimulate discussion of both the research ideas themselves and how research on these or related topics can inform public and private sector decisionmakers.

LESSONS FROM BROADBAND DEPLOYMENT IN OTHER COUNTRIES

Research question

South Korea, Canada, and a few other countries lead the United States in broadband uptake among households. Is their success due to country-specific demographic factors, industry patterns, effective public policies, or other factors? For example, 90 percent of households in South Korea are within 2.5 miles of a local telephone exchange. Can population density explain the difference in uptake rate between Korea and the United States? Has Korea created a lead by pumping government money into broadband infrastructure, or did it manage to create a good business climate that stimulated private investment? What kind of broadband policies have these leading countries been pursuing? Are there lessons that U.S. policymakers can learn from these international experiences?

Research approach

This research would go beyond direct country comparisons of uptake rates to identify what quantifiable factors explain international differences in broadband uptake. An initial estimate can be obtained with a simple regression model. A first guess at such a model might be:

Broadband uptake rate (% of households) = Function [population living in urban areas (%), telephones per 100 inhabitants, personal computers (PCs) per 100 inhabitants, gross domestic product per capita, price of broadband (U.S.$ per kilobits per second per month), households with dial-up Internet access, percentage of teleworkers in labor force, capital investment by telephone and cable suppliers, policy variables such as degree of competition in telecom sector and public subsidy of broadband investment].

Data for the regression analyses are available from both country sources and international organizations such as the Organisation for Economic Cooperation and Development (OECD) and International Telecommunication Union (ITU). Time-series data are also available and can be used to investigate whether the differences between the United States and other countries are getting smaller or larger over time. If evidence of a "policy factor" emerges, the study should then focus on the specific broadband policies employed. This second phase would be more qualitative and should examine several kinds of policies, including those aimed at (1) creating a common national broadband agenda, (2) creating the right conditions for private initiative, (3) encouraging fair competition, (4) supporting content and service development, (5) supporting application development and demonstrations (e.g., for telework or e-learning), (6) supporting broadband R&D, (7) subsidizing broadband demand for rural or other groups, and (8) otherwise providing direct or indirect subsidies for broadband.

Why the answers are important to policy choices

International comparisons can be useful to U.S. policymakers, but just comparing broadband uptake rates among countries operating under totally different conditions is not sufficient. This quantitative analysis should help decisionmakers (both public and private) identify the relative importance of policy choices versus "natural local conditions." To the extent that policy is seen to influence uptake rates, the research should help policymakers focus on which policies can be effective for accelerating broadband deployment in the United States.

ELASTICITY OF BROADBAND DEMAND

Research question

How price-sensitive is residential demand for broadband? This question of demand price elasticity is at the heart of many discussions about broadband's current status or about how quickly broadband uptake can grow with or without government intervention. However, two important qualifications are necessary. First, the price of broadband access alone does not determine the elasticity. Demand elasticity also depends on the availability and price of alternatives. Is dial-up access a good substitute for current broadband offerings for most consumer applications? Will consumers see contemporary broadband as an effective substitute for future 10–100 Mb/s broadband? Moreover, consumers consider the prices of PCs and other hardware, software, and content in addition to broadband access. Broadband demand will be less sensitive to a decrease in subscription fees if broadband content remains overpriced or largely unavailable. Second, demand elasticity may differ widely among market segments. For example, young people may be much more sensitive to the pricing of online video content than are older people. The options that households have differ too: Not all communities have a choice of broadband providers. Therefore, the research question must consider how the presence of substitute access technologies, and the prices of other items needed to use broadband services, factor into the price elasticity of demand for different groups of (potential) broadband users.

Research approach

The analysis should be quantitative in nature. It should start with a review of existing estimates of broadband demand price elasticity, most of which have been made using different data and different methods for different geographical areas. Factor analysis should be applied to existing data to assess which group characteristics (income, age, teleworker, etc.) drive differences in measured elasticity.

