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Debatable Premises in Telecom Policy

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Introduction

Many arguments for regulatory intervention in telecommunications markets rest on faulty premises. These are often ideas that make superficial or intuitive sense – and that have great political valence – but that don't stand up well to critical analysis. This paper collects and responds to a number of these premises that, collectively, underlie much popular, political, and academic support for increased telecommunications regulation.

The primary purpose of presenting these arguments in this form is to foster discussion about the nature of telecommunications policy debates and the role of telecommunications research in these debates. The critiques offered in this paper are, at some level, meant to challenge the validity of these premises. But their more important goal is more modest: to demonstrate that these premises are debatable. Too often these premises are assumed to be true or are simply presented as fact. One of this paper's own premises is that a core function of telecommunications research should be to add nuance and sophistication to policy discussions.

On the other hand, it does not require a great act of introspection to recognize that this is a field in which the line between scholarship and research on the one hand and advocacy, policy, and the press on the other is blurry and at times permeable. This is driven largely by the social and political role that communications infrastructure plays in modern democratic societies, both as a tool for communications and as a symbol of freedom, equality, and related value – these are the concerns that drive most popular and policy interest in these topics, as well as much scholarship. At the same time, these issues can be looked at from more technocratic perspectives, focusing on the underlying economics, technologies, demographic and usage patterns, and the like. It is frequently the case that these different approaches to the same questions lead to divergent policy proposals. And even when they could lead to convergent policy outcomes, the different approaches to issues may lead to divergent participation in the discussions.

The broadest goal of this paper, in some ways modest, in some ways ambitious, is to shed light on how we (that is, those discussing telecom policy) discuss these issues and to encourage us to think about the role of scholarship and research in policy and popular telecommunications debates.

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More narrowly, the goal is to demonstrate that important ideas in these debates require greater nuance than they are ordinarily afforded. In some cases, this lack of nuance yields a false dichotomy, such that consumers (it may be asserted) either need or do not need a given service; in some cases it results from incorrect technical understandings or overly-simplified models; and in other cases it results because the ideas that we debate are really implicit proxies for other political or policy views. In any of these cases, however, the result is that participants in telecom policy debates often talk past each other and adopt entrenched, self-reinforcing, positions.

The five premises that this paper considers are:

1. Everyone needs low-cost access to high speed broadband service
2. High-speed broadband is necessary for education, health, government, and other social services
3. Wireless can't compete with cable
4. An open Internet is necessary for innovation and necessarily benefits consumers
5. Telecommunications are better in Europe, Asia, or somewhere else.

Debates over telecom policy are necessary to the wellbeing and prosperity of our country. Sound telecom policy can benefit consumers nationwide; bad ideas can be terribly costly. At its best, telecom policy can help lift the poorest and least fortunate among us to prosperity, afford unparalleled access to education, health, and other essential services, and create platforms for expression and enterprise unknown at any prior point in human history. Few, if any, other technologies or industries have the potential to create so much good for so many.

As a result, these arguments tap into deep currents in the popular psyche. The questions at issue in telecommunications policy reflect values at the core of our democracy, social commitments to equality and universal access, and concern over censorship and centralized control of information. The intuitive appeal of these arguments ensures that they find substantial support among well-intentioned legislators, regulators, and much of the public. But intuitive appeal often leads analysis astray. This paper relies primarily on economic and technical analysis and research to demonstrate that the intuitive approach to these issues often leads to conclusions deleterious to consumers.

That the consumer must come first is a central theme that runs throughout this analysis, and should be a guiding principle through all telecom policy debates. It is too often the case that even well-intentioned and seemingly consumer-friendly policies do not fully appreciate the complexity of the market and therefore fail to place the interest of all consumers ahead of the interests of specific, often narrow, interest groups.

Hopefully, identifying faults in these premises will help us to address the issues that they represent with greater care; and hopefully this paper's presentation will foster discussion about the role of economically- and technically-informed research in policy debates. This is an exciting time in telecom policy. It is also a challenging time, given the fundamental shifts in technology and the industry that have occurred in recent decades.

This paper proceeds in six parts. Each of the first five parts corresponds to one of the premises listed above. Part six discusses themes that run through several of these premises and considers the role of substantive telecommunications research in telecommunications policy debates.

I. Premise One: Everyone Needs Low-Cost Access to High-Speed Broadband

The first premise considered is that everyone needs low-cost access to high-speed broadband. This idea is central to contemporary debates in the telecom space and guides much of current policy. This premise gives rise to several related policy prescriptions: ensuring the availability of service everywhere (universal service); ensuring that service is either low-cost or subsidized for those who may not be able to afford access; ensuring that at least one carrier offering such service is available to every consumer (a "carrier of last resort"); and imposing various service-level guarantees and quality of service requirements on every carrier.

As an initial matter, universal telephone service has historically been leveraged to support various important social commitments. Ensuring that everyone has access to some basic communications platform, so that they are able to get access to emergency services and avail themselves of other important government and social programs is an important value that we should strive to maintain. As will be repeated several times in this paper, the consumer must come first – it is unquestionably the case that there is a set of basic services that we should ensure are available to all consumers.[1]

The challenging questions are at what level and by what means do we maintain these commitments. Many in the telecom policy space – often those with the loudest voices – have long advocated that every American needs access to high-performance telecommunications services (today, that is high-speed Internet service) at low cost. Indeed, a majority of what the FCC does today is done with this goal, directly or indirectly, in mind. But while there is a strong argument that we should endeavor to provide every American with access to some level of connectivity, it is unclear what that level of connectivity should be. Indeed, as we have transitioned from narrowband voice communications to broadband Internet connectivity, the advocates and policy makers have consistently increased their target for sufficient levels of connectivity. Importantly, these changes have tracked changes in median (or even high-end) usage patterns, as opposed to tracking what is sufficient to provision socially necessary services.

Historically, the difficulty of determining what services belong in this set has been masked by the nature of telephone technology. The basic unit of connection – the twisted pair of copper wires – that was necessary for any service was also sufficient for most services of interest to most consumers. As a result, by requiring universal provision of the most basic services, we also facilitated the provision of more advanced services.

This no longer holds in today's digital economy. One can get connected to the communications network through various means: fiber, coaxial cable, wireless voice, fixed and mobile wireless data, satellite, and even still, the good old twisted pairs of copper. Each of these means of connecting to the network offers better or worse support for various services and applications. Fiber is very fast but expensive; cable and (especially) DSL are somewhat slower, but are also somewhat cheaper; wireless is generally a bit slower still (at least as of today), a bit less reliable and often somewhat more expensive than cable – but it's mobile, which is pretty great! Some of these technologies are better for voice service, for video service, for downloading large amounts of data, or for playing video games. Some of these services are also better or worse regarding our social commitments: mobile wireless, for instance, is great in that you can bring your connection to

[1] *See, e.g.,* Chairman Wheeler's Network Compact.

emergency services wherever you go; but it is problematic that it can be difficult for those emergency services to know your location should you need them to find you.

Developments in the many technologies suggest that we need to take a more nuanced view of how to provision communications networks to support important social commitments. The historical precedent, that we would provision a connection capable of supporting nearly the full range of possible services, was a happy historical accident. It was possible in part because the basic unit of service was capable of supporting the full range of consumer-oriented communications services. And it was possible in part because the relative elasticities of demand for communications services offered a relatively efficient mechanism for funding universal service buildout.[2]

The most difficult aspect of this more nuanced view is that we need to think seriously about what services are included in the bundle of basic social commitments.[3] Many advocates argue that every American should have access to low-cost Internet service capable of supporting streaming video services. That is quite an upgrade from the basic services historically provided through universal service – basic local voice communications service (long distance was available, but at substantial cost). Many advocates justify promoting this class of Internet service as "basic" on the grounds that such high-speed service is needed to ensure access to e.g., educational, health care, and governmental services. However, the reality is that most (and possibly all) of the services that clearly belong in the bundle of basic commitments – affordable access to a reliable communications platform that provides access to emergency services, essential government services and information, employment applications, and even basic e-commerce – do not require a class of service sufficient to support high quality streaming video. Those who think that other, more resource-intensive, services do belong in the bundle should face a stiff burden in advancing their argument.

Indeed, the idea that high-speed broadband is necessary in order to meet these social commitments, and also to provide various educational, healthcare, government and other services, implicitly excludes various disadvantaged communities from these services.[4] The only reason that high-speed broadband is necessary for many of these services is because they have been developed to offer rich multi-media experiences. That is, they use audio and video. This means that they are not accessible to the deaf and blind. In our race to leverage the latest and greatest technologies for various (legitimately important) services, we too often forget that not everyone can avail themselves of those technologies.

Perhaps the most tragic aspect of this premise is that it is largely needless: there is little reason for many of the services being deployed online to *require* rich multi-media. The push for a resource-intensive user experience is in many cases driven by the existence of the technology, not by the needs of the users. This, in turn, drives up consumer need to high-speed broadband.

A better, more modest, regulatory initiative may be to require essential services – the sort of applications that would justify ensuring access to broadband – to be developed so as to not require high-speed broadband. Rather than fueling a race to use more bandwidth-intensive design practices,

2 Cite discussing Ramsey pricing and how relative elasticities of demand for these services have changed over time (e.g., cross-subsidizing residential loops from business long distance is relatively more efficient than cross-subsidizing (inelastic) low-speed broadband from (elastic) high-speed broadband).

3 Another aspect of this is the relative lack of appreciation for the relative scale of bandwidth requirements for various applications.

4 See Premise Two, *infra.*

the government could instead lead the way in the adoption of more efficient, resource-conscious, design practices. This would serve the parallel goals of improving accessibility and decreasing reliance on high-speed broadband.

There is a more fundamental point underlying this idea: engineers optimize – that is they design products around – the simplest and least costly constraints. This means, for example, that if bandwidth is cheap and plentiful, programmers will design applications that make use of that bandwidth. If, on the other hand, bandwidth it costly, programmers will design applications that make less use of data – and consumers will demand such applications. For example as more users access Facebook with a mobile device, Facebook has re-engineered its mobile platform to decrease average monthly data use from 14MB/mo to 2MB/mo. Not only does this lower long term operating costs for Facebook, the lowered data requirement of the platform encourages users to access it more. Or consider recent research that computer users on metered Internet connections are more concerned about viruses and other harmful programs – thus they expend more resources to keep their computers free of such software to keep their monthly Internet bills lower.

And consider that in environments where bandwidth is scare, for example India, Pakistan, and parts of Africa, engineers and entrepreneurs conceive applications from the beginning as needing to function within strict bandwidth constraints. Video conferencing and streaming video applications need to be delivered on less than 1 mbps connections, so they design technologies that make more efficient use of bandwidth than do engineers in economies where bandwidth is cheaper and greater.

Recent telecommunications policy discussions have increasingly embraced ideas of dynamic competition and innovation. In the context of network neutrality, for instance, the FCC has made use of the idea that there is a "virtuous cycle," where openness today drives innovation in application development, which in turn will drive increased consumer demand for broadband.[5] But this cycle need not be "virtuous." If we peg required bandwidth floors to a level sufficient to accommodate the most bandwidth intensive applications, this will tend to increase the bandwidth consumed by all applications by virtue of removing bandwidth as a constraint – this, in turn, will increase the amount of bandwidth that needs to be offered. The resulting incentive structure unravels, creating a constant upward pressure. A policy that implements such an incentive structure has the perverse effect of supporting – even incentivizing – lazy innovation and poor design practices.

A critical question – the most important one – about these services is often overlooked: where is the consumer in all of this? Those advocating high-speed broadband as a universal service often have more to gain from such programs than the median consumer. Firms such as Google, that provide services and applications that run over communications infrastructure, are clear beneficiaries; as are networking equipment manufacturers. Politicians, too, often have much to gain from this strategy, as the costs of provisioning these networks are not transparent to voters and indirectly bourn. And the academy is more likely to reward academics who promote regulatory programs that appear to advance social needs than those who argue against programs that appear to benefit the public interest.

