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The impact of 4G technology on commercial interactions, economic growth, and U.S. competitiveness

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Executive summary

To maintain the mobile broadband lead the U.S. achieved during the 3G era and to bolster the nation's economic recovery, it will be important for the United States to compete effectively in the global race to deploy 4G networks

The United States is the world leader in mobile broadband innovation. It is the national market with the most 3G subscribers. American companies excel at developing new mobile broadband devices and services for domestic and foreign markets.

Mobile broadband has thus made significant contributions to U.S. economic growth and competitiveness, and it is a sector that policymakers view as a means to drive economic growth.

America's success with 3G has been driven by an "entrepreneurial innovation ecosystem" in which private enterprise pursues opportunities created when the government auctioned large amounts of spectrum, removed spectrum caps limiting individual carrier's spectrum holdings, and permitted market forces to operate. Maintaining and expanding the ecosystem is crucial as 4G technology emerges.

American 4G leadership is far from assured, however. More than 150 carriers in 60 countries are committed to 4G deployments and trials. U.S. mobile broadband use is pressing against the limits of available spectrum, and other countries are on track to exceed U.S. spectrum supply.

Thus the United States cannot expect to retain its mobile broadband position easily. To prevail it will need to deal with its challenges and capitalize on its strengths.

U.S. investment in 4G networks could fall in the range of $25-$53 billion during 2012-2016; conservatively, these investments could account for $73-$151 billion in GDP growth and 371,000-771,000 new jobs

Investment in 4G mobile broadband networks can fuel U.S. performance in the global race to exploit the potential of this advanced infrastructure and benefit the national economy through the expenditures made by wireless firms, their suppliers, and the workers these industries employ.

A Deloitte Consulting LLP analysis covering the period 2012–2016 suggests industry investment could be between $25 billion and $53 billion. The effects of investment at these levels can be estimated by applying industry-specific multipliers. The multipliers indicate that 4G networks could account for $73-$151 billion in GDP growth, and could account for 371,000–771,000 new jobs.

The lower levels of investment and economic benefits are consistent with a "baseline" or "business as usual" scenario in which U.S. 4G deployment proceeds at a moderate pace and the transition from 3G to 4G stretches into the middle of the decade. Under these conditions, U.S. firms would be vulnerable to incursions by foreign competitors capitalizing on aggressive efforts in their home markets to deploy 4G networks and develop 4G-based devices and services. The higher levels are consistent with a scenario in which the United States invests more rapidly in 4G networks than other countries, and begins producing popular 4G-based devices and services before foreign competitors gain traction in markets here and abroad. The demand stimulated by new offerings would justify additional network investment, setting off a virtuous cycle of investment and market response.

There is no guarantee that all the factors required to achieve the high-end investment levels and economic benefits will emerge as projected. However, the figures used in the calculations appear to be conservative. Further, they focus on 4G network investment alone. The traffic estimates reflect purchases of network access by suppliers and users of 4G devices and services, but the GDP and job estimates do not take into account the wider effects of applying 4G technology, such as the production of new devices and applications; the creation of new companies; and better ways of working, living, and learning. Any attempt to quantify those effects confronts the difficulty of anticipating the way entrepreneurs will make use of the new platform — just as in the early days of 3G mobile broadband it was impossible to foretell how social networks, smartphones, and tablets would emerge. Nevertheless, it is reasonable to assume that, as in the case of 3G, the new generation of mobile broadband technology will foster innovation and growth under the right conditions.

Assuming the United States deploys 4G networks rapidly, the nation's entrepreneurial innovation ecosystem could seize new opportunities before other countries catch up, enhancing commercial interactions in ways that spur productivity and job growth

Support for the proposition that the early deployment of 4G networks can stimulate a virtuous cycle of investment and market response is to be found in the improved capabilities of 4G technology coupled with cloud infrastructure and advances in areas such as displays, microsensors, processors, and chip manufacturing. These provide the basis for developing new devices and services that have the potential to change how organizations, households, and individuals function.

The engine for creating the new devices and services is already in place — the entrepreneurial innovation ecosystem that took shape in the 3G era. Because developers are increasingly able to rent cloud computing capacity, they can develop and analyze the market's response to new 4G applications, content, solutions, and business models more cheaply and quickly.

New devices and services along with the improved capabilities of 4G networks and related technologies enhance commercial interactions — among people, organizations, and machines. As 4G deployment proceeds, it can permit more such interactions in ways that are more efficient and/or that involve greater value. Improving efficiency and quality increases the ability to communicate, transact, adapt, and/or innovate. That translates into increased productivity, supporting GDP growth. Better efficiency and quality of interactions can also boost the number of jobs by stimulating demand and promoting the formation of new businesses, which in turn creates new employment opportunities. All of this strengthens the U.S. economy and sharpens competitiveness.

4G mobile broadband can augment fixed broadband as a means of bringing certain marginalized groups into the nation's economic mainstream, thereby serving the public interest and increasing U.S. competitiveness

There are special implications for certain disadvantaged markets — minority groups, rural communities, localities with limited access to full broadband connectivity, and some small businesses. In the case of low-income populations, 4G deployment has the potential to be particularly effective in helping resolve issues that suppress employability, both because mobile wireless devices are more affordable and familiar than desktops and laptops, and because 4G offers substantially more functionality than 3G. The U.S. economy will benefit if opportunities for employment and business location are not foreclosed by a lack of advanced communications infrastructure and related capabilities.

To promote U.S. leadership in 4G technology, policymakers should consider continuing the approach that has proven effective in the case of 3G, whereby government focuses on creating conditions conducive to market-based innovation

The success of 3G mobile broadband demonstrates the effectiveness of an approach whereby government promotes the potential of high-tech wireless infrastructure by creating conditions in which competition can flourish. Key requirements are ensuring sufficient spectrum supply and allowing available spectrum to be allocated through market mechanisms. The Federal Communications Commission (FCC) and Commerce Department are working to make 500 megahertz of spectrum available for wireless broadband in the next 10 years, but even if that goal is achieved, it could be difficult to keep U.S. commercial wireless spectrum supply and demand in balance as interest in new 4G offerings grows. Particulary given the competitive implications of growing spectrum supply in foreign markets, there is a need to find additional ways to make better use of available spectrum and to unlock more.

