Citi GPS

DISRUPTIVE INNOVATIONS III

Ten More Things to Stop and Think About

Citi GPS: Global Perspectives & Solutions

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DISRUPTIVE INNOVATIONS III

Ten More Things to Stop and Think About

Kathleen Boyle, CFA
Managing Editor, Citi GPS

Two years ago we published our first Disruptive Innovations report hoping it would be a fun and interesting look at some of the new technologies that were around the corner. At the time, there was also a growing debate surfacing over the lack of economic growth in the US and whether it was due to a lack of innovation. We disagreed with then that there was a lack of innovation and two years down the road we stick with our position. We see the pace of technological change accelerating as we move into a new Digital Age, helped by the continued decline in the cost of innovation coupled with increased interest in funding innovation.

In this new report, Disruptive Innovations III, we once again take a look at some of the newest concepts across sectors and identify new products which could potentially disrupt the marketplace. What stands out in the report this year is the size of the expected market opportunities for each product. In financial innovations alone, a combination of marketplace banking (peer-to-peer lending and crowdfunding) and Robo-Advisors touch a total addressable market of over $5.3 trillion. Autonomous driving along with the overall sharing economy could jointly be a $435 billion opportunity by 2030.

Also different this time is the increasing synergies between the different innovations. Driverless vehicles that facilitate “robotic taxis” should also enhance the sharing economy through companies such as Uber and Lyft. Virtual competitions designed to accelerate the pace of digital banking innovation, such as the Citi Mobile Challenge, wouldn’t be possible without the availability of public application program interfaces (APIs). As it continues to improve, Machine Learning and Artificial Intelligence (MLAI) is increasingly disruptive through direct impact and as a building block for other innovative technologies. The use and impact of MLAI can be seen as a factor in most of our highlighted innovations.

Autonomous driving, a topic we covered in detail in Car of the Future v2.0, is moving from concept to reality with 2020 now forecast as the start of the ‘driverless era’. Drones, initially used by the military, could soon be the preferred delivery method for small packages and the primary way we take pictures at family barbeques. Virtual and augmented reality has progressed to the point that computer games will soon behave more like the holodeck in *Star Trek: The Next Generation*.

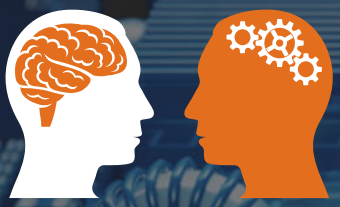
Even in places where we’ve already highlighted disruptive innovations, we’re seeing disruption being disrupted. Immunotherapy manufacturers, which we highlighted as disrupting the pharmaceutical market last year through targeted cancer treatments, are now being disrupted themselves with the advent of generic competition through biosimilars. Fracking in the gas industry was one of the biggest disruptive innovations in the energy sector as it opened up commercial opportunities for shale oil and gas reserves that the industry had known about for decades but had not bothered to pursue. In this report we look at Floating LNG, which has the potential to repeat this for stranded gas reserves.

There's big opportunity out there

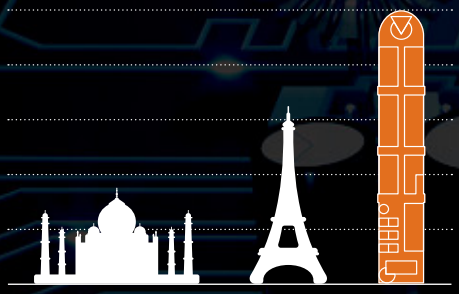
Autonomous Driving
By 2030, driverless cars could be a $100 billion market

Drones
Almost 800 million small packages could be delivered by drones in the US

Machine Learning/Artificial Intelligence
Humans can manage about seven variables in their working memory vs. computers which have no limit



Biosimilars
Biosimilars are poised to take over $110 billion in revenues from drug innovators over the next 10 years.

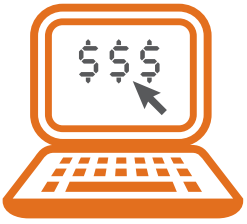


Floating LNG
The length of Shell's new FLNG facility is equivalent in size to the Eiffel Tower standing on top of the Taj Mahal

Public API
The rate of adoption for APIs has increased exponentially, similar to the adoption rate for smartphones

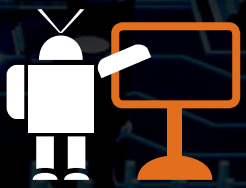
Sharing Economy
The five most prominent sharing economy sectors could rise to $335 billion from just $15 billion today

Virtual Reality
Starting with game makers and goggle-like game terminals in 2016, the VR/AR market could rise to $200 billion in the first 5 years



Marketplace Banking
The total addressable market for P2P lending is $254bn, or 8% of the total US consumer credit market

Robo-Advisors
From just $19 billion at end-2014 the target addressable market for Robo Advisors could rise to $5 trillion over the next 5 to 10 years



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How is Innovation Changing?