Next, the determinants of demand elasticity should be analyzed separately for different groups of users. These estimates should focus on cross-price elasticity, i.e., the sensitivity of broadband demand to changes in the price of narrowband Internet and complementary products such as subscription fees for music or other content sites. The findings should then be related to policy variables, industry trends, and wider economic trends. This analysis should strive to answer questions such as: How might future changes in technology, the price of broadband access, and prices of complementary products affect demand for broadband? Which groups would be most influenced by price changes? To what extent can the present slower growth rates of broadband be explained by the economic downturn? What could be the effects of economic stimuli for the use of broadband for telework or other potentially important applications?

Why the answers are important to policy choices

Better insight into what drives demand is important for policies intended to influence broadband uptake, as well as for business decisions. The results of this research can inform policymakers about the likely effects of proposed policies (e.g., those affecting infrastructure costs, content availability and cost, new applications, and direct or indirect subsidies) on the demand for broadband. The analysis can also provide input to projections of the extent to which different groups (e.g., rural or low-income households) will be affected by different broadband policies.

LESSONS FROM CABLE DEPLOYMENT

Research question

Some of the problems facing broadband deployment are similar to those faced in nationwide deployment of cable TV in the 1970s and 1980s. These similarities include issues of rights of way, fees and other concessions required by state and local governments, and questions about pricing and other drivers of demand. What lessons can federal, state, and local policymakers learn from the diffusion of cable TV and apply to the deployment of broadband, both now and in the future (e.g., 10–100 Mb/s digital service)?

Research approach

Three lines of research follow the questions posed above. First, what lessons can be learned about best practices of state and local governments? How did state and local government policies and practices evolve with respect to cable rights of way and fees? How were conflicting interests among different industry segments and other stakeholders resolved? How effective were the 1972 Federal Communications Commission (FCC) cable regulations and other federal efforts to harmonize state and local policies and practices? In the 1970s, the Ford Foundation funded the Cable TV Information Center to provide local governments with advice and expertise. It should be worthwhile to examine this initiative and evaluate its role in the deployment of cable.

Second, what do we know about the drivers of demand for cable at different levels of adoption? Cable TV went through several stages of providing content. Starting with the national TV networks, cable systems later added nonnetwork channels from other markets, premium content (HBO), narrowcasting (A&E, BET), and public service (C-Span) channels. It also went through several technology stages involving narrowband interactive services, analog set top converters, and digital set tops providing both video and data services. Were the drivers of demand significantly different at different levels of adoption (e.g., penetration up to 20%, between 20% and 50%, and above 50%)? How did the supply of content interact with demand?

Third, how did the price of cable services affect uptake? How did price elasticity differ among different groups of adopters? How did price elasticity change over time with the introduction of substitutes such as satellite? How important was churn in limiting the pace of uptake at different times and among different adopter groups? How did pricing of direct satellite TV affect cable prices and demand?

Why the answers are important to policy choices

As stated above, broadband deployment is facing many similar problems. The results of this study should be used to inform policies aimed at (1) local and state government practices, (2) broadband content and services, and (3) prices. The lessons learned can help policymakers build on cable policy successes and avoid repeating cable policy failures.

WIRELESS AS A DRIVER OF BROADBAND DEMAND

Research question

The premise of this research is that terrestrial wireless can provide a third facilities-based form of broadband access with characteristics different from DSL and Cable Modem. A key research question is how much can wireless deployment spur demand for broadband (and vice versa). Assuming the technology has promise in one or more deployment models, what policies should be considered to nurture it?

Research approach

This research should consider two principal models of deployment for broadband wireless access: (1) the last mile to the home or office, and (2) local hotspots (e.g., in airports and hotel lobbies) linked to other last-mile technologies. Wireless Local Area Network (LAN) evolution within individual homes or offices would not be a primary focus of this research.