With the proper policies in place, the United States will have the opportunity to achieve with 4G technology a repetition of the explosion of creativity that occurred when 3G technology was introduced, which would help strengthen its economic recovery and preserve its global competitiveness.

To maintain the mobile broadband lead the U.S. achieved during the 3G era and to bolster the nation's economic recovery, it will be important for the United States to compete effectively in the global race to deploy 4G networks

U.S. 3G leadership

The United States seized world leadership in mobile broadband innovation as 3G technology was being deployed. In early 2009, the United States surpassed Japan as the country with the highest number of 3G subscribers, and it continues to maintain its first-place position.[1] Although penetration is higher in other countries, the sheer number of subscribers is what matters more to developers and device manufacturers.

Exhibit 1. U.S. global leadership in 3G subscribers: selected comparisons[2]

Rank	Country	Millions of 3G subscribers, 3Q 2010	Percent 3G penetration	Percent 3G subscriber growth, 2009-2010
1	United States	141	47	27
2	Japan	109	95	12
3	South Korea	40	79	12
9	Indonesia	21	11	54
10	France	21	33	30
11	China	20	2	458
12	Brazil	19	10	117

Of the top five smartphone operating system suppliers based on global 2010 fourth-quarter shipments, three are American. The two foreign companies, Nokia and RIM, occupy second and fourth places, but their 2010 fourth-quarter year-over-year growth rates are far below those of the top two American companies, first place Google (615 percent) and third place Apple (86 percent).[3] Furthermore, enabled by 3G technology, Apple has redefined the handset market, selling devices with a $625 average sales price, far above its competitors. These companies' market valuations are additional evidence that the United States is the leader in this space. Nokia had a $222.2 billion market capitalization at the end of 1999 compared to Apple's $16.5 billion; at the close of 2010 Apple was the highest-valued technology company in the world, with a market capitalization of $295.5 billion versus Nokia's $38.3 billion.[4]

At least 60 percent of Apple's current revenue is estimated to be from product lines added in the past four years.[5] Along with the iPod Touch, Apple's iPhone is credited with the fastest new tech take-up in history. Between mid-2007 and mid-2009, the global number of users of these devices rose to almost 60 million.[6] In 2009, consumers worldwide downloaded 300 million mobile apps. In 2010, that number increased more than 16 times to five billion.[7]

The tablet market has experienced explosive growth after the introduction of Apple's iPad in 2010 (with both a Wi-Fi and 3G/Wi-Fi offering). In its first year, Apple sold 15 million units and other vendors have introduced competing products. The tablet market is projected to swell from 18 million units globally in 2010 to 70 million units in 2011, with half of the tablets sold in North America.[8]

The United States also has a lead in commerce-related mobile application development, including mobile advertising (from operating system providers such as Google and Apple and from a network of independent marketing firms and developers), location-based retail services, and couponing.[9]

In the United States, the contribution of wireless services to overall gross domestic product grew more than 16 percent annually from 1992 to 2007, compared with less than 3 percent annual growth for the remainder of the economy.[10] During the 2007–2010 recession, wireless continued to do better than the economy as a whole.[11] Investment in U.S. wireless infrastructure ran at an average level of $20 billion annually during the final years of the last decade despite the recession.[12]

U.S. policy environment

Two major factors have been cited in explaining how the United States established its 3G lead. The first is the role of the federal government in making spectrum available. From 1994 to 2000, FCC auctions tripled the amount of spectrum available for commercial mobile services.[13] However, spectrum caps limited U.S. carriers to 55 MHz per market, while abroad most European and Asian carriers were allowed to own 80 to 90 MHz. In 2003, the spectrum caps were removed, which freed American carriers from the constraint on developing mobile broadband networks. Additionally, the fact that the FCC allowed U.S. carriers to buy and sell spectrum meant that the available airwaves were allocated efficiently by market forces. The FCC spectrum auctions and their reverberations are credited with prompting a 250 percent increase in investment and a 300 percent increase in jobs in the mobile market.[14]

The second factor was what can be called an "entrepreneurial innovation ecosystem."[15] This is the set of connections, relationships, and processes that developed as U.S. carriers, high-tech companies, and their markets interacted and from which emerged a flood of new devices and services. The FCC spectrum policies thus succeeded in creating conditions that were conducive to a flourishing of private-sector creativity, and the private sector was energetic in seizing the opportunities available in an open market.

Capitalizing on the U.S. position

The world is now at the start of the 4G era.[16] As U.S. carriers embark on the widespread deployment of 4G networks, maintaining and expanding the entrepreneurial innovation ecosystem is crucial. The U.S. economy is on the mend, but the recovery remains weak and uncertain.[17] Meanwhile, American economic competitiveness is under challenge from a growing array of countries, particularly in the developing world.

The United States is seen as having momentum as the 4G race heats up. U.S. wireless carriers are upgrading their networks, and within the high-tech industry companies are producing an increasing variety of 4G-oriented offerings.[18]

- One analysis projects that the U.S. will have more LTE subscribers than the entire Asia-Pacific region by the end of 2014 (based on the assumption that one-fourth of global LTE investment over 2009–2014 will occur in the United States). Another suggests the United States will lead the world in LTE service adoption, with more than 20 percent of all U.S. mobile lines using LTE by 2014, exceeding the global average of just 2.1 percent.[19]

- FCC Chairman Julius Genachowski has said, "mobile broadband is being adopted faster than any computing platform in history. The number of smartphones and tablets being sold now exceeds the number of PCs."[20]

International competition

Continued American leadership is far from assured, however. Countries such as China, France, Germany, Hong Kong, Japan, Singapore, and South Korea have adopted national broadband plans that include goals and policies designed to upgrade their wireless as well as wireline broadband platforms.[21] One study shows that 154 carriers in 60 countries are committed to 4G deployments and trials.[22] South Korea and Sweden already have substantial 4G deployments. China is a driving force behind the development of a competing version of LTE and is pushing to develop an ecosystem around the technology that could give Chinese vendors a competitive edge.[23] Consequently, the United States cannot underestimate the competitive threat from abroad, particularly in a high-visibility area such as mobile broadband.