5 See *infra*.

But just as communications technologies and the services that they facilitate are diverse, so too are consumer preferences. It is absolutely the case that there are basic services to which we should do our best to ensure that everyone has reasonable access. But today we need to think more carefully about what these services are than we have historically needed. Most important, we should resist the urge to treat every American as though he or she has the same needs and wants as Washington, Silicon Valley, and academic policy makers.

Along these lines, the meaning of "universal service" is long past a need for review. Returning to the earlier discussion of how the basic unit of transmission has changed – from a unit capable of supporting the full range of telecommunications services to a range of units capable of supporting a range of services – the central question that "universal service" faces is what services need to be universal. There is a strong argument, for instance, that the basic service universally available should be sufficient to support access to basic news and information, health, educational, and governmental services. There may be some argument that such a connection should be capable of supporting basic online video services. But there is only a much weaker argument that high-definition, or even 4K, online video needs to be universally available.

Adding to this, we should also remember that broadband is rarely, if ever, a final product. Consumers don't pay for Internet service for the sake of having Internet service.[6] Rather, Internet access is merely an input that enables consumption of online goods and services. Universal Service support – and in many ways broadband marketing generally – therefore, should be developed around actual consumer demand and delivered in ways relevant to consumers.

It may make sense, for instance, to reframe universal service goals to focus on enabling certain classes of applications. Rather than define universal service as generic high-speed Internet (itself defined at, e.g., "4 mbps down/1 mbps up" service), universal service could be defined as service sufficient to support a minimum bundle of services. That bundle may include, for instance, healthcare, education, employment, and government, services, common news and information services, basic online video services, and VoIP and other common over-the-top services.

There are two basic challenges to such an approach. The obvious challenge is defining what services should be included in this basic bundle – though this is the sort of task routinely overseen by regulators. A more subtle and potentially difficult challenge is that it may create an incentive for application designers to make excessive use of bandwidth. This incentive may exist because access providers would be required to provide a bundle of services sufficient to support those applications, no matter how inefficiently designed they may be. This approach to defining universal service, therefore, would need to be careful to take this into consideration. It may, for instance, be possible to competitively benchmark the bandwidth (and other) requirements of like-services in determining whether an access provider is sufficiently provisioning its network.[7]

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6 For some consumers it may at times appear that they do. Consumers may, for instance, prefer having the highest-speed Internet available, even if their usage patterns don't benefit from that speed as compared to a lower-speed option. But even in these cases, the consumer likely derives some extrinsic value from having the higher-speed option, for instance through indicating status. In this sense, high speed Internet may be a form of Veblen good. In other cases, consumers simply may not appreciate how much speed their particular usage patterns require, so opt to purchase the highest-speed option available.

7 For instance, if a party were to raise concerns that an access provider's network was insufficiently provisioned to handle a certain quality of streaming video offered by a given service, that concern could be rebutted by

More generally, the Commission may want to encourage similar experimentation with how Internet services are marketed and sold. Few consumers have an appreciable understanding of the difference between 6 mbps and 25 mbps service, or of the difference between the resources required to deliver an email as compared to a 60 minute streaming video. The norm of marketing Internet access in terms of peak download and upload capacity is confusing to consumers, ignores the possibility of service commitments and competition along other metrics (e.g., latency or jitter), and is generally irrelevant to what consumers care about. It would almost certainly be more relevant and less confusing to consumers were Internet access to be marketed in terms of the services that they support. And, perhaps even more important, such marketing would likely provide consumers with more meaningful remedies should access providers fail to live up to these promises. An express commitment that a given service package is capable of supporting HD streaming video, for instance, would more likely create an enforceable contractual commitment than the current approach to marketing; it would make enforcement actions by the FCC or FTC easier to bring and more likely to be successful; and it would require Internet access providers to upgrade their infrastructure to match changing requirements of various services. While anathema to the views of many policy advocates – those, for instance, who would view this idea as turning Internet access into a "cable-like" system – it could be among the most consumer-friendly of possible changes to how Internet services are marketed and provided.

A final possible innovation to universal service would be to allow localities to "buy out" of the system. While universal service, as defined by the FCC, may be an important federal goal, local municipalities may face other priorities, or have other ideas about how to best achieve the universal service goals. Just as we should recognize consumer welfare and preferences should be the loadstone of telecommunications policy, we should recognize that municipal governments may have a better sense of the wants and needs of a local population than the federal government. It may therefore be reasonable to allow local governments to "buy out" of federally-administered universal service programs by accepting a one-time payment of some amount less than that which would be invested in the locality through the federal program.

II. Premise Two: High-speed broadband is necessary for education, health, government, and other social services

The idea that high-speed broadband is necessary for education, healthcare, and other social and government services is related to the first premise. This premise is problematic both because it is factually dubious, and also because its power is based in an implicit appeal to inherently emotional issues. It creates a sense that the only way to support high-quality education, provide access to healthcare and employment opportunities, and address concerns about the digital divide is to support a specific broadband policy – namely one of extensive government subsidies for high-speed broadband. As recognized in the previous installment, broadband Internet service and other communications technologies support many important services that should be viewed as basic social commitments – but the focus in telecom policy debates should be on ensuring Internet access that is sufficient to realize these basic social commitments, not on subsidizing higher-speed luxury services or services that the market would otherwise provide at competitive prices.

demonstrating that other services (including those offered by the provider's own vertically-integrated offerings) were capable of delivering similar quality video.

The first, most important response to this premise is that high-speed broadband connectivity isn't typically needed for education, healthcare, or other social services. It is especially true that the bandwidth sufficient for high-quality video streaming services – a critical benchmark for most broadband advocates – isn't necessary for these services. For example, today's system requirements for video conferencing applications, including programs routinely used for distance education and MOOCs ("Massive Online Open Courses"), is in the 1-2 mbps range.

The developers of these applications recognize that their products need to work even in low bandwidth environments, so design their applications to even without high-speed broadband. Adobe Connect, for instance, only requires 512 kbps connection for classroom participants. Coursera, a popular MOOC platform developed by Stanford, Princeton, the University of Michigan, and the University of Pennsylvania and that today comprises a consortium of over 100 universities, has recently announced a mobile-optimized app that allows students to view recorded class sessions on their mobile devices. Similarly, Adobe Connect has a mobile application that allows for real-time video participation.

More bandwidth is of course preferable, but typically is not required for basic operation. In technical terms, it is important to recognize that most of the video delivered in the MOOC setting is highly compressible. Unlike television or movie content, most of the frame is relatively static, with relatively simple background settings. Such video is readily and substantially compressible. Moreover, because MOOC software needs to support the typical student's computer hardware (e.g., a moderate resolution monitor displaying both in-class video and other class-related materials on a single screen), the typical resolution of video in the online teaching environment will be far below that of HD streaming video services.[8] Additionally, and perhaps counterintuitively, MOOCs with their large enrollments generally require less bandwidth than smaller online teaching settings. The large class sizes mean that most video will be delivered one way, from the instructor to the students – due to the large number of students, interactivity will be achieved through non-video means (such as quizzes or written questions moderated by an in-class assistant). In such a setting, the user experience will be less sensitive both to bandwidth and latency variations.

This reveals another often overlooked aspect of broadband policy debates: bandwidth isn't the only, and often isn't the most important, metric. Latency (the time it takes a packet of data to traverse the network), jitter (the chance in latency between packets), and packet loss (the percentage of packets of data that never make it across the network) are incredibly important metrics, especially for applications in education and health care – applications where the user may need to interact in real time with a teacher, classmates, or healthcare professional. Substantial or irregular latency and packet loss can lead to jumpy, broken, or lost audio and video – it is far preferable to have a lower resolution but consistent-quality audio and video than high-quality but unreliable audio and video.

The idea that latency and packet loss can be as important as bandwidth is not new. But it is one that plays little role in contemporary policy debates. The failure to appreciate the importance of these metrics is a serious flaw in these policy discussions. It is akin to having a transportation policy that focuses on miles of highway constructed but pays no attention to whether those highways actually decrease commute times or accidents.

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8 See also Arnold Kling, *Many-to-One vs. One-to-Many: An Opinionated Guide to Educational Technology* (Sept. 12. 2012), available at Many-to-One vs. One-to-Many: An Opinionated Guide to Educational Technology (arguing that the more fundamental change to education enabled to technology is many-to-one teaching through adaptive textbooks, rather than the massive one-to-many model of teaching facilitate by MOOCs).

Indeed, where education, healthcare, or other services require high-performance Internet service, one important alternative to provisioning high-speed Internet service in high-cost areas is to rely instead on quality of service (QoS) and prioritization techniques to ensure sufficient performance over lower-speed links. This would not allow a service requiring an average 2 mbps throughput to operate over a 1 mbps link – but, where such a service may not function well on a 3-4 mbps connection, prioritization could allow it to operate over a lower-speed (e.g., 2 mbps) link. To make sure this paragraph's suggestion is clear: lower-speed links that do not adhere to "network neutral" routing may often be able to support the same services that would require a higher-speed (and higher-cost) connection on a neutral network.

Another important, and often overlooked, metric, is adoption. In recent years survey evidence, such as the Pew Research Center's study on Internet and American Life, has made clear that availability and price are not the primary reasons that people in the United States do not have Internet access. Rather, low adoption is driven by concerns about usability, relevance, and worries about online harms. These concerns are particularly salient among older demographics – those who would be most likely to benefit from (or even need) Internet-based healthcare, government, and other services.

Other issues with the idea that high-speed broadband is necessary for these services become clear when looking at each service individually. In the case of health care, for instance, it is unlikely that residential users would have any need for the sort of telemedicine devices that require high-speed connections.[9] Rather, consumer-grade healthcare applications are more likely to be used for monitoring and reporting – applications that either send occasional large bursts of data or send consistent, possibly latency-sensitive, small packets of data, and that in either case do not require particularly high-speed connections. The greater challenge for these applications is likely to come from the multiplicity of such devices – the so-called Internet of Things, where dozens of devices in one home or millions of devices on larger networks. There is concern that millions or billions of devices, each sending small bursts of data, will overwhelm networks. In such cases, even if the network provides sufficient bandwidth, it may not be able to handle the multiplicity of connections. To use the comparison with highways, the more cars you put onto a single road, the more accidents and delays there will be, independent of the speed limit or number of lanes. A network transmitting 100 million small packets per second will be far more congested than one transmitting 10 million large packets per second, even if they are both transmitting the same total amount of data.[10]

It is important to distinguish between consumer-oriented Internet service and Internet service used by institutions such as schools and hospitals. There is a much stronger case that institutions need access to high-speed Internet service. Schools, for instance, often need to support simultaneous Internet use by hundreds of teachers and students. And, while each student remotely connecting to a video-based classroom may only need a modest amount of bandwidth, on the institutional side, connecting several students to the classroom will require a much greater amount of

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9 Such devices include equipment such as MRIs and other imaging devices.

10 Importantly, most network switches are provisioned in terms of the number of packets they can switch per second, as the switching logic is more computationally intensive than copying data from an input port to an output port. For instance, the standard line-rate gigabit Ethernet port can switch 1,488,100 packets per second. If the typical packet size is 100 bytes, which may be typical for machine-to-machine communications, the network will only be able to run at less than 20% of its provisioned capacity.

bandwidth for the institution as a whole.[11] There is legitimate concern that students need access to some sufficient level of bandwidth at home for educational purposes. But to date there have not been serious efforts to determine how much bandwidth is "sufficient" for educational purposes – rather, advocates' estimates have tracked median consumer bandwidth preferences, which in turn track the bandwidth requirements for high-definition streaming video content.

Similarly, the amount of bandwidth needed by a hospital for real-time telemedicine applications, even for things as simple as transferring a patient's MRI data to a doctor in another hospital for a "virtual" consultation, can be substantial. So, it is certainly the case that that these institutions need for high-speed Internet access. But the market for these sort of institutional connections is much different from – and much more competitive than – the market for consumer-oriented Internet access. Still, as is usually the case for commercial-quality products compared to their consumer-oriented counterparts, Internet connections suitable to meet these institutions' needs are often quite expensive, especially for public and non-profit institutions such as schools and hospitals. While current programs to assist in getting these institutions online (e.g., E-Rate) have their problems, there is a much stronger argument to be made for government support of these institutional Internet-access needs than for government support of consumer-oriented high-speed Internet access.