Up to now, fixed line-of-sight (LOS) terrestrial wireless to the home or office has not been competitive with other local access technologies. However, adaptive systems, multihop mesh networks (a form of peer-to-peer architecture), and other non-LOS developments may change that balance. Moreover, fixed wireless might offer symmetric high-speed access, which would differentiate it from contemporary forms of broadband (e.g., DSL and Cable Modem). What effects could symmetric high-speed access have on the demand for broadband in general and for new applications specifically? For instance, symmetric access may be important for telemedicine or telework, and it allows users to run a web server from a small office or at home. Users rather than carriers also might finance wireless access, although user financing faces its own issues and impediments. If analysis suggests that wireless access could spur broadband demand, what government polices could accelerate its deployment without distorting the relevant markets? What research and demonstration projects should the government consider?

Wireless hotspots are booming but face both technical and nontechnical problems in offering reliable broadband access to large numbers of customers. A first research question is what effect expanded hotspot coverage would have on overall demand for broadband. How can concerns of incumbents that sharing wireless access cannibalizes their business be addressed? Would scale-up require more spectrum, or should new approaches to using the available spectrum be considered? How do providers and users deal with interference issues? Can hotspot wireless access be made plug-and-play? What level of interconnection between independent hotspot networks is required? What services can be made available using this model? How can privacy and security of wireless access be improved? Can campus-based deployments of wireless hotspots be used as case studies to better understand this model of deployment?

Consideration of mobile wireless deployment should be deferred. Neither 3G nor other forms of mobile wireless are expected to provide broadband in the 10–100 Mb/s range anytime soon.

Why the answers are important to policy choices

Because wireless could be a major force in accelerating broadband demand, a closer look at the prospects for and impediments to its deployment is warranted. The results of the study would inform spectrum and other policies specifically related to wireless, as well as policies for stimulating demand for symmetric access services that wireless can deliver.

PROSPECTS FOR TECHNOLOGY LEAPFROGGING

Research question

Do new technologies hold promise for stimulating new broadband demand and leapfrogging existing access methods in the next few years? As one example, Gigabit Ethernet over Fiber (GEF) is becoming widely used in LANs and Wide Area Networks (WANs). GEF provides symmetric access at speeds at least two orders of magnitude greater than current DSL or Cable Modem services. Similar advances in computing have led to wholly new applications and demand patterns, as expressed by "Hamming's Law," which we paraphrase as: "When technology performance changes by an order of magnitude, fundamentally new applications and effects follow."

Research approach

This research should be structured around three themes. First is application development and demand for broadband. What kinds of new applications and services might 10–100 Mb/s access bring? For instance, could it enable new telework applications, new uses of television, and routine video conferencing for business and pleasure? How might such new services affect demand for broadband?

Second is the relevance of Hamming's Law for broadband. In computing, order-of-magnitude advances in hardware have led to a continuous introduction of new applications (such as spreadsheets, digital publishing, and digital photo processing), which drive demand. What new applications might arise if we apply Hamming's Law to broadband access itself? Could a 10–100 Mb/s symmetric access service cause fundamental changes in the use of the Internet compared to 0.1–10 Mb/s asymmetric access services?

Third are impediments to the deployment of leapfrog technologies such as GEF. By definition, leapfrogging rather than an incremental approach makes current infrastructure obsolete, which may be fought by incumbent broadband providers. However, new approaches such as user financing of GEF, along with aggressive marketing by real estate developers and apartment owners, could provide an alternative deployment path. This research should also examine the recent Canadian experience with user-financed GEF for schools and local community organizations.

Using these analyses, the study should assess the case for additional public and private sector funding of broadband R&D and demonstration projects. Examples could include telemedicine applications in retirement communities, broadband e-government applications, and broadband distance learning in homes, schools, and community centers. There may also be applications in the area of national security, such as web cams combined with video data processing used as surveillance tools, which would have obvious privacy as well as security implications.

Why the answers are important to policy choices

Leapfrog rather than incremental approaches could dramatically spur demand for broadband. This study aims to inform policymakers about the prospects for leapfrog technologies such as GEF, the new applications and demand patterns they may catalyze, and the policies that might increase the public and private benefits from their development and deployment.