Spectrum may be America's Achilles' heel. Smartphones, tablets, and other advanced devices use many times the data of prior cell phones, and there is a risk of getting behind the curve in terms of meeting the growth in domestic demand.[24] In its National Broadband Plan, the FCC says it has only 50 MHz of spectrum in inventory, "just a fraction of the amount that will be necessary to meet growing demand." [25] FCC Chairman Julius Genachowski has warned of a "looming spectrum crisis."[26] The federal government is committed to increasing the amount of spectrum available over the next decade, but there is no guarantee supply will match demand even if all of the needed policy actions are completed expeditiously.[27] Meanwhile, countries such as France, Germany, Japan, and the UK are moving to allocate more spectrum than does the United States to commercial wireless service.[28]

These efforts by governments, carriers, and high-tech industries abroad indicate that the United States cannot expect to retain its mobile broadband position easily. Other countries will move with determination to gain a global advantage. Whoever wins in capitalizing on the potential of this technology will gain substantial economic benefits not only within the wireless industry, but in other sectors as well. To prevail, the United States will need to deal with its challenges and capitalize on its strengths.[29]

With the United States under competitive pressure from abroad and facing possible spectrum shortages, it is important to understand the economic stakes in the race for global 4G leadership. The next section explores the potential magnitude of 4G investment in this country, and what effects these expenditures could have on GDP and employment.

U.S. investment in 4G networks could fall in the range of $25-$53 billion during 2012-2016; conservatively, these investments could account for $73-$151 billion in GDP growth and 371,000-771,000 new jobs

Connecting telecom investment to broader economic benefits

4G network investment affects U.S. economic competitiveness in two interrelated ways. First, the pace and magnitude of the network investment affects the economic activity of wireless carriers, their suppliers, and the workers they employ. Second, the pace and magnitude of the investment influences the economic activity of the organizations, households, and individuals who use the new networks. The sooner the investment occurs, the more it gives the United States a head start in reaping the benefits of this activity and thus reinforces the nation's global lead in the mobile broadband space. This section focuses on the potential scale of U.S. 4G network investment and the economic benefits that could flow from that investment.

Projecting U.S. carrier 4G network investment

Deloitte Consulting LLP has projected U.S. wireless traffic and U.S. wireless industry capital expenditures for the period 2012–2016 based on research and modeling using data from industry sources. The calculations suggest that U.S. 4G network investment over the five-year period could fall in a range between $25 billion and $53 billion.[30]

The projections are highly approximate, but are still useful for exploring the economic impact 4G networks could have and for illustrating the potential significance of an accelerated 4G network deployment.

- The $25 billion figure assumes a 41 percent compounded annual growth rate in mobile data traffic over the period 2012–2016. This is consistent with a "baseline" or "business as usual" scenario, in which the United States deploys 4G networks at a moderate pace and steadily shifts from 3G- to 4G-oriented devices and services. However, it also suggests a situation in which the United States is an also-ran in international 4G competition and thus foreign firms gain ground in markets here and abroad.

- The higher $53 billion figure assumes a 77 percent compounded annual growth rate in mobile data traffic over the period 2012–2016. This suggests a scenario in which U.S. carriers and high-tech companies deploy 4G networks more expansively and quickly. As U.S. suppliers of 4G-enabled devices and services capitalize on the earlier availability of the 4G platform, a virtuous cycle materializes in which the more intense scale and pace of investments produce new offerings that evoke especially positive responses from customers here and abroad, which results in a more sizeable traffic increase that justifies substantial additional investment, and so on.[31]

Measuring potential benefits

The economic implications of these estimates can be determined by applying industry-specific multipliers that make it possible to project how 4G network investment could increase U.S. GDP and employment.

Investment is the main driver of economic growth in a market-based economy. It is from investment that an economy expands its capital base, gives a boost to productivity, and increases exports through greater competiveness. As a result, investment increases employment, income, and federal government tax revenue by expanding the workforce and income base. Increased telecom investment expands overall capacity, thereby applying downward pressure on consumer prices.

The Deloitte Consulting LLP analysis focuses on incremental growth in U.S. GDP and employment caused by 4G investment. It employs a GDP multiplier that is a weighted average of the 2009 RIMS II Bureau of Economic Analysis multipliers for two industry sectors: wireless communication equipment and construction. These are the sectors that directly experience a rise in demand as a result of increased spending on broadband networks. The weights used to calculate the hybrid multiplier are adjusted to account for the mix of spending as between these two categories. For wireless broadband, the 2009 weighting was estimated at 93 percent wireless communication equipment and 7 percent construction. This approach yields an output multiplier of 2.873 for wireless broadband investment.[32] This suggests that an increase of $1 in investment in wireless broadband networks results in an increase of $2.873 in final U.S. output (or GDP).

Using the same hybrid approach, the estimated jobs multiplier for wireless broadband is 14.67. That is, an increase of $1 million in wireless broadband investment results in roughly 15 new U.S. jobs.

Exhibit 2. Incremental impacts of 4G investment for the period 2012–2016[33]

	Multiplier	Baseline: $25 billion 4G investment	Robust: $53 billion 4G investment
GDP	2.873	$73 billion	$151 billion
Jobs	14.67	371,000	771,000

As noted, the estimates of 4G investment and the projections of GDP expansion and jobs growth are intended only to provide a rough sense of 4G's economic implications. Many factors will affect how the process unfolds, including government policy, the state of the larger economy, and decisions by industry players. There is no certainty that the actual performance of the economy will align with the numbers that result from applying the formulae described above. Indeed, as the higher set of projections suggests, an important variable is whether the United States gets a jump on the rest of the world in deploying 4G networks. The benefits of 4G will be less if the United States ends up bringing devices and services to markets that are already being served by foreign competitors.

That said, it is worth noting that the use of the investment multiplier approach is conservative given the broad effects of broadband technologies. Put simply, the investment multiplier approach looks at existing patterns of inter-industry purchases to arrive at a final economic impact number. Moreover, the focus is on telecom investment and on the economic effects of spending by carriers, their suppliers, and the workers they employ. The multipliers do not, in any significant way, capture the effects of spending for purposes other than buying network access by the high-tech industry, by other industries using 4G networks, and by consumers. This is a significant point because the experience with 3G technology illustrates how widespread and positive the effects of a broadband technology can be. As described in the first section, the deployment of 3G networks in the United States created waves of innovation and growth that went well beyond the telecom sector.

That investment helped create an entrepreneurial innovation ecosystem that is behind a host of leading-edge 3G hardware, software, and content that has changed many aspects of how Americans and others live and work.