It is undoubtedly the case that broadband Internet can be an important tool for various educational, healthcare, and other social and government services. But speed – especially "high-speed" – isn't the only or most important metric to consider when provisioning these services. It is unfortunate that advocates of government-sponsored consumer high-speed broadband Internet use the indisputable importance of services such as healthcare and education to buttress their argument for government intervention in the high-speed broadband market. At best, this represents a misunderstanding of these services' actual requirements. It may also represent a willingness on the part of broadband advocates to assert their idealized view of how the Internet should be used over the needs of those who actual will rely on these services. At worst, it is a deliberate tactic, being used as an emotional appeal to advocate for a preferred policy that is not otherwise supportable by technical requirements.

III. Premise Three: Wireless can't compete with cable

The next premise is that wireless is not a viable competitor to wireline broadband services – and in particular that it is not a viable substitute for cable.

The basis for this premise is seemingly reasonable: both wireline services (such as cable) and wireless services transmit data over electromagnetic spectrum. They both use the same techniques to encode machine-intelligible bits of data into electromagnetic energy, and the laws of physics subject both to the same constraints. Wireless carriers in any geographic area share several hundred megahertz of spectrum, and their signals are subject to interference from both other carriers and

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11 That said, a review of studies of how much bandwidth is needed by educational institutions suggests that the required bandwidth is often over-estimated. For instance, in presentations made at George Mason University's Information Economy Project, both Robert Kenny and Scott Wallsten have raised concerns about these studies, finding basic errors in some (such as misattributing the bandwidth requirements of a small town for those of a single school in that town) and expressing concern that many of these studies are developed by hardware manufacturers with an interest in selling equipment.

natural sources. Coaxial cable, on the other hand, gives a cable company roughly 800-MHz of dedicated spectrum – several times the spectrum available to most current wireless carrier – and transmits signals along a shielded corridor that protects them from most sources of interference. Because coaxial cable offers cable companies more spectrum than is available to wireless carriers, and because that spectrum is better shielded from interference, one may reasonably expect that cable companies will always have a competitive advantage compared to wireless.

While this intuitive understanding seems reasonable, it grossly oversimplifies the underlying technology, unsurprisingly leading to incorrect conclusions. As an initial matter, the differences between wireline and wireless explained above refer to the peak capacity of individual transmission units – i.e., a coaxial cable or cell tower – not the capacity available to individual users. An individual coaxial cable is typically shared by a couple hundred users; an individual cell sector may be shared by a few to a few hundred active users. Therefore, the correct thing to look at is each system's capacity per user, not the peak capacity of the individual transmission unit, and the costs (in terms of both money and time) of provisioning new resources to add capacity or to address congestion.[12] Whether provisioning additional capacity to meet demand is more economic for either cable or wireless will depend on the particular characteristics of a given network, its surrounding physical and regulatory environments, and the underlying cost structure.

More important, wireless has clear advantages over coaxial cable in the long run. This is because anything coax can do wireless can do, too – and there are things that wireless can do to improve performance that coaxial cannot. As mentioned above, both technologies transmit a signal over spectrum, and both use the same encoding techniques. Any new encoding technique that works for a signal sent via cable will also work for a signal sent via wireless. But cable has a fundamental limitation compared to wireless: a cable transmits its signal, in one dimension, along a straight line. A wireless signal is transmitted through space, in three dimensions. This means that wireless can avail itself of transmission and reception techniques using multiple antennas – so-called spatial diversity or antenna arrays. Such systems are often referred to as MIMO ("multiple-input, multiple-output," referring to the number of receiving and transmitting antenna).

MIMO technologies have been taking the wireless world by storm over the past decade – early MIMO technologies have been incorporated into current standards for WiFi and LTE. And there is active discussion of developing "Massive MIMO" technologies for 5G wireless networks.[13] There are three primary applications for MIMO: interference mitigation, signal multiplexing, and beam-forming. By comparing the signals received at each of multiple antennas, complex algorithms are able to detect, and cancel-out, interference. This means that MIMO-based wireless transmissions can have interference characteristics comparable to those of coaxial cable. Using this interference-cancellation technology, MIMO also allows multiple signals to be sent over the same spectrum simultaneously. In other words, a carrier with 40-MHz of spectrum could use a 4x4 antenna to transmit 160-MHz worth of signal (4 x 40-MHz carriers) in that spectrum. There is some loss as

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12 Assuming a greenfield build, the economic case for wireline over wireless generally turns positive with three or more active Internet users per household. *See* Michael Horney and Roslyn Layton, *Innovation, Investment and Competition in Broadband and the Impact on America's Digital Economy* (Mercatus Center at George Mason University, August 15, 2014), http://mercatus.org/sites/default/files/Layton-Competitionin-Broadband.pdf. This assumes that the users do not also have mobile Internet access, or derive incremental value from mobility. Where that is the case, the economic case for wirelines likely turns positive at an even larger household size.

13 See, for instance, almost any recent issue of IEEE Communications, which regularly includes articles discussing developments in MIMO.

signals are added – but MIMO systems are already able to increase capacity by 200% to 300% using 4 streams. In other words, 300-MHz of wireless spectrum can carry as much as 800-MHz of coaxial spectrum. Massive MIMO technologies are being developed today that could increase performance by another factor of 30 in 5G wireless networks.

(The third basic MIMO technique, beam-forming, is a bit too complicated to explain here. Basically, using multiple antennas, a wireless signal can be focused in a single direction (into a "beam") – or into multiple beams, each going a specific direction. The beams don't interfere with each other, such that each can use the full spectrum capacity of the sector, allowing more users to be served by a single cell or access point without reducing speeds available to each other user.)

Some advocates dismiss MIMO's capabilities by arguing that MIMO does not work well in a mobile setting. This is not a technically accurate statement. The correct statement is that mobile MIMO cannot work better than fixed MIMO. MIMO technologies can work in a mobile setting – and, indeed, they are already being implemented in LTE devices. The number of antennas that can be fit in a cellphone is limited (typically to two) due to the size of the device; and fast-moving devices (e.g., a cellphone in a car) receive reduced benefits from, for instance, interference mitigation and beam-forming. But the basic technologies do work in a mobile setting, are being deployed today, and are improving at a rapid pace.

There is a more fundamental problem with the critique that MIMO doesn't work well in a mobile setting: high-speed broadband is generally needed in fixed, not mobile, settings. That is, you are far more likely to need high-speed broadband to watch high quality streaming video on your large television than on your small phone. The proper comparison between cable and wireless capacity is between cable and fixed wireless. Here, given the availability of, and continued development of, MIMO technologies, the long-run advantage is with wireless. It is difficult to argue that wireless cannot compete with cable in a world where a single base station using 20-MHz of spectrum is capable of concurrently delivering 20 mbps service to 950 homes over a multi-mile radius.[14]

This is particularly true given that the capacity of cable is limited to perhaps a couple of GHz of spectrum. Cable operators cannot change this without massive upgrades of their infrastructure – which would likely require replacing the last mile with fiber instead of coaxial cable. Wireless is not subject to this limitation. As wireless applications are reaching into the millimeter-band ranges (technically in the 30- to 300-GHz range, but often also including spectrum in the 15-GHz range), engineers are developing fixed wireless systems delivering 10- to 100-gbps class performance over multiple-kilometer distances, and mobile wireless delivering 10- to 100-mbps class performance in dense cell environments.[15] Such technologies have real potential to dethrone coaxial cable as the dominant residential fixed broadband technology.

14 *See, e.g.,* Larsson, et al., *Massive MIMO for Next Generation Wireless Systems*, IEEE Communications (Feb 2014).

15 Id. *See generally* Evolutionary & Disruptive Visions Towards Ultra High Capacity Networks, IWPC Whitepaper (April 2, 2014), *available at* https://www.keysight.com/main/editorial.jspx?cc=US&lc=eng&ckey=2280123 &id=2280123&cmpid=46278. *See also* Eric Torkildson, et al, *Millimeter-wave MIMO: Wireless Links at Optical Speeds, Millimeter-wave MIMO: Wireless Links at Optical Speeds*, IEEE Global Communications Conference 2009 (Globecom), Honolulu, Hawaii, November 2009. See also *Ericsson Trial 10Gbps 5G Mobile Broadband Network in Japan* (May 12, 2014), http://www.ispreview.co.uk/index.php/2014/05/ericsson-trial-possible-10gbps-5g-mobile-broadband-network-japan.html (discussing testing of 10gbps+ cellular technologies in the 15 GHz band)

One of the most common critiques of this possibility is that millimeter-wave spectrum is subject to substantial atmospheric attenuation, primarily in the form of "rain fade." Because the wavelength of millimeter-wave spectrum is similar in magnitude to the diameter of rain drops and other atmospheric moisture, such moisture can cause substantial degradation in signal quality. But the most recent research suggests that rain fade is a surmountable obstacle, particularly in cellular networks but also over longer distances.[16] The other common critique is that the power required to transmit at millimeter-wave frequencies is substantially greater that that required to transmit in the traditional CMRS bands – and, to a lesser extent, that the signal processing required by MIMO technologies also requires more power than traditional signal processing. Both of these are valid concerns in the mobile setting. In the fixed wireless setting, where radio equipment does not rely on battery power, these issues are not a serious concern.

And while the characteristics of mobile devices – that they are small and mobile – means that they will not be able to reap these benefits to the same extent as fixed wireless networks, they too stand to see marked improvements in performance with these technologies. Indeed, the short wavelength of millimeter-wave spectrum means that mobile devices operating on that spectrum are better able to take advantage of MIMO technologies. In particular, the shorter wavelength means that more antenna can be placed in a single device, substantially increasing the device's resistance to interference and signal fade and increasing the potential bandwidth available to the device. This next generation of devices therefore has the potential to offer better performance than current lower-frequency spectrum technologies. It is entirely possible that the next generation of mobile wireless devices will offer performance comparable to what is available from cable Internet providers today; in the future they may even be on parity with then-available cable offerings.

And lest we forget, portability is a desirable characteristic that itself creates a great deal of value for many consumers. Here, consumers have been voting with their wallets in ways that demonstrate the value of mobility. This is a fundamental point that those who assert wireless cannot

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[16] *Millimeter-wave MIMO: Wireless Links at Optical Speeds, Millimeter-wave MIMO: Wireless Links at Optical Speeds* ("a 5 Gbps link over a 1 km range, even in heavy 25 mm/hr rain, can be maintained with only 160 mW transmit power at each subarray."); F.Versluis, *Millimetre wave radio technology, Microwave Engineering Europe* (Nov 2008) ("The physical properties of high-frequency radio transmission in the presence of various weather conditions are well understood. With proven models of worldwide weather characteristics available, link distances [in the 71 - 86 GHz range] of several miles can confidently be realized over most of the globe. ... New millimetre wave radio systems can provide 'fibre like' connectivity at distances of up to 2 miles in cities such as New York, and can deliver significantly longer lines in cities with drier climates."); Theodore Rappaport, et al, *Millimeter Wave Mobile Communications for 5GCellular: It Will Work!*, IEEE Access May 30, 2013 ("A common myth in the wireless engineering community is that rain and atmosphere make mm-wave spectrum useless for mobile communications. However, when one considers the fact that today's cell sizes in urban environments are on the order of 200 m, it becomes clear that mm-wave cellular can overcome these issues. Fig. 1 and Fig. 2 show the rain attenuation and atmospheric absorption characteristics of mm-wave propagation. It can be seen that for cell sizes on the order of 200 m, atmospheric absorption does not create significant additional path loss for mm-waves, particularly at 28 GHz and 38 GHz. Only 7 dB/km of attenuation is expected due to heavy rainfall rates of 1 inch/hr for cellular propagation at 28 GHz, which translates to only 1.4 dB of attenuation over 200 m distance. Work by many researchers has [demonstrated] that for small distances (less than 1 km), rain attenuation will present a minimal effect on the propagation of mm-waves at 28 GHz to 38 GHz for small cells."); Zhao, et al, *28 GHz Millimeter Wave Cellular Communication Measurements for Reflection and Penetration Loss in and around Buildings in New York City*, 2013 IEEE International Conference on Communications (ICC), June 9, 2013 ("In addition, despite myths to the contrary, rain attenuation and oxygen loss does not significantly increase at 28 GHz, and, in fact, may offer better propagation conditions as compared to today's cellular networks when one considers the availability of high gain adaptive antennas and cell sizes on the order of 200 meters.").

compete with wireline broadband have yet to confront: evidence shows that for many consumers wireless does compete.[17] Wireless broadband subscription growth is outpacing wireline broadband growth by double-digit percentages in the US and other countries around the world. Mobile broadband has proven to be attractive relative to wireline for several discrete populations. This is particularly true for some minority groups, younger or single demographics, and those who move or travel frequently.[18]

Contrary to common assertions by many who would like to see the market for high-speed Internet service more broadly regulated – and especially by those who see government-sponsored deployment of high-speed broadband infrastructure as the necessary response to a perceived lack of competition in the communications industry – wireless is a strong potential competitor to cable Internet. Today, wireless may play a limited role as a competitor to wireline Internet services, but its future as a competitor is bright. Indeed, the technological opportunities for growth in wireless capacity likely exceed those available to coax-based broadband providers and should provide comfort to those who are worried about the relative lack of competition in today's communications marketplace.