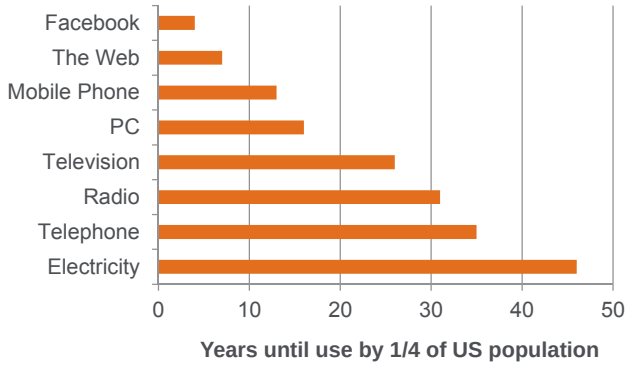
Robert Garlick
Global Product Head

Two of the questions raised post last year's Disruptive Innovation II report were 'How is innovation changing?' and 'Why if innovation seems so prolific in today's increasingly digital economy, are productivity statistics poor in much of the developed world?' Growth in US productivity, or economic output per hour worked, has downshifted noticeably since late 2007, averaging 1.25% per year compared to 2.75% per year over the preceding decade.[1] Economist Robert Gordon in his paper "Is US Economic Growth Over? Faltering Innovation Confronts the Six Headwinds", argued persuasively that the low hanging fruits of innovation have already been picked. However, we disagree and argued in a recent Citi/Oxford Martin School Technology at Work GPS report that it is not the lack of innovation that's causing a decrease in productivity, but the changing nature of innovation.

The Pace of Innovation is Accelerating

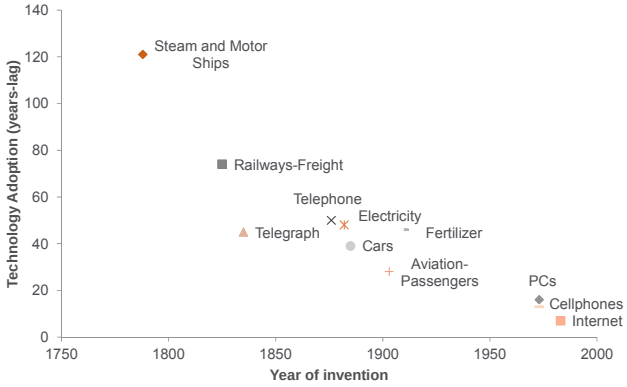
Statistics confirm what we all intuitively feel: that the pace of technological change has been speeding up. The US has seen a rapid increase in the rate of adoption of new technologies (Figure 1) while globally not only has there been a drop in the average technology adoption lag but that has also been a convergence between Western and non-Western adoption times.[2] Globalization — including the fall of the Iron Curtain, the opening up of China, the spread of low cost travel, higher literacy rates and the advent of mobile communications and the Internet — has helped integrate and connect the world's population. This increased connectivity is evident in a 2011 Facebook user study which trumped the theory of 'six degrees of separation', by finding that on average there were only 4.7 degrees of separation between any two users anywhere in the world.

Figure 1. Years Until Technology Was Adopted by ¼ of US Population



Source: Sinfulatiry6, Internet World Statistics, Citi Research

Figure 2. Global Estimated Adoption Lags of Technology Diffusion



Source: Comin (2013), Citi Research

Nor is this increased connectivity over. The International Telecommunications Union estimates that 43% percent of the world's population will be online by the end of 2015, up from just 6.5% in 2000, but this still leaves 4 billion people from mainly developing countries that remain offline.[3] Smartphones will help connect many of these — GSMA forecasts smartphone connections will grow threefold over the next 6 years to reach 6 billion and account for two thirds of the 9 billion mobile

[1] Fed Chair Janet Yellen, 22 May 2015.
[2] Comin D, Mestieri M, Technology Diffusion, Measurement Causes and Consequences, May 8, 2013.
[3] ITU, International Telecommunications, May 2015.

connections by 2020. GSMA also estimates four out of five smartphone connections worldwide will come from the developing world by 2020.[4] Increasing connectivity opens up new markets, aids collaboration and unlocks brainpower to help solve the world's problems — all driving the pace of innovation.