Quantifying the broader economic effects in advance runs into the difficulty of anticipating the way entrepreneurs will make use of the new 4G platform and how markets will react. Any projection would be like trying to predict the ramifications of deploying 3G networks at the outset of the 3G era – even in the mid-2000s few foresaw with any accuracy how and on what timetable social networks, smartphones, and tablets would materialize in the marketplace, and how the use of the new devices and services would affect the American economy.

For example, 3G industry forecasts in 2005 did not mention tablets. Also in 2005, one report predicted an amount of nonvoice wireless revenues in 2008 that turned out to be only one-fifth of the actual, and another offered a prediction of smartphone penetration in 2009 that was one-third of the actual. In 2006, one report predicted that only 5 percent of consumers would use 3G phones for video, and another was low by 70 percent in predicting the 2010 size of the 3G installed base. Moreover, consumers themselves tended to underplay the significance of 3G applications they would soon embrace with enthusiasm. In a 2005 survey, for example, multimedia capabilities came in low on the list of things consumers said they would look for when making their next handset purchase. Similarly, in a 2006 survey, when consumers were asked what factors would influence their next handset purchase, use of the Web got little support.[34]

Thus 4G network investments can be projected to have positive GDP and job-creation effects on the U.S. economy and its global competitiveness. With respect to the broader impact from putting these networks to use, any predictions would be of doubtful utility, but it is possible to offer some indication of the positive dynamics that could result. The discussion in the next two sections highlights the positive implications of a scenario in which American firms pursue 4G deployment aggressively and succeed in being ahead of the rest of the world in offering leading-edge devices and services that capitalize on the potential of the new technology.

Assuming the United States deploys 4G networks rapidly, the nation's entrepreneurial innovation ecosystem could seize new opportunities before other countries catch up, enhancing commercial interactions in ways that spur productivity and job growth

4G networks combined with cloud computing and other advanced technologies could have benefits that reach beyond the telecom sector. The capabilities of these technologies working in concert can enhance the functioning of the entrepreneurial innovation ecosystem that has made the United States a mobile broadband leader. The creativity that arises from the interaction among application developers, end markets, and newly deployed infrastructure could result in offerings that meet needs in domestic markets and that elicit interest in markets abroad as well. So long as U.S. firms are in the vanguard of those rolling out 4G networks and developing leading-edge devices and services based on the new technology, the economic benefits could be substantial.

Advantage of 4G and related technologies

The case for high-end investment levels and economic performance begins with the attributes of 4G networks. From a technical standpoint, 4G promises three benefits over 3G: increased throughput, lower latency, and stronger security.[35] One result is a reduced cost per megabit.[36] Progress in related areas expands the potential. For example, there are pertinent new developments involving displays, microsensors, processors, and chip manufacturing.[37]

An especially important complement is cloud computing, a market in which the United States is currently the clear leader: in 2009, U.S. cloud revenues overall were 60 percent of the world total and stood at $35 billion; by 2014, they could more than double to $76 billion.[38] Cloud-based services allow handheld devices to be more compact and efficient while making them tremendously more useful and powerful. Applications, storage, and computing power can be largely resident in the cloud, but this is possible only if connectivity is robust, reliable, and secure; hence the importance of pairing 4G with cloud computing. Salesforce.com, a leading provider of Web-based services, is an example of a company that is making the development of mobile cloud computing technologies a key element in its strategy.[39]

The advent of high-performance wireless capacity coupled with cloud infrastructure and other advances is causing a proliferation of new offerings and capabilities that build upon and exceed what has been possible with 3G technology. Not only consumers, but a variety of U.S. end-user industries, including nonprofit and government entities, are likely to use devices and services incorporating the capabilities of 4G technology to better serve their customers, patients, clients, and students.[40] As illustrated in Exhibit 3, areas with promise include augmented reality applications for businesses, machine-to-machine applications involving the use of sensors and actuators, smart highways, enhanced immersive interactive education, telemedicine, augmented shopping, and entertainment and recreation.[41]

Exhibit 3. 4G network capabilities compared to predecessor wireless broadband technologies[42]

	2.5 – EDGE	3G – UMTS/HSPA	4G – LTE/WiMax
Device type	• Basic handset	• Smartphone/tablet • Air card • Some sensors, appliances, etc.	• All personal electronics: phone, TV, tablet, camera, automobile • Widespread sensors, machines, kitchen, appliances, etc.
Device computing and storage	• Limited physical memory	• High-powered CPU • Limited access to cloud storage	• Input/output client with cloud computing and multi-device access
Communications media	• Voice, SMS, instant messaging	• Over-the-top applications • Social networking	• Video calls • Collaboration via cloud
Applications	• Carrier walled garden with basic UI • Limited M2M	• Phone functionalities • Downloadable apps • MP3 player, camera, etc.	• Monitoring, automation, and smart systems • HDTV streaming and conferencing
Application examples			
Security and monitoring	• Emergency response	• Vehicle security • RFID identification	• Streaming video surveillance • Vehicle tracking
Transportation	• Basic voice	• Automatic crash notification • Public transportation navigation	• Smart traffic flow/infrastructure • Real-time vehicle monitoring and control
Location-based services	• Maps and basic GPS navigation • 911 functionality	• Localized, personalized recommendations near location • Mobile check-in	• High definition, location-based video advertisements • Augmented reality for field technicians
Video/music/gaming	• Ringtone dowloads	• Video streaming onto smartphone or tablet	• Multi-device mobile HDTV streaming from cloud-based content locker
Education	• Collection and transmission of student data	• eBooks • Game-based learning	• Immersive gaming • Enhanced immersive interaction education

Intensifying the dynamics within the entrepreneurial innovation ecosystem

In economic terms, the positive effects go beyond the appearance of exciting new goods and services. Even more significant is the prospect of improvements in the operation of the entrepreneurial innovation ecosystem that took shape in the 3G era. In summary, 4G networks combined with cloud computing and other advanced technologies have the potential to facilitate interactions among all components of the ecosystem, and thereby accelerate the process through which supply and demand signals interact and create new economic activity. This is the dynamic that boosts investment and economic growth, and it is this effect countries are vying to secure by leading the global race to deploy 4G networks.

The leading-edge applications, content, and solutions discussed above and the related expectations of soaring spectrum demand are based on the capabilities of 4G networks and complementary technologies. However, beyond the ability to make enhanced offerings available to business and individual users, it is important to also consider implications of the improved connections between end-user markets and the high-tech sector that develops new offerings.