IV. Premise Four: An open Internet is necessary for innovation and necessarily benefits consumers

The next premise is that innovation requires open access, and in particular a (so-called) open, or neutral, Internet.

This premise is a doozey. It is the beautiful premise that launched a thousand ships on the sea of Network Neutrality. But its beauty is skin deep. While it is true that open access can facilitate some types of innovation, it both precludes other forms of innovation and imposes costs of its own.[19] In the telecommunications context, open access is mostly about network neutrality – the idea that broadband providers should not be able to charge users or content providers for preferential access to specific services, let alone block specific content or services entirely (absent some compelling legal or technical justification).

The key takeaway from the relevant technical and economic literatures is that "openness," in whatever forms it may take, is rarely unambiguously good or bad. It is unquestionably the case that open access can facilitate certain types of innovation. It reduces R&D and other transaction costs (especially search and negotiation costs to get permission or access to use existing infrastructure) and reduces opportunities for rent extraction by those who otherwise control an infrastructure. On the other hand, it makes some forms of innovation more expensive or difficult to implement.

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17 In Denmark 7 percent of the population has chosen to rely solely on 3G or 4G mobile connectivity. Mobile-only broadband subscribers outnumber FTTH subscribers by 100,000, even though 100 mbps connections are available to 70 percent of the population . See Layton, supra

18 Mary Madden et al., "Teens, Social Media, and Privacy," *Pew Research Center's Internet & American Life Project*, accessed June 2, 2014, http://www.pewinternet.org/2013/05/21/teens-social-media-and-privacy/.

19 For one of the seminal treatments of this subject, *see* Bresnahan & Trajtenberg , *General Purpose Technologies "Engines of Growth?",* 65 J. Econometrica 83, 94–96 (1995).

There are substantial literatures showing the benefits of vertical integration[20] and the importance of defining proper modular boundaries.[21] Nowadays, however, this point can be made more simply by analogy: Apple's hardware and software designs are part of a tightly-controlled, vertically integrated, closed product ecosystem. Apple would not exist if we had the equivalent of network neutrality for computer hardware or software. This does not mean that either an open or a closed model is necessarily better in any given case; it does mean that we want a more nuanced approach than one that mandates either approach in every situation.

It should be noted that engineers employed by the Department of Defense to develop the then top secret project of the ARPANET, the forerunner of today's internet, did not work in an "open" environment. Openness or neutrality was not a goal for the design of that system. This is not to say that they would have frowned on such concepts, but as ARPANET engineer and co-author of the original "end to end paper" David Clark explains[22]

> Back then we didn't use the word 'open'. It's not really part of our language. We understood generality…if you go back to the end to end paper I wrote with Jerry Saltzer and David Reed – which has been used as a religious tract far beyond what it will sustain if you are a strict constructionist (A person who construes a legal text or document in a specified way) – I believe I verified that the paper does not contain word 'open'. That paper was about correctness, which is a narrow objective. It's not even about performance.

Thus the assertion that the internet was "always open and neutral" is simply a modern-day ascription to create an idealized history.

More critically, we can survey the internet in China, arguably an isolated entity created by the Golden Shield Project (*jindun gongcheng*) also known as the "Great Firewall" of China, a surveillance and censorship project conceived by the Ministry of Public Security in 1998 and launched 2003.[23] China certainly does not have an "open" approach to the internet, but there is indeed innovation in the Chinese internet. The Chinese government has through a combination of blocking of key American applications and local protectionism, nurtured home grown and government-approved versions of Google (Baidu), Facebook (Renren), Twitter (Sina Weibo, QQ Weibo), WhatsApp (Weixin, also known as WeChat), and Amazon and Ebay (Taobao, Aliaba), not to mention YouTube (Sohu.com and Youku).

Already by 2008 the Chinese internet was the largest in the world by number of users. There are 700 million smart phones in China, and mobile ecommerce there passed the $335 billion level last year. Alibaba is twice the size of eBay and Amazon combined and may be the first trillion dollar company, and China has 3 other significant internet companies of global scale. [24] Indeed many Americans use Chinese internet applications. Though we don't advocate

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20 See also Skorup & Theirer, *Uncreative Destruction: The Misguided War on Vertical Integration in the Information Economy*, available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2162623.

21 Id.

22 http://www.fcc.gov/events/open-internet-advisory-committee-meeting (at minute 65).

23 Gianluigi Negro, "Chinese Internet Regulation: An Historical Overview of the Main Chinese Departments and Ministries." (presented at the Oxford Conference on Chinese Media. Programme in Comparative Media Law and Policy, Oxford, United Kingdom, 2012).

24 Mary Meeker, "2014 Internet Trends," Kleiner Perkins Caufield Byers, May 28, 2014, slide 138, available at http://www.kpcb.com/internet-trends.

the Chinese model, the Chinese internet proves that internet innovation can also flourish in closed environments.

Moreover American companies in a variety of industries from software to pharmaceuticals to consumer products use both open and closed models for innovation within the same company. Which model they use depends on a variety of factors related to research, product development, marketing, and so on. There is nothing that suggests that internet companies or ISPs should be any different. In fact a mandate that all models must be open could prove detrimental to innovations in many firms.

Consider that most of the well-known internet firms have significant intellectual property and operate closed R&D and product development departments. One cannot waltz into Mountain View and request a copy of Google's search algorithm, which changes with every search performed. To be sure, Google publishes in broad strokes information about how it search platform works,[25] but this does not mean that Google search is an "open" platform. Furthermore it's not clear that it would benefit consumers more if Google search were open. Indeed Google's ability – and incentive – to create incremental innovation may have much to do with its ability to control its proprietary algorithms.

Indeed we find that supporters of so-called openness and neutrality may change their policy position when governments begin to demand that platforms become open and unbundled. It is illogical to require openness and neutrality to the access network if the rest of the internet – the operating systems, the devices, the platforms (search engines, social networks etc) – can remain proprietary and closed. The French government has realized this contradiction, and their Digital Council had recently published a report[26] on platform neutrality, which was commissioned the Ministry of Economy and Digital Affairs and the Secretary of State on Digital Affairs.

To be sure, the French government has political motivations. Platforms such as Google create externalities in its economy. Tax authorities can't recover tax because Google legally invoices its French customers from Ireland, so revenue is never booked in France. Nevertheless the French make an important point of logic and consistency.

Indeed the French report on platform neutrality singles out what Minister Delegate for Small and Medium Enterprises, Innovation, and the Digital Economy Fleur Pellerin calls the "American giants", GAFTAM (Google, Apple, Facebook, Twitter, Amazon, Microsoft). The report declares that platforms maintain their dominant position by three activities: acquisition, diversification and exclusion. Their size and capital allows them to buy startups long before they ever become a competitive threat. Their scale allows them to diversify into a number of complementary products and distribute those products at little to no cost. Finally the reports suggests that platforms exclude competitors, citing the example that the launch of Google Maps and Shopping, which lowered the ranks of competing GPS and commerce applications.

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25 *How Search Works*, available at http://www.google.com/intl/en /insidesearch/howsearchworks/ algorithms.html.
26 *Platform Neutrality*, available at http://www.cnnumerique.fr/plateformes/.

There is no doubt that platforms can have market power, but there is also evidence that consumers benefit from the bundling effects of platforms. The point is openness and neutrality can both welfare enhancing and welfare reducing effects, but blanket fiat standard applied to just one part of the internet or all parts of the internet will likely have negative consequences for consumers. It may be better to adjudicate these matters on an ex post, case by case, basis to ensure that consumers are not deprived by the preclusion of any technology or business model

There is almost no empirical evidence about openness and net neutrality with regard to internet innovation. The literature of net neutrality comprises some 7000 articles and is almost entirely theoretical. Indeed even the top ten most cited articles, each with a few hundred citations, conflict dramatically about whether net neutrality is even needed. Thereafter most articles have just one or two citations. The policy arguments for net neutrality and internet openness typically rely on assertions of Lemley & Lessig's "end to end principle" and more recently the "virtuous circle of innovation", two notions which are surprisingly under-theorized in the academic literature given their popularity in the media and net neutrality debates.

The FCC attempts to bolster its case for net neutrality rules and openness by proffering what it calls the "virtuous circle of innovation" in its Open Internet Report & Order of 2010.[27] The virtuous circle is the notion that the growth of content and applications stimulates demand for internet subscriptions which generates revenue for operators which then invest in infrastructure. This Open Internet Coalition[28] and a group of engineers[29] assembled in support of the FCC as part of the case *Verizon v. FCC* expressed support for this notion. More recently Netflix[30] and Mozilla[31] mention this in their filings to the FCC's May 2014 NPRM on net neutrality.

Specifically the FCC describes the "virtuous circle of innovation"[32] as follows

> The Internet's openness is critical to these outcomes, because it enables a virtuous circle of innovation in which new uses of the network – including new content, applications, services, and devices – lead to increased end-user demand for broadband, which drives network improvements, which in turn lead to further innovative network uses. Novel, improved, or lower-cost offerings introduced by content, application, service, and device providers spur end-user demand and

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27 Open Internet Report & Order, 2010, https://apps.fcc.gov/edocs_public/attachmatch/FCC-10-201A1.pdf.

28 Goldberg and Michalopoulo, "Brief of Intervenors Open Internet Internet Coalition, Public Knowledge, Vonage Holdings Corporation, and National Association of State Utility Consumer Advocates." http://www.fcc.gov/document/brief-open-internet-coalition-no-11-1355-dc-cir

29 Internet Engineers Amicus Brief, No. 11-1355 (D.C. Circuit), November 1, 2012, http://www.fcc.gov/document/internet-engineers-amicus-brief-no-11-1355-dc-cir.

30 "Comments of Netflix to the Federal Communications Commissions. Notice of Proposed Rulemaking in In the Matter of Protecting and Promoting the Open Internet Framework for Broadband Internet Services," July 15, 2014, http://apps.fcc.gov/ecfs/document/view?id=7521491186.

31 "Comments of Mozilla to the Federal Communications Commissions. Notice of Proposed Rulemaking in In the Matter of Protecting and Promoting the Open Internet Framework for Broadband Internet Services," July 15, 2014, http://apps.fcc.gov/ecfs/document/view?id=7521479935.

32 FCC Open Internet Report & Order 10-201, December 21, 2010. Paragragh 14. https://apps.fcc.gov/edocs_public/attachmatch/FCC-10-201A1_Rcd.pdf

> encourage broadband providers to expand their networks and invest in new broadband technologies (emphasis ours).

However potent the "virtuous circle of internet innovation" may sound in a policy discussion, it is a new topic not yet cited in the academic literature of net neutrality.

Another tenet of internet openness is the "end to end principle"[33] as appropriated by Mark Lemley and Lawrence Lessig from the earlier article by ARPNET engineers Saltzer, Reed and Clark.[34] Attempting to derive a policy argument from engineering principle,[35] Lemley and Lessig praise the the virtues of the "inherent" internet architecture, its openness, how the "ends" of the network where users and applications reside should be "intelligent", and that the protocols and pipes be as simple and general as possible.