The next stage for connectivity is a move from connecting people to connecting things through machine-to-machine communication — the 'Internet of Things'. In 2013, Cisco estimated that 99.4% of physical objects were unconnected, and forecast the number of connected devices will increase from 13 billion in 2013, to 50 billion by 2020 and 500 billion by 2030. Increased digital connectivity is fuelling a data boom, with the amount of data estimated to double every 18 months.[5], Technology is helping analyze this tidal wave of data, often in real time, enabling innovators to know much sooner if products or services are working, and allowing them to adjust accordingly.

The Costs of Innovation are Falling

In addition to an expanding pace, the costs of innovation have been falling, which in turn lowers the barrier to entry and the price of failure. The costs of computing power, connectivity and information have been falling for years, but the advent of cloud computing over the last 15 years has been revolutionary for many start-ups. Cloud allows firms to buy technology capacity as needed, and at ever lower prices. — the costs of cloud computing are estimated to have fallen 50% every three years since 2006.[6] The Internet has also lowered distribution costs, sometimes to zero, and improved both niche and mass marketing. Previously many firms were priced out of wide (national or international) advertising in mediums such as TV, radio or newspapers. Firms can also scale up quickly in the digital world without large investments in people. WhatsApp is a poster child for this — started with $250,000 of seed funding and employed just 55 workers when it was acquired by Facebook for 19 billion. Forbes noted that WhatsApp gained more followers in its first six years of existence (700m) than Christianity did in its first nineteen centuries.[7]

The rise of the Internet has allowed new open source models to develop, offering universal access via the free license of a product's design and its subsequent enhancements. These models allow thousands of developers to take part in open-source projects driving better, cheaper, easier and faster products when compared to proprietary alternatives. Without open source many cloud computing, big data and mobile applications would not exist. Google's Android platform, Tesla (electric vehicles and energy storage), Toyota (hydrogen cars), Khan Academy (already the world's largest education organization) and some 3D printing blueprints are all examples of open source ecosystems that help foster further innovation. So too does the App Economy, where the cost of innovation appears low (a recent survey by OMS's Carl Frey estimated the average cost to develop an app was just $6,453) and the gains for some can be substantial (both Apple and Google share 70% of the gross bookings with app developers). Mark May, Citi's US Internet analyst has forecast the App economy could reach $52.5 billion by 2017, up from $29 billion in 2014 and zero in 2008. This new economy helps entrepreneurs distribute and monetize their ideas around the world.

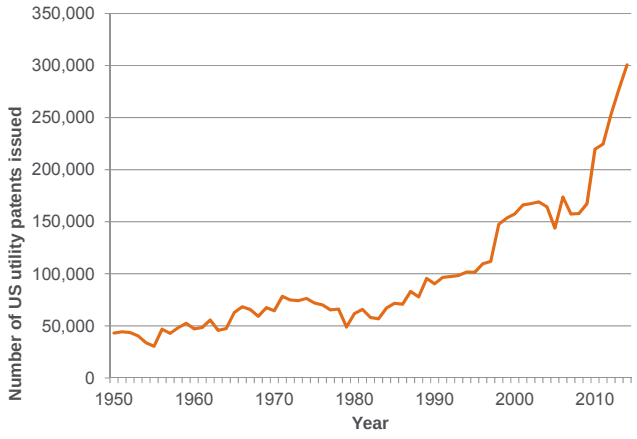
[4] GSMA Intelligence, 12 September 2014.
[5] IBM, Demystifying Big Data, 2012.
[6] Economist, 4 October 2014.
[7] Forbes, 8 January 2015.

Funding and Patents Have Surged

While the cost of innovation has decreased, exceptional gains for some entrepreneurs have attracted significant new capital. The Venture Capital (VC) industry invested $59 billion in 2014, the highest amount since the dot-com era, according to 2015 Annual Venture Industry Report, Pitchbook. Cross-over capital and corporates (CVC) are also keen to have a seat at this table. CVC now accounts for a record 15% of the VC industry. Often CVC's will also act as "incubators" or "accelerators" for young companies helping with mentoring and getting products to market. New crowdsourcing and crowdfunding models are also opening up capital opportunities to start-ups beneath the radar of traditional VC's. The crowdfunding market is estimated to have grown from $1.5 billion in 2011 to $16.2 billion in 2014. Crowdfunding can also help young companies with marketing and pre-testing to improve time-to-market cycles. When Pebble raised $20 million in financing via Kickstarter earlier this year, a crowdfunding record, it had 78,471 backers helping market the company.