Developers are experiencing reductions in overhead costs as the supply of cloud computing capabilities grows. Rather than buy storage and computing facilities, they rent them at increasingly competitive prices. Along with the capabilities of 4G networks and new devices, this improves

the ability to develop and analyze the market's response to leading-edge applications, content, solutions, and even business models.[43] The low cost and rapid cycle time of experimenting and determining success or failure allows entrepreneurs to invest in ideas rather than infrastructure.

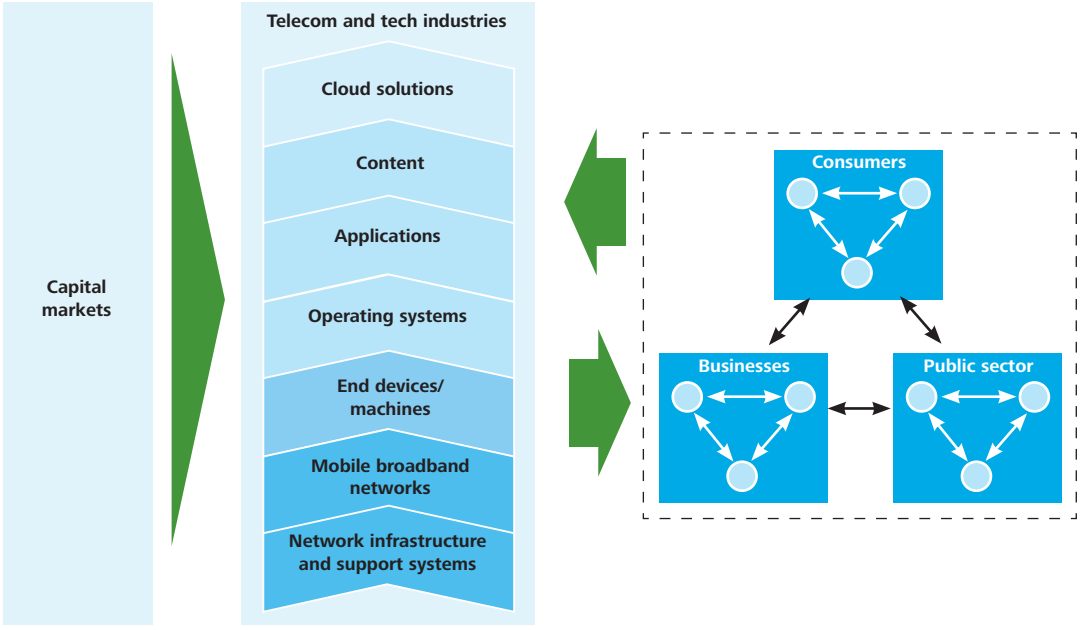
Additionally, the scale of the 4G market that will take shape over the next several years is a major advantage for developers in the United States; as noted, there are projections that by the end of 2014 the United States will have the highest number of LTE subscribers in the world. [44]

A precedent can be found in the surge of entrepreneurial innovation that occurred as the PC industry moved to more and more advanced standards, which yielded order of magnitude improvements in product variety, consumer demand, and the number of new product innovations. It also stimulated significant growth and job creation in adjacent industries.[45]

A new feature may be the expansion of machine-to-machine connections via mobile networks, which could spark not only new applications and solutions, but also new approaches to data management and analysis as the amounts of information transmitted and stored strain the capabilities of existing methods and equipment.[46]

4G networks, cloud servers, and related technologies can thus support interactions among developers, carriers, computing facilities, and the marketplace that are far more intense than what has been feasible previously. As megabits and other resources are used more efficiently, there is likely to be a tendency to use more of them.[47] The result could be a virtuous cycle, in which signals from the market stimulate new offerings, which encourage new uses, which invite new offerings, and so on. The American entrepreneurial culture can speed up and enhance the process through which innovations are created, tested, and commercialized, thus inviting investment, boosting economic growth, and allowing the U.S. economy to be a stronger competitor in the mobile broadband market and across the board.

Exhibit 4. The entrepreneurial innovation ecosystem[48]



Enhancing commercial interactions

The way the entrepreneurial innovation ecosystem affects the economy can be described as enhancing commercial interactions among people, organizations, and machines.[49]

As 4G deployment proceeds, it can permit more such interactions in ways that are more efficient and/or that involve greater value in terms of the richness of the information that can be communicated.

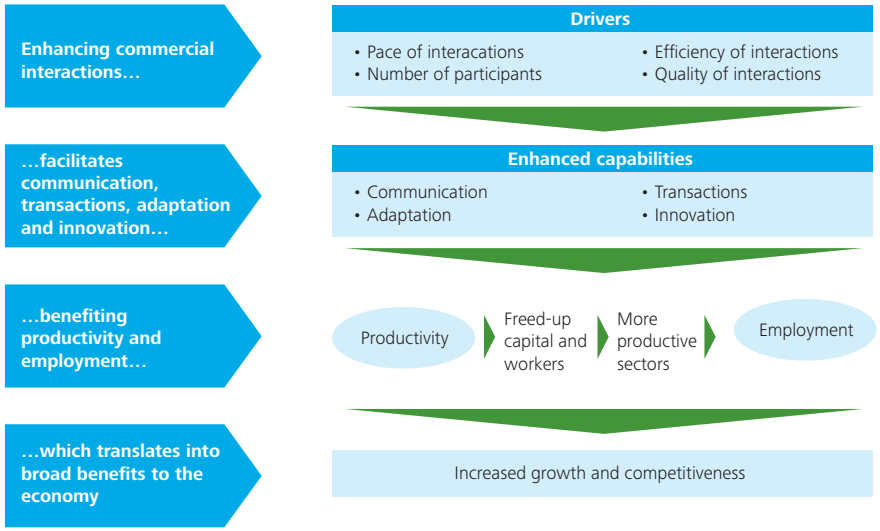
- Increasing efficiency entails producing the same outputs with reduced inputs or producing more outputs with the same inputs. For example, mobile communications increase efficiency by making it possible to conduct transactions, meet, exchange information, or carry out other interactions on an anywhere-anytime basis. The greater throughput of 4G networks allows more mobile interactions to be conducted more efficiently — for example, transactions and payments, information and data transmission, and interactive collaborations or enhanced communications such as video calls and social media.