Yet the original end-to-end principle is more modest and simply states,

> The principle, called the end-to-end argument, suggests that functions placed at low levels of a system may be redundant or of little value when compared with the cost of providing them at that low level.

End-to-end in the engineering sense is about where it appropriate to place functionality in the network depending on the benefits to be delivered. It says nothing about telecommunications policy. Just as Lemley and Lessig use it as a justification for openness, the principle could be interpreted as an argument for prioritization, that functions should be applied at the higher level (or core) of the network because it is less costly.

Lemley and Lessig published their article in 2000 and predicted that unless cable networks were unbundled, that the end-to-end principle which "governed the internet since inception" would be compromised and that internet innovation would be harmed. But interestingly, a number of internet innovations have emerged without the unbundling of cable including Skype, Facebook, WhatsApp, and the online version of Netflix.

Even Lemley and Lessig observe that there are other important features of the network's design beyond the end-to-end principle and further, "As we have said, no one fully understands the dynamics that have made the innovation of the Internet possible."

In open internet and net neutrality discussions, the end-to-end principle and virtuous circle are invoked, frequently dramatized by the proverbial hacker in the garage or dorm room who becomes a billionaire. However compelling this image may be in contemporary culture, it is a romanticized view of the internet innovation that is the exception, not the rule. The internet we know today would not be possible without fundamental innovations in computers, chips, servers, and storage – all of which required massive investment, corporate

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33 Lemley, Mark and Lawrence Lessig. "The End of End-to-End: Preserving the Architecture of the Internet in the Broadband Era." October 1, 2000. UC Berkeley Law & Econ Research Paper No. 2000-19

34 J. H. Saltzer, D. P. Reed, and D. D. Clark, "End-to-End Arguments in System Design," *ACM Trans. Comput. Syst.* 2, no. 4 (November 1984): 277–88, doi:10.1145/357401.357402.

35 Richard Bennett, *Designed for Change: End-to-End Arguments, Internet Innovation, and the Net Neutrality Debate* (Information Technology & Innovation Foundation, 2009), http://www.itif.org/files/2009-designed-for-change.pdf.

coordination, government grants, and more often than not, closed laboratories and environments. This is not to say that the innovation in networks is more important than applications, but policy need not make false choices that favor one type of innovation over another.

Lessig and Lemley's paper along with Tim Wu's eponymous tract[36] have just about 500 citations each, and rate as the most cited papers in the net neutrality/open internet literature. However there are over 1 million articles about using the internet itself (or internet enabled platforms) as a form of innovation for industry and society, but precious few articles suggesting that the internet must be one way or another, whether open, closed, red or blue. Given that openness and neutrality policy principles are under-theorized in relation to innovation, it is helpful to review the general literature of innovation with its rich and long tradition.

The notion of open innovation was popularized by Henry Chesbrough in 2003 followed by a book[37] of the same name. Essentially Chesbrough argued that in the information age firms need to look beyond their own walls for the paths to new products and markets. He was particularly concerned how traditional hardware and computing firms, e.g. IBM and Xerox, could reinvent themselves by being more attune to external ideas. Chesbrough's ideas today are largely internalized and practiced by many firms through market research, business intelligence, and shared risk-reward partnerships. Chesbrough does not advocate neutrality or any internet policy as such.

A notable theory of innovation is creative destruction, which Austrian economist Joseph Schumpeter presented his re-interpretation of Marx in *Capitalism, Socialism and Democracy*[38] first published in 1942 and since cited cited 27,386 times. Giving the example of the dearth of wood forcing a need to find energy substitutes, Schumpeter promoted the idea that necessity creates invention. Rather than see the business cycle as a Marxist process of accumulation and annihilation of wealth, Schumpeter proposed creative destruction as an engine of renewable economic growth. Creative destruction is a force "*that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one"*. Schumpeter saw entrepreneurs as creating economic growth and destroying established industries and monopolies. He would have likely celebrated the emergence of over the top technologies (OTTs) as competitors to dedicated network services.

Search engines provide an example of Schumpeter's trilogy: invention, innovation, and diffusion. A search engine is an invention, the first of which was "Archie", a tool used to search webservers by scientists at McGill University in Canada in 1990. Seven years later Google created the innovation of pairing search results with advertising, an idea they reverse engineered from Goto.com. Diffusion could be described as the process by which users adopt Google's services. None of these developments has anything necessarily to do with openness or neutrality.

36 Tim Wu, *Network Neutrality, Broadband Discrimination*, SSRN Scholarly Paper (Rochester, NY: Social Science Research Network, June 5, 2003), http://papers.ssrn.com/abstract=388863.
37 William Henry Chesbrogh, *Open Innovation: The New Imperative for Creating and Profiting from Technology* (Harvard Business Review, 2005).
38 J.A. Schumpeter, *Capitalism, Socialism, and Democracy.* (Harper, 1942).

Everett Rogers is known for the Diffusion of Innovations[39] theory, cited over 57,000 times. He defined diffusion as a process in which innovation is shared over communication channels over time among the members of a social system. Rogers' model and its attendant bell curve have been applied to numerous innovations, especially the growth in smartphones. Rogers notes that adoption can also be driven by fiat, for exmaple, the government can mandate the switch from analog to digital televison. In Rogers' world, access to innovation itself enough to drive adoption. He mentions laggards, people who refuse to adopt technology regardless of the benefits it brings. Rogers suggests that people have to be introduced to innovation through peers.

Disruption is a another term frequently used with innovation. It comes from Clay Christiansen's *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*[40] cited almost 10,000 times from its first publishing in 1997. Christiansen describes how "good", well-managed companies lose their footing because low-cost competitors focusing on an unprofitable market segment create "disruptive innovation". They underperform existing products at first, but then emerge to be simpler, better, faster, and cheaper than existing products. Skype and WhatsApp are salient examples of disruptive innovation.

In the context of the "virtuous circle" discussion, it's important to realize that Skype and WhatsApp can't exist unless a larger network is already in place, an assertion of David Teece in his theory of complementary assets. His 1986 paper "Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy"[41] observed that most innovations are not products themselves. Innovations have to be combined with complementary assets *before* they can be marketable products. Such partnerships lower barriers to entry for the innovator and can provide rewards to the innovator upfront.

Teece discusses a number of generic and specialized assets that must be in place in order for innovation to occur. HTML is generic asset, a language that allows innovators to create websites. A specialized asset may be an operating system that runs on a mobile phone, such as Apple iOS or Android. A co-specialized asset may be a 4G mobile network and its complementary asset is an Apple iPhone 4s. The iPhone features can't be realized unless they are delivered on the appropriate 4G mobile network.

For both Teece and Rogers the end-to-end principle would likely not be necessary or sufficient for internet innovation. Teece essentially says that different parties have to make partnerships or "join complementary assets" (e.g. content provider and broadband provider) in order to make applications known. Applications on their own have no value, or will almost never be found, unless they are joined with their complementary asset. Rogers observes that just because innovations are available and accessible is not enough reason for them to be adoptedIn contrast to the virtuous circle, the justification that net neutrality is needed because

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39 Everett Rogers, *Diffusion of Innovations*, 5th Edition (Free Press, 2003).

40 Clay Christiansen, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail.* (Harvard Business Review, 1997).

41 David Teece, "Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy," *School of Business Administration, University of California, Berkeley, CA 94720, U.S.A.*, June 1986, http://www4.lu.se/upload/CIRCLE/INN005/Teece_Reflections.pdf.

it drives innovation and network investment, Teece implies that internet innovation results *because of* pre-existing investment in network.

Indeed we suggest that may possible that the virtuous circle turns *both* ways, that growth in traffic both drives and responds to available bandwidth and network investment. Indeed, the relationship may be mutually reinforcing. However there is no evidence that the virtuous circle turns only one way or that there is an essential one directional relationship of content and applications driving network investment. Building a regulatory regime on top of such a notion, however intuitive it may sound, is premature to say the least.

If anything, there is some evidence may disprove the virtuous circle theory. The virtuous circle implies that network investment follows internet traffic growth, but the rates of network investment vary wildly. The US may continue to invest, but most notably, the EU has *decreased* its level of investment compared to a decade ago, even though internet traffic has increased significantly in the region.

Indeed if we take theories of innovation on academic weight, then there would be a different set of policy prescriptions on the table today. Schumpeter and Christiansen would likely oppose regulation, noting that big enterprises naturally sow the seeds of their own destruction and that upstarts topple giants without the help of government. Most notably Chesbrough and Teece, both cited about 8000 times each, would likely encourage business models and partnerships because they help bring innovation to consumers. Ironically many supporters of net neutrality oppose partnerships such as zero rating, sponsored data, and paid prioritization and so on, but the leading academic scholars of innovation including Chesbrough, the very coiner of the term open innovation, support partnerships.

The scale is tipped even further against mandated openness and neutrality in the case of the Internet when looking at the literature of two-sided markets, which numbers more than 360,000 articles and is less than a decade old. The Internet is a two-sided market – a market in which two or more distinct groups of consumers are brought together via some intermediary platform. That is, users and Internet content providers (e.g., firms such as Google, Facebook, and Netflix) reach each other via the Internet. This has both technical and economic implications.

On the technical side most historical perspectives on the Internet architecture make clear that, while it has long had an "open" character, this character is at least in part accidental, does not equate with "neutrality," and in any event may be undesirable.[42]

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[42] For a sampling of technical literature explaining that mandated network neutrality is not desirable, see: Richard T.B. Ma, et al, *On Cooperative Settlement Between Content, Transit and Eyeball Internet Service Providers*, Procs of 2008 ACM Conf Emerging Network Experiment and Tech (CoNEXT 2008), Madrid, Spain, December, 2008 ("Paid-peering is identical to zero-dollar peering in terms of traffic forwarding, except that one party needs to pay another. By applying the Shapley revenue distribution to the Content-Transit-Eyeball model, we find the justification of the existence of paid-peering between transit ISPs. ... "Our previous work ... showed that ... selfish ISPs have incentives to perform globally optimal routing and interconnecting decisions to reach an equilibrium that maximizes both individual profit and global social welfare. ... In this paper we extend our model ... Our result [finds instances where paid-peering can benefit welfare].") David Clark, *Network Neutrality: Words of Power and 800-Pound Gorillas*, 1 Int'l J. Comm. 701 (2007) ("As a technical mechanism, QoS seems to be beneficial. It directly addresses the real performance requirements of different sorts of Internet traffic … This reality begs the question of whether we can find a set of rules that might distinguish between "good" or

Similarly, on the economic side, the crux of the two-sided markets analysis is that the platform that brings the different sides together – that is, broadband Internet access providers – ordinarily charge either or both sides of the market for access to the other. How much to charge each side, including whether to charge either side nothing or even to subsidize one side's access to the platform, involves a complex set of tradeoffs – and, most important, how much each side is charged can have substantial effects on the social value of the network. Critically, and we will say this in italics because it is so important, *the literature studying two-sided markets consistently shows that there is no reason to believe that a network neutrality rule necessarily benefits consumers, and consistently shows that such a rule can harm consumers.*[43]

"acceptable" forms of discrimination, and "bad" discrimination. Unless we can find a bright line, using regulation of discrimination to define acceptable behavior may cause more trouble than it cures."); Hazlett & Wright, *The Law and Economics of Network Neutrality* (2011) (quoting 2009 Comm Daily discussion with David Clark: "'The network is not neutral and never has been,'" Clark said, dismissing as 'happy little bunny rabbit dreams' the assumptions of net neutrality supporters that there was once a 'Garden of Eden' for the Internet. NSFnet, an early part of the Internet backbone, gave priority to interactive traffic, he said: 'You've got to discriminate between good blocking and bad blocking.'"); Jon Crowcroft, *Net Neutrality: The Technical Side of the Debate*, 1 Int'l J. Comm. (2007) ("This paper describes the basic realities of the net, which has never been a level playing field for many accidental and some deliberate reasons"; "In conclusion then: We never had network neutrality in the past, and I do not believe we should engineer for it in the future either."); Douglas A. Hass, *The Never-Was-Neutral Net and Why Informed End Users Can End the Net Neutrality Debates*, 22 Berkeley Tech. L.J. 1565 (2007); RFC 2475 ("Service differentiation is desired to accommodate heterogeneous application requirements and user expectations, and to permit differentiated pricing of Internet service."); RFC 2638 (discussing paid prioritization, saying: "It is expected that premium traffic would be allocated a small percentage of the total network capacity, but that it would be priced much higher."); RFC 1633 ("real-time applications often do not work well across the Internet because of variable queueing delays and congestion losses. The Internet, as originally conceived, offers only a very simple quality of service (QoS), point-to-point best-effort data delivery. Before real-time applications such as remote video, multimedia conferencing, visualization, and virtual reality can be broadly used, the Internet infrastructure must be modified to support real-time QoS, which provides some control over end-to-end packet delays." ... "The first assumption is that resources (e.g., bandwidth) must be explicitly managed in order to meet application requirements. … An alternative approach, which we reject, is to attempt to support real-time traffic without any explicit changes to the Internet service model. The essence of real-time service is the requirement for some service guarantees, and we argue that guarantees cannot be achieved without reservations. … We conclude that there is an inescapable requirement for routers to be able to reserve resources, in order to provide special QoS for specific user packet streams, or 'flows'."). See also Justin (Gus) Hurwitz, *An unfounded principle: Ammori's non-neutral network history*, TechPolicyDaily.com (Nov. 13, 2013) (explaining that network neutrality is not "a foundational principle" of the Internet), *available at* http://www.techpolicydaily.com/ internet/unfounded-principle-ammoris-non-neutral-network-history/.