DO "KILLER APPS" FOR BROADBAND EXIST?

Research question

Do "killer apps" exist for broadband? Many believe not. While e-mail remains a popular Internet application, it is no longer the dominant one. It may have started as a killer application, but it is now one of many applications in use. It clearly does not require broadband. Web surfing can be enhanced by broadband, but there is little evidence that higher speed alone will bring new demand for access to current web offerings. Studies by the Pew Internet and American Life Project and others suggest new applications, such as publishing and sharing rich media (e.g., home video) that are enabled for and used by subscribers with contemporary broadband (1–10 Mb/s). However, these same studies point out that there is no single killer application driving demand and that subscribers seem to be moving to broadband from dial-up as their use of the Internet matures and broadens. Mature, content-based industries, e.g., broadcast television and book publishing, do not appear to have killer applications—even the biggest hits have a small market share. Why should the Internet, a multipurpose/service infrastructure, be any different?

Others argue that on-demand music and video entertainment represent broadband killer applications that are constrained today by business and legal impediments to their widespread diffusion. Remove these obstacles, they contend, and demand for broadband will skyrocket. Still others suggest that applications such as multiplayer games, virtual reality, telework, telemedicine, or videoconferencing will become killer applications for broadband in the near future.

Are diffusion rates driven by a single dominant application significantly faster than diffusion rates driven by multiple useful applications with no dominant killer application? Is the role of a killer application associated with the introduction of a technology, and are killer applications replaced by multiple applications, with smaller market shares, as a technology diffuses?

Research approach

This research would examine the role (if any) of killer applications in driving the diffusion of past information and communication technologies, such as the telephone, broadcast and cable television, and personal computers, and then examine the policy implications for broadband.

Telephone service started with a single killer application (voice), and much later added other applications such as fax, voice mail, and call forwarding. However, the infrastructure has gone through several systemwide upgrades that enabled these new services, which are clearly not killer applications. Wireless telephone service started with the same single killer applications (voice) and is now adding additional applications such as Short Message Services and digital image capture and transmission. What lessons can be drawn?

Television service began with a generic killer application (one-way black-and-white video entertainment) that diffused into more than 90 percent of U.S. households within a decade of its postwar introduction. Subsequent developments added more diverse content (genres), subscription versus broadcast services, and pay-per-view services but no new killer applications. Why?

In contrast, PCs have diffused multiple generations of products, each able to run a successively broader set of applications. While spreadsheets may have been the initial killer application, what caused consumers and businesses to continue to upgrade their PC infrastructure and adopt multiple new applications and services? What are the implications for broadband?

Do emerging applications, such as multiplayer games, virtual reality, telemedicine, or videoconferencing have the potential to be killer applications? Are any of these applications impeded by the current broadband access technology performance (i.e., less than 10 Mb/s)? Would any of these applications dramatically improve with additional access bandwidth (i.e., 10–100 Mb/s)? Can the potential market size for each of these candidates be estimated? Does the potential market size of any of these candidates make it a potential killer application?

There are some environments where broadband has already highly penetrated, e.g., large business offices, some foreign countries, such as South Korea, and some communities, such as Blacksburg, Virginia. Has the behavior in these environments changed in a way that would help to understand the role applications play in driving the penetration of broadband in other environments? Do new applications, such as videoconferencing, remote training, and remote storage, arising in the highly penetrated business environment help to understand the presence or absence of a killer application? Do highly penetrated consumer groups, such as Blacksburg or South Korea, provide any insights about the role of killer applications?

Why the answers are important to policy choices

If history suggests that infrastructure diffusion is not driven by killer applications but rather by the accretion of multiple marginally valuable applications, then policies that nurture the collective benefits of multiple applications would be in order. Conversely, if killer applications have been essential to interactive infrastructure diffusion, policies that nurture the search for them would be in order.

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