- Increasing quality relates to the level of performance or value of goods or services, such as the extent to which the richness of the communication associated with an interaction is appropriate to the needs of the parties, or the security with which information integral to the interaction is exchanged and documented. For example, for virtual business meetings, remote education, or personal conversations, value is enhanced to the extent the experience resembles being there in person. The visual and auditory information inherent in the type of high-quality video available via a 4G network creates the opportunity for an anywhere-anytime, high-quality interaction that can augment the capabilities of wireline broadband.[50]

Improving efficiency and quality increases the ability to communicate, transact, adapt, and/or innovate, which translates into increased productivity, a major contributor to growth in GDP. The impact when new infrastructure enhances commercial interactions is shown by examples such as the increase in productivity in the United States following expansion of the interstate highway system and the increase in global consumption resulting from electronic payments.[51]

Better efficiency and quality of transactions can also boost the number of jobs by increasing demand and promoting the formation of new businesses, which in turn create new employment opportunities.

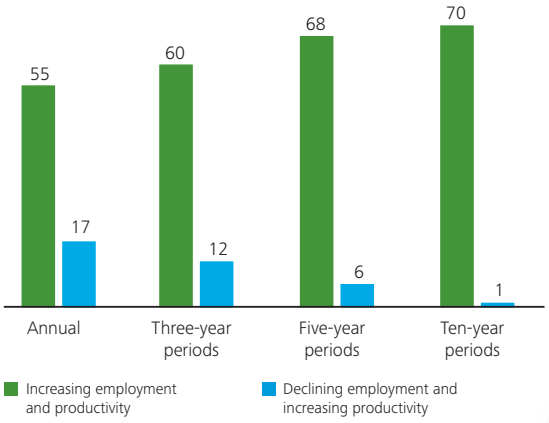
Exhibit 5. How enhancing commercial interactions produces economic benefits[52]



Although some efficiency increases and quality improvements displace existing functions and businesses, over time the freed-up workers and capital are typically put to work in other, more productive companies and sectors. As the next exhibit shows, less than one-third of the years since 1929 have resulted in declining jobs and increasing productivity (17 of 80 years), and over longer periods, as the economy adjusts to new technologies and business models, the proportion with both employment and productivity rises — the number of decades with net employment losses is 1 percent. This suggests that the tradeoff between productivity and employment, if one exists, is a short-term phenomenon.[53]

The early deployment of 4G networks could therefore intensify the dynamics within the entrepreneurial innovation ecosystem and enhance commercial interactions. Such developments could make additional investment feasible and increase the beneficial effects on the economy. These are the dividends that flow from a position of world leadership. The next section discusses how 4G networks can help equip certain marginalized groups to move further into the nation's economic mainstream, thereby serving the public interest while helping to increase U.S. competitiveness.

Exhibit 6. Relationship between employment and productivity levels over time[54]
Rolling periods of employment and productivity change, 1929-2009



4G mobile broadband can augment fixed broadband as a means of moving certain marginalized groups further into the nation's economic mainstream, thereby serving the public interest and increasing U.S. competitiveness

Identifying benefits specific to certain population subgroups

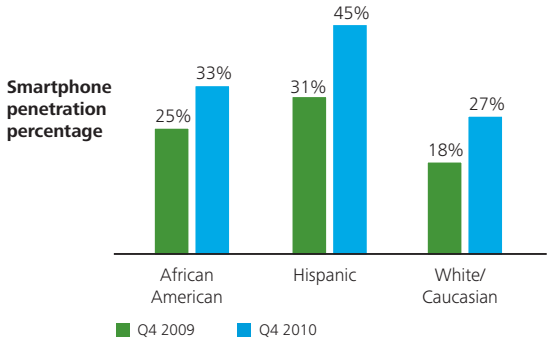
The deployment of 4G mobile broadband has special potential to bring into the economic mainstream people and organizations who would otherwise participate at a less than optimal level or not at all. The potential applies to minority groups, rural communities, localities with limited access to full broadband connectivity, and small businesses for which mobile broadband is a workable option in addition to dedicated access or fixed broadband. Increasing participation by these groups could help promote greater social equality while helping to elicit new contributions to U.S. economic growth and global leadership.

Minority groups

It is well established that poverty is higher among minority groups than among whites, and that a significant amount of minority-group poverty is found in urban areas.[55] With respect to information and communications technology, research shows whites are more likely to own a desktop or laptop computer than are African Americans and Hispanics, and in general a "digital divide" is apparent in measuring minority group broadband access compared to that of whites.[56]

However, minority populations are especially heavy users of mobile broadband devices and services. As the exhibit below shows, smartphone ownership is higher among members of minority groups than among whites. Similarly, minority populations access the Web more often from mobile broadband devices and spend more time on the Web using handhelds than do whites. Studies differ on whether African-Americans or Hispanics are the most intensive users of mobile broadband services, but there is agreement that, as with smartphone ownership, minority group usage significantly exceeds that of whites.[57]

Exhibit 7. U.S. smartphone penetration by race/ethnicity: Q4 09-Q4 10[58]



Further, mobile broadband use by teens from low-income households has been found to exceed that of other teens. A 2009 Pew survey shows that lower-income teens who have cell phones use them to access the Internet more often than their more affluent counterparts — 41 percent of teens in lower-income households said they use cell phones to access the Internet while for higher-income households the rates ranged around 25 percent.[59]

As popular as mobile broadband has been among minority groups, the limits of 3G technology and spectrum shortages have constrained the potential of mobile broadband in urban areas where many minority Americans live. Spectrum allocations do not perfectly scale to population density and demand. Many carriers have the same amount of spectrum in second- and third-tier cities as they have in New York or San Francisco, but the density and demand of the latter cities may be five to 10 times as great.[60] As a result, minority groups along with other residents of first-tier large cities stand to benefit from the greater spectral efficiency 4G offers.

With the enhanced performance of 4G, mobile devices move closer to the functionalities of desktop and laptop computers, but with the added advantage of anywhere-anytime use and, in many cases, greater affordability.