43 The literature here is voluminous, often demonstrates benefits from non-neutrality, and consistently notes ambiguous results. For some examples (most of which cite to the broader literature) see: Nicholas Economides and Joacim Tåg, *Network neutrality on the Internet: A two-sided market analysis*, 24 Information Economics and Policy 91 (2012) ("We have showed that one can find such parameter ranges both in the monopoly model and in the duopoly model suggesting that network neutrality regulation could be warranted even when some competition is present in the platform market. *However, the overall effect of implementing network neutrality regulations can still be both positive and negative depending on parameter values.*") (emphasis added); Paul Njoroge, et al, *Investment in Two-Sided Markets and the Net Neutrality Debate*, 12 Review of Network Economics (Feb 2014) ("This paper adds to the growing body of formal economic analysis that will help inform policy makers on the net neutrality debate and sheds light on the validity, or lack thereof, of the arguments proposed by the different advocacy groups involved. In particular, this article develops a game theoretic model based on a two-sided market framework … to investigate the effects of a net neutrality mandate on investment incentives of ISPs, and its concomitant effects on social welfare, consumer and CP surplus, and CP market participation. ... More specifically, the results regarding the comparison between the neutral and non-neutral regimes for our theoretical and numerical-simulation models are as follows. *In both models, the non-neutral regime leads to a higher*

In practice, a network neutrality rule is little more than a subsidy from the consumer side of the market to the content provider side of the market.[44] Some, but not all, content providers benefit from this rule. Other content providers may be harmed by such a rule – especially those who offer, or would like to develop, services that would benefit from enhanced quality of service features or other features that may require some integration with Internet service providers.

Even more problematic, a network neutrality rule can harm consumers. It prevents ISPs and content providers from working together to offer innovative new products that consumers want. More tragic, it prevents these providers from developing lower-cost service packages – packages that could expand opportunities for access to currently underserved and disadvantaged communities. These rules likely increase cost of access and limit the development of potentially cheaper offerings that are more responsive to consumer demands – this is exactly the opposite of good telecom policy.

This point relates back to a concern in the first premise considered above: the paramount importance of respecting consumer preferences, and not substituting the Washington-Silicon Valley-academic views of what consumers should want for what they actually do want (and, more importantly, need). By requiring that every consumer's Internet connection offers full-fare, first-class service, complete with movies, television, and free drink service, we price consumers who would be happy with discounted-fare economy Internet service out of the market.

We don't mean to give away the barn. The key takeaways from the literature in this field are all nuanced – different price structures "can" or "may" benefit *or* harm consumers. In some cases, "non-neutral" price structures may benefit consumers, in some it may harm them, and conversely. (Noted paraleptically, our own reading of the literature suggests that, given current market structures, non-neutral pricing is likely to be better for consumers than neutral pricing.) But this does not mean that we should prescribe *ex ante* prophylactic pricing rules – rather, it means that we should monitor conduct and pricing in the Internet ecosystem and be ready to bring *ex post* actions against pricing decisions that are demonstrably harmful to consumers.

Some additional comments bear mention in light of the FCC's recently adopted Notice of Proposed Rulemaking relating to its Open Internet rules. Whatever rules the Commission may ultimately adopt, the Commission should be careful that it does not proscribe pro-consumer conduct. Given the difficulty of knowing *ex ante* whether any specific conduct is likely to benefit or harm consumers, whatever rules the Commission ultimately adopts likely should be limited to general principles – they should not define conduct that is to be prospectively permitted or prohibited, but rather (at most) indicate certain types of conduct that may bear scrutiny from the agency and the terms under which that conduct will be evaluated. Should the Commission take such

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overall social welfare. This result is driven by the higher investment levels caused by the non-neutral regime, which in turn increase consumer surplus and CP gross surplus.") (emphasis added); Jay Pil Choi, Byung-Cheol Kim, *Net Neutrality and Investment Incentives*, 41 RAND Journal of Economics (2010) ("Considering all three channels through which net neutrality can have an influence upon short-run total welfare, we can conclude that static welfare implications of net neutrality regulations depend on the trade-off between transportation cost saving and inefficient production. If the margin difference is significantly large relative to the degree of product differentiation, the discriminatory network would be preferred from the viewpoint of social welfare."; "We find that the relationship between the net neutrality regulation and investment incentives is subtle. Even though we cannot draw general unambiguous conclusions, we identified key effects that are expected to play important roles in the assessment of net neutrality regulations.").

44 See, e.g., Justin (Gus) Hurwitz, *Let Them Eat Cake and Watch Netflix*, 8 FSF Perspectives 22 (2013), *available at* http://www.freestatefoundation.org/images/Let_Them_Eat_Cake_and_Watch_Netflix_090413.pdf.

an approach, it may yet craft an approach that passes judicial muster, provides useful guidance to agencies, and – most important – protects consumers from harmful conduct on the one hand while allowing them to benefit from pro-consumer innovation on the other.

It may be the case then that the goal of net neutrality supporters that the internet be regulated so that it no proprietary or commercial elements. They can make that as a policy statement, but it is not a fact that either openness or neutrality is inherent or essential to innovation. Any law built on such a statement is a faith-based, not a fact-based policy.

V. Premise Five: Telecommunications are better in Europe, Asia, or somewhere else

The final premise is that things are better in Europe, Asia, or other regions of the world. A corollary premise is that such a comparison matters at all.

This premise, frequently expressed as "America falling behind in ____ (fill in the blank)," is a common refrain for the policy *crise du jour*. Essentially it says that America, and other nations, are simply the sum of a single measure. It begs the question as to better for what and for whom and to what end.

Such statements frequently come from the playbook of the culture of fear, part of a larger genre colloquially called "airport economics", referring to a type of business literature sold at airports as a way to popularlize public policy. Books such as *Trading Places - How We Are Giving Our Future to Japan and How to Reclaim It* (1993) are designed be read in the length of a cross-country flight. When you take off in New York, the world is coming to an end, but by the time you land in Los Angeles, all will be righted if the author's recommendations are followed. The best-selling book *Japan Inc.* personified the evil zaibatsu writ large, and the Mitsubishi Group buying Rockefeller Center was the proof point that Japan would take over the US. But none of the fear-monger books about Japan predicted that its bubble would burst and its subsequent 25 year recession.

A review of popular media over the last 30 years will show a litany of fear-mongering about countries poised eat America's lunch: not just Japan, but India, China, the Asian Tigers, the BRICs, CIVETs, the Next 11 and so on.

Comparative rankings of global Internet speeds and prices are a staple of telecom debates. They feature prominently in the work of advocates across the political spectrum. And the past year has seen at least three major efforts to study the relative costs and speeds of Internet access around the world: the ITIF,[45] ITU,[46] OTI[47], and Christopher Yoo.[48] . Smaller scale, but no less important, work has been undertaken by scholars such as Susan Crawford[49] and Roslyn Layton.[50]

With regard to broadband in the popular press, the "America is falling behind" assertion is "evidenced" by citing a few random broadband statistics on speed or price without proper context. Cherry picking any one measure or data points can make a country look good or bad, but that doesn't translate into bankable insights for economic growth, let alone informed policymaking.

The faulty premise of the assertion implies that broadband itself, measured by a discrete variable such as speed, is the end goal. However it is arguably more important not to view broadband as an end in itself, but as an enabler of social and economic value. Viewed in this way, we need to take a more comprehensive, holistic view of broadband that encompasses not just networks and their characteristics, but adoption, applications, digital readiness, market development, and so on. Indeed the OECD Council's principles[51] for internet policy embrace a range of broad outcomes, but no one metric of speed or network type.

Many politicians and policy makers like such hard and fast measures because it gives them something to enforce and regulate. When election time comes, they can grandstand on progress of clear deliverables. But the in bigger picture, the focus simply on discrete broadband measures and not broadband-enabled social or economic value releases politicians of the the greater challenge and responsibility to ensure that broadband has a productive use in society, something that is far harder to achieve.

Being the "best" in any broadband measure matters little if it does not does not improve social welfare or make an economy and its workforce more productive. The United States, even without having the fastest broadband speeds, has been able to create digital social platforms for communications, forge global Internet companies, transform its workforce, and innovate a growing stream of digital products and services. This has a lot to do with everyday Americans having broadband access and using it to produce and consume a range of goods and services.

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45 ITIF, *The Whole Picture: Where America's Broadband Networks Really Stand*, http://www2.itif.org/2013-whole-picture-america-broadband-networks.pdf.

46 ITU, *Measuring the Information Society 2013*, http://www.itu.int/en/ITU-D/Statistics/Documents/publications/mis2013/MIS2013_without_Annex_4.pdf.

47 New America Foundation, *The Cost of Connectivity 2013*, http://newamerica.net/publications/policy/the_cost_of_connectivity_2013

48 Christopher Yoo, *U.S. vs. European Broadband: What Do the Data Say?* (University of Pennsylvania Law School, 2014), https://www.law.upenn.edu/live/files/3352-us-vs-european-broadband-deployment.

49 Susan Crawford, Captive Audience: The Telecom Industry and Monopoly Power in the New Gilded Age (Yale University Press, 2012).

50 Roslyn Layton, *The European Union's Broadband Challenge*, http://www.aei.org/article/economics/innovation/internet/the-european-unions-broadband-challenge/ and Horney and Layton, *Innovation, Investment and Competition in Broadband and the Impact on America's Digital Economy*.

51 *OECD Council Recommendation on Principles for Internet Policy Making*, 2011, http://www.oecd.org/sti/ieconomy/49258588.pdf.

A typical trap is presenting broadband prices without comparing the same kinds of networks, speeds, and services. This is frequently done with assertions about the EU being "better" than the US. Yet in 2013, 75% of broadband connections in the EU were DSL, a slower technology with a lower price. DSL made up only 34% of internet connections in US. Cable, offering faster speeds, was available to 88% of Americans, but just half as many Europeans. About a third of Americans subscribed to broadband by cable, while just 17% of Europeans did. Moreover Americans had twice the rate of availability of fiber to the home (FTTH), and 4G/LTE availability in the US outnumbered the EU by almost a factor of four.[52]

If person subscribes to a newer, faster technology that delivers more data, she typically pays a higher list price, however she gets better value because of lower unit cost. Americans consume on average at least one-third more data than Europeans, and are on track to surpass South Korea to become #1 in the world for internet consumption per capita.[53] Looking at list prices without accounting for the network type, speed, or amount of data consumed can provide a false conclusion about whether a given price is better.