Among other things, this suggests handhelds are becoming better able to augment fixed broadband infrastructure in the delivery of computerized learning. A variety of schools, government agencies, nonprofits, foundations, entrepreneurs, and corporations are researching, demonstrating, and applying computerized learning using the mobile broadband platform. A substantial proportion of these efforts incorporate approaches that depart from the teacher-driven model of learning and involve methods that are more personalized and flexible.[61]

The more flexible approach to education is thought to be especially beneficial for poor minority youth. For example, Harvard Business School professor Clayton Christensen argues that computer-based learning has important potential for helping disadvantaged students escape poverty because it lends itself to a "student-centric" education model, with modularization and customization that avoid the uniformity he sees as a fundamental weakness of conventional classroom instruction.[62]

Teachers, administrators, and producers of instructional materials are still in the process of determining how to adjust to the mobile broadband platform, but a 2010 survey indicates that students are interested in making the transition: between 35 and 68 percent of the students surveyed confirmed an interest in using mobile devices for Internet research, collaborating on projects, and making and sharing documents, podcasts, and video reports. Moreover, when parents of students in Grades 6–12 were asked if they would help pay for their children's use of mobile broadband for educational purposes, about 70 percent said they would buy a device and about 60 percent said they would buy a data services plan — and the percentages did not vary significantly for low-income parents.[63]

Thus the enhanced mobile broadband capabilities that come with 4G technology, combined with cloud computing and other advanced technologies, mean the deployment of 4G networks can introduce a cost-effective complement to fixed broadband infrastructure in bringing educational opportunities to minority groups. The same potential applies to other areas pertinent to minority groups, such as employment search, health care, public safety, and civic engagement. The improvement in a familiar and congenial infrastructure can enhance the utility of existing offerings and open the way for new ones that can increase minorities' participation in American society and in the mainstream economy, with follow-on effects that benefit American economic performance and global competitiveness.[64]

Rural communities

With respect to smaller cities and towns, 4G networks can offer advanced infrastructure capable of attracting and serving manufacturers, warehouses, energy industry operations, specialty agriculture, technology support centers, knowledge workers, retiring baby boomers, and immigrants.[65] In localities that lack the educational levels, skills, and familiarity with the Internet required to take full advantage of the opportunities generated by high-tech infrastructure, 4G networks can provide access to learning, training, health care, social services, and other remedial aids that are instrumental in closing such gaps.[66]

Research confirms that the economic effects of fixed broadband networks in rural markets are positive. Studies arrive at different findings as to the extent of the economic benefits and point to distinctions between rural areas located on the peripheries of metropolitan areas and those that are more remote. However, there is agreement that broadband does play a role in increasing employment, increasing the efficiency of business operations, and countering rural-urban migration. Some studies using matched pairs of communities show that those obtaining broadband first do better economically.[67]

As the deployment of 4G networks proceeds, the extension of advanced mobile communications could cause an increase in the number of businesses retained, relocated, and started in rural communities. Allowing rural markets to participate in the enhancement of commercial interactions that 4G networks enable could help stimulate economic growth and new job creation that would not have happened without the new infrastructure.

As in inner city neighborhoods, 4G networks serving rural communities could augment the contributions of desktop or laptop computers connected to fixed networks and create new opportunities to learn and work. The affordability, familiarity, and capabilities of 4G mobile broadband devices could help rural residents who would not be viable candidates for employment in a fixed broadband world gain entry to the online realm and obtain the information and skills required to begin to climb up the vocational ladder. The addition of people to the workforce who were previously on the sidelines would help increase the rate of growth in America's GDP, employment, and competitiveness.

There is the argument that businesses choosing to locate in rural areas cannibalize growth that would otherwise occur in urban areas. However, that could be akin to arguing that globalization is a zero-sum game in which developed nations lose as developing nations grow, the counter to which is that both sides benefit as the economic pie expands.[68] There will always be wins and losses, but the U.S. economy overall will benefit if business and household location decisions do not go against rural areas by default due to a lack of advanced infrastructure and related capabilities.

Underserved pockets

4G networks may be the best choice to address the need for additional broadband coverage that exists in pockets across all types of geographic markets. Ninety percent of the U.S. population lives in counties in which at least 75 percent of the inhabitants have access to mobile and/or fixed broadband service with advertised speeds of at least 6 Mbps (which can accommodate real-time two-way video teleconferencing). That still leaves about 33.5 million people living in counties with less high-speed coverage — close to the population of Canada. Examples include San Diego County, Waukesha County (west of Milwaukee), and Cass County, Missouri (Kansas City metro area). Upgrading or augmenting coverage in these arguably underserved areas might be more efficiently accomplished by leveraging the reach of current mobile networks instead of trying to deploy new fixed networks.[69]

Exhibit 8. Availability of broadband service offering > 6 Mbps advertised speed[70]

Tier	Counties in which households have access to >6 Mbps broadband	Number of counties	Population (millions)
1	More than 75%	1,628	272.7
2	50%–75%	867	21.1
3	25%–50%	322	8.0
4	Under 25%	323	4.4

Small businesses

Currently 58 percent of small businesses use digital subscriber line (DSL), followed by cable; only 9 percent use dedicated access.[71] Just 28 percent of buildings with more than 20 employees are served by fiber.[72] For some small businesses, 4G mobile broadband could therefore be a workable option due to its enhanced anywhere-anytime benefits and given the costs of upgrading DSL to very high speed DSL and fiber to the home.

The deployment of 4G networks could thus help address situations in which certain American communities and businesses are at a disadvantage due to a lack of leading-edge broadband connectivity and the readiness to make full use of the Internet. Doing so could bolster U.S. economic performance and competitiveness in the process. The concluding section reviews the policy environment needed to ensure that the United States does not miss out on these and other opportunities presented by the advent of 4G technology.

To promote U.S. leadership in 4G technology, policymakers should consider continuing the approach that has proven effective in the case of 3G technology, whereby government focuses on creating conditions conducive to market-based innovation

Experience with 3G indicates that a successful approach for reaping the benefits of 4G mobile broadband technology is for government to focus on creating conditions that are conducive to the functioning of market forces, enabling private enterprise and competition to determine the optimal way forward.[73]

Global 4G competition

As noted in the first section, governments in other countries are pursuing national broadband plans that include upgrading domestic wireless networks, and more than 150 carriers in 60 countries have 4G deployment commitments and trials. In some cases, governments play a more significant role in their telecom sectors than is the norm in the American system. Certain governments own shares in domestic telecom and high-tech companies. Some treat the success of their telecom and high-tech sectors as a matter of national industrial policy and offer assistance through means such as tax incentives, R&D funding, and end-user subsidies in addition to directly supporting particular entities through their ownership position.

Exhibit 9. Efforts by selected governments to promote 4G deployment[74]

Country	Government actions
China	• Providing R&D for a Chinese version of 4G wireless infrastructure • Coordinated large-scale LTE trials • Financing the export of China's wireless technology through state-owned banks
South Korea	• Actively field testing what has been rated the world's fastest LTE network • Providing funds to build a "mobile cluster" industrial zone to support LTE product development • Provided undisclosed support for Ericsson to set up a 4G R&D facility in the country
Japan	• Identified 400 MHz of spectrum to reallocate for mobile broadband purposes • Supported NTT DoCoMo, the leading wireless carrier, with LTE field tests
France	• Made available 30 MHz of spectrum in the 800 MHz band and 70 MHz of spectrum in the 2.6 GHz band for 4G service • Mandated that 90 percent of the population will be covered by 4G by 2025, creating a large market for 4G services
Sweden	• Deregulated market three years before the United States • Made the 2.6 GHz band available to carriers in April 2008 • Provided Ericsson, a leading 4G network equipment vendor based in Sweden, an undisclosed level of financial support

Continuing reliance on market forces

In the United States, government has played a more limited role in guiding and regulating the commercial mobile service sector. For the most part, public policy has embodied the premise that robust competition encourages innovation and investment, benefiting all consumers.

In 1993 Congress preempted state regulation of mobile service rates and entry, meaning that states focus mainly on consumer protection. Congress authorized the FCC to forebear from enforcing standard common carrier regulatory provisions with respect to mobile services, which it has done. In addition to licensing wireless carriers, the FCC has administered interconnection, pole attachment, and roaming rules and has established a limit on the time local governments can take when making tower siting decisions. The shift to spectrum auctions and the removal of spectrum caps were likewise consistent with the policy of relying on market forces to determine the direction of the U.S. wireless sector.[75]

For example, in commencing the proceeding that provided spectrum for 3G services, the FCC said, "the marketplace and not the government should determine how this spectrum is used. Thus our proposals allow flexibility for licensees to provide third generation and other advanced wireless services in the near term, while fostering innovation and agility so they can quickly adapt to changes in technological capabilities and marketplace conditions into the future."[76]

Thus, although governments play a strong role in the telecom sectors of many other countries, America's mobile broadband leadership has been established through a model that involves greater reliance on market forces. Over the past decade, with the more market-oriented approach in place, the U.S. wireless sector has experienced an explosion of mobile broadband devices and services, wireless networks have been expanded and upgraded, wireless service prices have fallen, and there have been increases in the numbers of wireless connections and subscribers and in the proportion of users with access to three or more mobile broadband providers.[77] And, as discussed in the first section, U.S. firms are in the vanguard of the mobile broadband revolution.

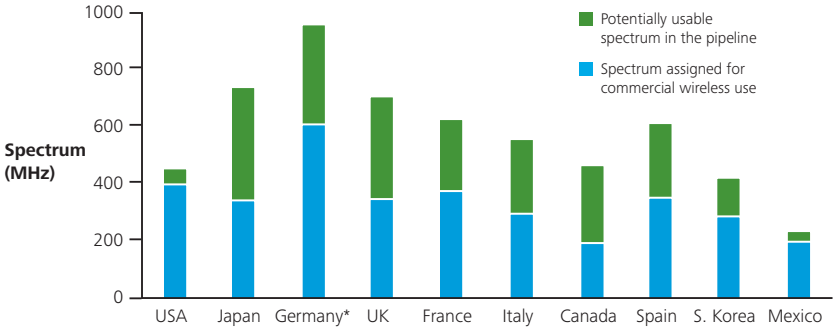
Ensuring sufficient spectrum

As the first section also pointed out, however, there are indications the spectrum currently and potentially available for U.S. commercial wireless service will be insufficient to meet the demand that can be expected as mobile telecommunications increasingly shift from voice to data applications. Further, as the chart below illustrates, the amount of spectrum available for commercial wireless services in the United States could be exceeded by the supply in other countries.

The FCC has said that the growth of wireless broadband will be constrained if insufficient spectrum is made available to enable network expansion and technology upgrades.[79] A recent report on this subject concluded that without adequate spectrum the United States would be hobbled in its efforts to capitalize on the benefits of mobile wireless. Networks would become congested, with applications behaving unreliably and erratically. Promising advances might not reach the marketplace, investment levels would drop, and the market would not reach its full potential.[80]

The federal government is committed to making new spectrum available for flexible use, including spectrum for mobile broadband services, and proposals are pending to permit incentive auctions that will encourage current spectrum owners to allow some of their holdings to be reallocated.[81] Auctions made spectrum available for 3G mobile broadband and thus could be effective in the case of 4G as well. Additionally, stipulating that spectrum is for flexible use allows market forces to determine how spectrum is to be used, which can be more efficient than relying on government proceedings to prescribe adjustments made necessary by new technologies, business models, and demand patterns.[82]

Exhibit 10. Comparison of spectrum assigned and in the pipeline[78]



*Germany recently auctioned 350 MHz

However, experience shows that years or even a decade can pass between the initiation of a spectrum reallocation and the time when the spectrum becomes available for use.[83] Congress is now considering the FCC's proposals for procedures that the commission believes could avoid a solution this slow, but the outlook for action is uncertain.[84]

Exhibit 11. Time required to reallocate spectrum[85]

Band	First step	Available for use	Approxmate time lag
Cellular	1970	1981	11 years
PCS	1989	1995	6 years
EBS/BRS	1996	2006	10 years
700 MHz	1996	2009	13 years
AWS-1	2000	2006	6 years

Moreover, supplying spectrum in the vast amounts required to meet surging demand will be difficult.[86] And increases in mobile broadband demand boosts the need for microwave backhaul and unlicensed networks.[87] It is therefore important for the United States to continue the search for ways to use existing spectrum more efficiently and to expand spectrum supply as expeditiously as possible. Insufficient spectrum could cause the United States to go from leader to laggard in the global competition to claim the benefits of 4G technology.

The success of 3G mobile broadband demonstrates the effectiveness of an approach whereby government creates conditions in which competition can flourish, in particular by ensuring an ample supply of spectrum and allowing market forces to determine its disposition. Continued government action following this pattern could help intensify the virtuous cycle involving mobile broadband investment and the introduction of new offerings and the creation of new demand. This in turn could help boost the growth of GDP and employment and ensure that the United States remains a leader in mobile broadband and in global economic competitiveness generally.

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