Another challenge is presented by sample size. Even the OECD data, one of the most comprehensive broadband data sets, is based on prevailing prices in major cities, not in suburbs or rural areas. Broadband is typically cheaper in cities where people are more densely concentrated and deployment costs are lower. Thus this reporting works to the favor of the EU, but it obscures the fact that next generation networks are available to only 12% of people in rural areas of the EU, but 54% in the US.[54]

When calculating the real cost of international broadband prices, one needs to take into account media license fees, taxation, and subsidies. Neither the OECD Broadband Portal[55] nor the ITU's statistical database[56] provides this information. However, these inputs can have material affects the cost of broadband, especially in countries where broadband is subject to value-added taxes as high as 27 percent, not to mention the compulsory media license fees in two-thirds of European countries and half of Asian countries, where households pay a media license fee on top of the subscription fees to use devices such as connected computers and TVs. Media license fees can add up to hundreds of dollars per year on top of the list price of broadband. When these real fees are included in comparisons, American prices are an even better value.

With regard to wireless, comparison data frequently fail to account for whether subscriptions are prepaid and postpaid subscriptions. This can have a material impact on comparisons because countries with high prepaid penetration, as in many places in Europe, users have multiple subscriptions. Thus the number of subscribers is often overrepresented

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52 Supra, Layton.
53 "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2013–2018," Cisco, February 5, 2014, http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white_paper_c11-520862.html.
54 Supra, Yoo.
55 "Broadband and Telecom," Organisation for Economic Co-Operation and Development, January 9, 2014, http://www.oecd.org/sti/broadband/oecdbroadbandportal.htm.
56 "Statistics," International Telecommunications Union, 2014, http://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx?utm_source=twitterfeed&utm_medium=twitter.

while the total amount of any one subscriber pays will likely be underrepresented. Adding to the complexity is the type of termination regime (calling party pays vs. caller/receiver pay) which also drives prices and packages in the market. In practice in high prepaid penetration countries, a person will have multiple SIM cards which he uses to call different sets of people on different networks.

Another device to veil policy preferences under the objectivity of evidence is to compare geo-demographically dissimilar regions without making the proper disclosures. South Korea is the crucible of FTTH, but people forget that it's a country the size of Minnesota but with 10 times the population. The economics of FTTH in South Korea and the US are not the same. To be sure broadband has enabled entertainment applications and video conferencing, but South Korea still earns most of its GDP from its traditional, pre-broadband industries (chemicals, shipping, manufacturing etc). The national project has not yielded the jobs that were expected as a report by the Korea Information Society Development Institute bemoans the situation of "jobless growth."[57]

Indeed broadband can even have socially negative consequences. The Korean government is also concerned about Internet addiction, which afflicts some 10 percent of the country's children between ages 10 and 19, who essentially function only for online gaming but not in other areas of society.[58]

Interestingly the OECD reports that South Korea and Canada have the same average advertised speeds, 66.83 mbps.[59] While South Korea's connections are largely FTTH, Canada's wired broadband is mainly cable and DSL. The statistic shows that it's not essential to have FTTH to have high speeds, adding further nuance to the first and second premises about whether it's essential to have high speed broadband. Furthermore advertised speeds and actual speeds are shown to differ markedly in the EU,[60] but not in the US.[61] Indeed Europeans frequently pay for something they don't get.

Another device[62] is to compare speeds of an American city to a small European country, for example San Antonio, TX to Riga, the capital city of Latvia, small Baltic republic with just two million inhabitants but with a new FTTH network that achieves higher speeds than most connections in San Antonio. It's important to remember that when the Eastern bloc was liberated from communism, there were no communication networks to speak of. So naturally when a country deploys a new network it will go for the current state of the art. In that way, any new network will always be the fastest. That said, a new broadband network may have high speeds but it does not an economy make.

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57 Ju Jaeuk and Jung Hyun-Joon, "A Study on the Impact of New ICT Service and Technology on Employment," *Research Report* 12, no. 11 (n.d.): 1–76.

58 Supra, Layton

59 Layton, Roslyn "10 takeaways from the OECD's updated broadband statistics", Jan 13, 2014. TechPolicyDaily.com, http://www.techpolicydaily.com/communications/10-takeaways-oecds-updated-broadband-statistics/#sthash.023rxbUc.dpuf

60 European Commission Press Release and Report. "EU Digital Scoreboard: How did you fare?" May 28, 2014 http://europa.eu/rapid/press-release_IP-14-609_en.htm and

61 Bennett, Richard. June 27, 2014. TechPolicyDaily.com "What the FCC Broadband Tests Really Measure." http://www.techpolicydaily.com/communications/fccs-broadband-tests-really-measure/

62 http://www.nytimes.com/2013/12/30/technology/us-struggling-to-keep-pace-in-broadband-service.html?pagewanted=all&_r=0

However it's important to look at the larger perspective about what role broadband plays in it. San Antonio's gross domestic product (GDP) is three times that of the country of Latvia, and the largest company based in the city, Valero, had global revenues four times the revenue of Latvia in 2012. San Antonio's economic development includes oil & gas, financial services, health care, media, supermarkets, military/government service, financial services, tourism, manufacturing and ICT-based companies. The level of broadband it has today supports the economy, and there is not necessarily an argument that deploying a new network will create economic growth that exceeds the cost of the network investment.

Broadband speed measures are some of the least understood and most abused broadband measures, particularly the crowd-sourced apps which essentially measure device speed but are proffered as an indication of the speed of the network. The speed a user experiences can be impacted by a dozen factors beyond the access network itself, even before data enters the last mile. While no measure is perfect, Akamai, a provider of content delivery services, is a more reliable source. It publishes speeds experienced by its customers on quarterly basis and shows that US speeds have increased since 2009, with a 25 percent last year. If US states were ranked as countries in the Akamai report, nine states would rank equally among the 15 fastest regions in the world, with Washington, DC, third in the world, Massachusetts fourth, and Virginia fifth. Indeed, 36 states plus Washington, DC, recorded peak speeds of 30 mbps or faster, according to Akamai.[63]

Broadband is frequently sold in a "triple-play" bundle with telephony, internet access, and video, offering consumers volume discounts and ease of payment. Consumers might avail themselves to upgrades, device subsidies, premises equipment, and other special offers. Consumers themselves through their choices may add value which not be captured in list prices for broadband.

Perhaps most challenging is comparing prices for broadband-content bundles across countries. In general there is more global demand for Hollywood blockbusters than European art house films (or the local language content of any non English-speaking country), so various content bundles will have a higher or lower price depending on the region, the copyright, and so on. This is particularly important when comparing cable prices, as American cable bundles offer far more content and diversity of content than most European or Asian providers. Indeed as the internet becomes digital television, the economics of the content market will become more important and likely better measured.

There is assertion that we need better, faster broadband for the sake of "innovation", but there is no reliable measure of broadband as an input to innovation. The OECD reports that broadband penetration has only an mild correlation to GDP in its member countries.[64] Innovation is highly complex and results from the interplay of many factors in a larger innovation ecosystem comprising entrepreneurs, firms, human and financial capital, knowledge and technologies, market structure, and so on.

One factor frequently overlooked is the importance of a digital single market, essentially a economies of scale. The US has common language, currency, and federal government, and

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63 "The State of the Internet, 3rd Quarter, 2013 Report," *Akamai* 6, no. 3 (2013), http://www.akamai.com/dl/akamai/akamai-soti-q313.pdf?WT.mc_id=soti_Q313.

64 Supra, Layton.

theoretically, offers innovators a potential market of 311 users. The EU – with 28 nations, 27 languages, and 11 currencies – is hardly a single market physically, let alone digitally. It's not surprising the entrepreneurs come to the US, not the EU, to launch their innovations. Consider the impact of the single market for mobile innovation in North America. Though the United States and Canada have only 5 percent of the world's population, these two countries account for more than half of the world's 4G/LTE subscriptions, making it a hotbed for mobile innovation, notably the home of Apple, Google, and Blackberry.[65]

There is no one metric that captures the breadth of importance of broadband. That's why it's important to look at a range of measures related to industry, employment, and digital skills. US Telecom estimates that about 11 million full-time jobs, representing 9 percent of America's workforce, are directly enabled by broadband ICT companies.[66] Forrester Research predicts that 43 percent of the US workforce will be telecommuting by 2016, allowing for more time with family and less on the way to work.[67] Broadband enabled goods and services drive digital exports, at $356.1 billion in 2011 already the third largest category of exports. Moreover broadband accounts for about 5% of US GDP. In fact By 2009, the GDP of *just the Internet* of the US was already greater than the total GDP of Sweden, Ireland, Switzerland, or Israel.[68]

Another important measure of America's broadband health can be seen in the number of leading Internet companies that come from the United States. Mary Meeker's annual state of the internet report notes that the US has 13 of the top 20 Internet companies; China, 4; Japan, 2; South Korea, 1. The EU has zero.[69] US companies comprise 90 percent of the market value and 80 percent of the revenue for these 20 firms. This does not take into account all the small and medium-sized US firms that would have never existed without broadband, not to mention Microsoft, a major company which is not included on Meeker's list.

From an economic perspective, America's current broadband policy which focuses on dynamic competition between networks and a a limited role for government has been successful to stimulate investment in broadband networks in a nearly unprecedented scale, some $1.2 trillion since 1996 and ongoing high rate of investment per capita for some time. This contrasts with European investment which has largely fallen across the continent on a per capita basis. Layton explains,

> A decade ago, the EU accounted for one-third of the world's communications capital expenditure. Today, the EU's share has plummeted to less than one-fifth.

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65 Supra, Layton.
66 Patrick Brogan, "Broadband and ICT Ecosystem Directly Supports Nearly 11 Million High-Paying U.S. Jobs" (Research Brief, USTelecom, Washington, DC, February 28, 2012), http://www.ustelecom.org/sites/default/files/documents/022812_Employment-Research-Brief-final.pdf.
67 Ted Schadler, "US Telecommuting Forecast, 2009 to 2016" (Digital Home Report, Forrester Research Inc., McLean, VA, March 11, 2009), http://www.forrester.com/US+Telecommuting+Forecast+2009+To+2016/fulltext/-/E-RES46635?isTurnHighlighting=false&highlightTerm=US%20telecommuting&al=0.
68 Matthieu Pélissié du Rausas et al., "Internet Matters: The Net's Sweeping Impact on Growth, Jobs, and Prosperity" (report, McKinsey Global Institute, McKinsey & Company, May 2011), http://www.mckinsey.com/insights/high_tech_telecoms_internet/internet_matters.
69 Mary Meeker, "2014 Internet Trends," Kleiner Perkins Caufield Byers, May 28, 2014, slide 138, http://www.kpcb.com/internet-trends.

> Americans, on the other hand, are just 4% of the world's population, have enjoyed one-fourth of the world's broadband capex for a decade. In fact, per capita investment in the US is twice that of Europe, and the gap is growing.[70]

From a social perspective we can see that broadband adoption in the US is high. The ITU reports that 81 percent of America's population uses the Internet (double the world average), but Pew Research Center's study on Internet and American Life reports that 86 percent of all adults go online, and 95 percent of teens.[71]

The elderly are a different story. Those who did not grow up with the Internet and never used it for their job may find little reason to start. However, the elderly can benefit greatly from the Internet – whether to check health information, connect with friends and family, or engage in hobbies good for aging brains such as bridge or learning a language – but they often need help getting online. Those who don't use the Internet cite the lack of usability and relevance as the reasons for their infrequent use, not cost. If there is a role for the government to play in broadband, it maybe to support the education of people who lack digital skills rather than to deploy broadband networks. It bears mention that increased broadband deployment does not solve the problem of adoption. It doesn't matter if FTTH is brought to every last corner of the United States. If a person never used a computer before and doesn't know how, no network connection, however fast or fancy, will get him to start.[72]

At this point, it has been amply demonstrated that the idea that the US is "falling behind" is debatable at best.[73] We might not have the fastest Internet in the world – but the countries who do often lament the low adoption rates seen after billions of dollars of state-sponsored investment. We might not have the cheapest very-high-speed Internet access in the world – but we have some of lowest prices for access to entry-level high-speed Internet– which is most important for consumers, especially when the essential set of services does not require high speeds. And, as much as we lament how much better everything is in other countries, those other countries lament how much better things are in the United States..

The results of this market-driven investment are clear: US consumers enjoy significantly higher rates of access to cable, LTE, FTTH, and 100+mbps broadband than their European peers.[74] Despite this higher per-capita investment, these numbers also show that when you include fees collected by the government (e.g., taxes and media licensing), US consumers pay less for broadband than their European counterparts.[75]

When taking these points into consideration, it is difficult to deduce that America is falling behind in broadband. America's broadband networks have allowed the country to

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70 Layton, *supra.*

71 Mary Madden et al., "Teens and Technology 2013 – Main Findings," Pew Research Center, March 13, 2013, http://www.pewinternet.org/2013/03/13/main-findings-5/.

72 Kathryn Zickuhr and Aaron Smith, "Home Broadband 2013," Pew Research Center, August 26, 2013, http://www.pewinternet.org/2013/08/26/home-broadband-2013/.

73 See, e.g., Yoo and Layton, both cited *supra. See also* Richard Bennett, http://www.techpolicydaily.com/communications/falling-behind/ and http://www.techpolicydaily.com/internet/quils-mangent-de-la-brioche/; and Sarah Leggin, *Less Is Not Necessarily More*, *available at* http://freestatefoundation.org/images/Less_is_Not_Necessarily_More_122313.pdf.

74 Id. See also Yoo.

75 Id.

develop new digital industries and transform old ones. Users are on track to consume more data than any country in world. A more correct premise may be to pursue the level of broadband development appropriate to America's economic and social needs, rather than aspiring to be the "best", which is certainly subjective and not necessarily welfare-enhancing for consumers.

There is a perhaps even more important question than whether the US has the fastest Internet in the world: does it even matter? We talk about these comparisons because we don't have a better way to assess our spending on broadband infrastructure. But we could unquestionably have the world's fastest broadband service if we wanted – all it takes is money. Would such an investment at a scale to ensure we would top the Internet speed rankings from now and into eternity make sense? Probably not. We could also have the world's fastest roads, highest literacy and graduation rates, safest schools, largest airports, and cleanest energy – if we were willing to pay for any of these things. Figuring out how much to spend on any of these priorities requires a complex set of tradeoffs that is ignored by advocates concerned with whether average broadband speeds in the United States are a few percent slower than our friends in Europe. And it bears emphasizing that even the studies most critical of US broadband speeds show only minor differences in absolute speed between ordinal rankings. (And recall, as discussed in the second premise, speed and cost are only two of many metrics important to understanding the value of broadband Internet access – others, especially latency and jitter, can be as or even more important than speed.)

If we are to have a coherent discussion about how fast our Internet architecture should be, we need to have a more sophisticated goal than "faster than anyone else." In particular, we need a more sophisticated metric than just speed. More speed will always be better than less speed; and more speed can always be acquired by expending more resources. The race to have the fastest Internet in the world, therefore, is little more than a race to spend resources. Maximization always needs to be done subject to some constraint. Rather than comparing speeds, we should instead think about why we value high-speed (and, then, higher-speed) Internet service, and how marginal increases in Internet speeds affect that goal.

VI. Part six: The role of telecom research in telecom policy

Having looked at several important, but problematic, premises in current telecommunications policy debates, we now turn to consider several themes that run through these premises and also the role of telecommunications research in telecommunications policy debates.

A first theme seen in several of these premises is constrained vs. unconstrained optimization, and the selection of relevant metrics and policy levers – or, stated differently, consideration of benefits without respect to costs or costs without respect to benefits. Thus, it will always be the case that more bandwidth is better than less, and that if we are willing to spend more money we can have better or faster networks. It is meaningless to discuss how robust networks should be without consideration of the value of applications that more robust networks may support as compared to the cost of building out those more robust networks.

Related to this, there has been surprisingly little attention paid to the requirements of applications running over broadband networks. What we expect of networks has been driven by the requirements of median uses of networks. This, in turn, has largely tracked the bandwidth (and other) requirements for streaming video. But streaming video's technical requirements are different from many other applications – it generally requires orders of magnitude more bandwidth than any other applications, and is less sensitive to latency and jitter than many other important applications.

The focus on supporting the requirements for video has been driven in large part by the high private value placed on streaming video. It is almost certainly the case that video is the Internet's "killer app" – the one thing for which consumers are likely to pay the most. But the social value of online video is likely small relative to other applications – and these other applications likely have very different technical requirements. Thus, the goal of provisioning ubiquitous high-speed Internet access is at odds with provisioning ubiquitous access to important online educational, health care, employment, and government service resources. In a world of unconstrained resources we would of course have unlimited bandwidth connectivity that supported universal access to these socially-valuable resources. But in a world of constrained resources, we face a tradeoff between the rate of provisioning networks that support the most resource-intensive and highest private-value services and the rate of provisioning more modest networks that support the most socially-valuable services but that may not support the highest private-value services.

This idea of constrained vs. unconstrained optimization doesn't only apply on the policy side: it also applies on the application side. A common definition of engineering is solving problems subject to constraints. Good engineers find ways to work within technical constraints – but in the telecom arena, engineers have the option of petitioning the government to obviate those constraints. This is one understanding of the modern network neutrality debate, combined with arguments for universal availability of low-cost high-speed broadband access: proponents are trying to leverage regulation to overcome technical constraints; opponents are advocating engineering the network to work within these constraints. Neither of these approaches is necessarily "better" or "worse" than the other, let alone "right" or "wrong." Indeed, the best approach is probably the combination of both that minimizes the cost of building new infrastructure subject to the constraint of engineers' ability to design applications that can run on the available network resources.

Another aspect of the premises considered above is that they are often framed in terms that have substantial emotional valence. This can again be framed in terms of constrained vs. unconstrained optimization. Arguments with strong emotional valence are framed to overcome or deny practical constraints – at a policy level, to say that something is necessary is to say that it must be provided no matter the cost. Thus, we need to have universally available, open, high-speed networks in order to support various applications (both socially and commercially necessary). But appeal to emotional valence – really, any argument than denies marginal constraint – is rarely analytically rigorous. Indeed, from an economic perspective "necessary" services will have very inelastic demand, and therefore are often the most likely services to be provisioned by the market.

A single thread has run throughout this discussion and this paper: good telecommunications policy is rarely simple. The premises considered above are faulty because they are binary and unbounded. They yield policy prescriptions that are invariant with respect to any state of the world: we must always invest more in building consistently faster wireline networks; those networks must always be neutral and support both privately- and socially-valuable applications.

Sound policy demands constraints – and sound policy should reject premises that do not admit of constraint. One of the most important roles of research is to identify those constraints and to operationalize them into meaningful policy levers. Much of the literature that this paper relies upon is in one sense very unsatisfactory. The technical and economic literature relating to general purpose technologies and network neutrality, for instance, is unambiguously ambiguous. At the same time, this is perhaps some of the most important literature for modern telecommunications policy, precisely because it identifies a range of outcomes and relevant factors to consider in understanding why the market may obtain various results within that range. In a world where the lines between research, policy, and advocacy are often blurry the most important research may not be that which provides answers but rather that raises questions.

Conclusion

In examining the faulty premises of telecom policy, we acknowledge our own premise, that telecom policy should be informed by critical analysis and evidence not just normative statements, however compelling they may sound. We consider addressing consumer needs as the ultimate goal, but demonstrate that seemingly consumer-friendly policies, when they don't take into account the complexities of economics and engineering, can have the opposite or negative effects of what they intended. The faulty premises are examined to improve policy proposals, transcend the narrow interests of specific groups, and create better outcomes for consumers.

The first premise is that everyone needs low-cost access to high speed broadband. Users have a diverse set of needs which might not reflect the preferences of Washington or Silicon Valley. We explore the historical notion of basic telephone service and find that is has limited application to inform what kind of services should be part of the basic bundle of social commitments today. Emergency, employment, health, government and e-commerce applications don't require high speeds. Thus a question remains whether high speed video should be part of the basic set of essential services. Indeed rich media is not driven necessarily by consumer demand, but rather the bandwidth and technology that makes it available. Furthermore rich multi-media is not accessible to the deaf and blind, so a key group is already marginalized by insisting that video is an essential service.

An alternative approach to mandating high speeds at low cost is to require that essential services be developed so that they do not require high speed broadband. Another pro-consumer policy would be to move away from defining broadband in terms of speed (mbps) but instead offer categories of service depending on application, e.g. a basic services package for health, education, government, and employment applications versus a streaming video package. This will make it easier to enforce remedies that ensure providers fulfill their obligations with a particular package, rather than to attempt to deliver everything on a given speed.

We examine the specific bandwidth requirements for key applications in health and education and show that the bandwidth needs for these services are modest and thus we expose the fallacy that high speeds are needed so that these essential services can be realized. Moreover we demonstrate that speed is not the only important aspect of broadband. For certain health and education applications which require real time communications, the elimination of latency, jitter and packet loss are more important.

We challenge the notion that wireless can't compete with cable. While wireless may have certain limitations currently, in the short term, its portability makes it the preferred broadband connection for an increasing number of people. In the mid- to long-term, as wireless moves into millimeter-wave bands accessing many GHz of capacity, wireless may well supplant cable in terms of throughput. In any case, it's important to recognize that different users may value the technologies differently, and it is by no means a fait accompli that basic set of services can only be realized on one kind of technology.

In current telecom debates the premise that openness and neutrality are perquisites for innovation border on religious dogma, but we find that this premise too is not necessarily true. Indeed openness and neutrality are not unambiguously good or bad. Openness may facilitate some innovation, but inhibit others. We see a variety of open and closed business models in which consumers benefit. Furthermore openness and neutrality are under-theorized concepts in the academic literature of innovation, and there is little evidence for the benefits they are purported to provide. In fact, not only do the most cited articles of the net neutrality literature conflict about the welfare effects of the policy, a review of the literature of innovation suggests that openness and neutrality are not key drivers for innovation. However the literature notes other salient factors for innovation such as the joining of complementary assets, partnerships, and the need to look "outside the box" for new ideas. We find that ironically proposed net neutrality policies may prohibit the very things that the literature suggests promote innovation, namely partnerships. In any case, it may be premature to build a regulatory regime on the notion of net neutrality, which lacks intellectual consensus on the issue of market failure, let alone the build a regulatory regime of an a priori concept that mandates openness while prohibiting other models. Until more evidence is available, an ex poste case by case approach to determine whether consumers are being harmed by any particular model is prudent.

We investigate the claims that telecommunications are better in Europe, Asia, or somewhere else. We find the statement "America is falling behind" is a common refrain across a number of policy issues where emotion and fear overrule analysis and rigor. No country is the sum of a single measure. As such, the myopic focus on broadband as an end in itself, by simply the sum of discrete measures such as speed or price, miss important nuances about how broadband is create economic and social value. Simply put, broadband is not an end in itself but an enabler.

There is no value in being the "best" in any broadband metric if it does not deliver economic or social welfare. Assertions that America is falling behind in broadband are frequently based on cherry-picked data taken out of context to gratuitously support a particular policy position. Informed policymaking on broadband necessarily requires the analysis of many measures and a holistic perspective.

The sixth section reviews the themes that run through the policy debates, namely constrained vs. unconstrained optimization. There is a lack of attention to bandwidth requirements of applications, which is arguably more important than bandwidth itself. Indeed consumers don't buy bandwidth for its own sake but to access content and applications.

Certain users place a high value on streaming video, but the social value of streaming video compared to other applications, whether emergency communications, government, education, health, or ecommerce, may be much smaller. Thus we must address the tradeoff between resource-intensive networks serving high private value services versus modest networks that support socially-valuable services, that may not be first be the main interest of highest private value users.

Finally we analyze critically emotional arguments in favor of certain telecom policies, that certain things need to be done regardless of the cost, a technique which is often used to end debate and discussion about important issues. However if any service is inelastic as advocates purport, then it is more likely to be provisioned by the market anyway.

Good telecommunication policy is rarely simple. As such we should resist temptation to make binary interpretations of the world where more nuanced views can ultimately deliver better social outcomes.