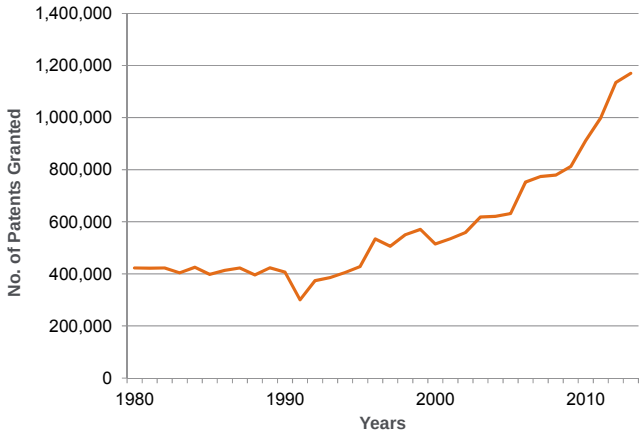
One of the biggest engines of research and new discoveries within economies are universities. Governments around the world are encouraging universities to be incubators of innovation and capital is following to transfer discoveries to the private sector for commercialization. US university research led to 5,163 patents in 2013, up from 250 in 1980, and US university licensing activity is estimated to have contributed $181 billion to US GDP between 1996 and 2013[8]. As innovation opportunities and funding around the world have risen, so too has the number of patents issued. While there is a debate over whether patents facilitate or hinder innovation, they do at least provide one pulse on the level of inventions that companies are trying to protect. Data from the US Patent and Trademark Office shows patents issued have almost doubled since 2008 (Figure 3). Data from the World Intellectual Property Organization shows patents granted in Asia have more than tripled since 2001 (Figure 4) to a level that exceed those issued in the US.

Figure 3. Number of Utility Patents in the US From 1950 to 2013



Source: US Patent and Trademark Office

Figure 4. Number of Utility Patents in Asia Region



Source: World Intellectual Property Organization

Innovation and Productivity

So if innovation seems to be booming, why has productivity growth been muted? A common argument is that the effect of innovation is being incorrectly measured. The advent of the Sharing Economy, which forms a chapter in this report, and free

[8] Dr Michael Crum of Iowa State University on patent reform, 18 March 2015.

services help support this theory. Much of this is coming out of the Digital Economy and Stanford economist Nicholas Bloom recently said "You can't be in the Valley without thinking we're in the middle of a productivity explosion." Most people don't live in Silicon Valley and an alternative argument, that overall investment spending has remained low post the Global Financial Crisis (GFC) is well founded. Despite high EBIT margins, Citi Global Equity Strategist Rob Buckland has shown that shareholders have pressured companies to return money rather than investing in new projects — in 2014 global listed company capital expenditures fell 6%, while buybacks and dividends rose 15%.

There is also an argument that companies are playing defense and trying to protect existing profit pools in an innovation environment that is increasingly disruptive. Digital innovations in particular often provide products more conveniently and cheaply, but via substitution or the redistribution of sales rather than the creation of new incremental sales. A market can move from zero-sum to negative-sum for the disrupter and the disrupted. The poster child for disruption risk has been music, where 46% of the market shifted to digital between 2004 and 2014 while total industry revenues fell 35%. Productivity may have improved, but only for those that survived. There are other cases where disruption has become destruction - Blockbuster, which at its peak employed 60,000 employees, filed for bankruptcy just 3 years after Netflix launched its streaming service.

Building on the Technology at Work GPS report showing the scope of disruption is widening — posting a risk for labor substitution and rising inequality — the list of industries where we see disruptive innovations continues to grow: films (Netflix); TV (YouTube); newspapers; books (Kindle); encyclopedias (Wikipedia); yellow pages (Google search); digital marketing (programmatic advertising); telecommunications (Skype, WhatsApp, SDNs); retail (E-commerce); travel agencies (Expedia); hotels (Airbnb); taxis (Uber); cars (Lyft); electric vehicles (Tesla); recruitment (LinkedIn); technology (cloud, SAAS, virtualization, tablets); cameras (smartphones); manufacturing (robots, 3D Printing); energy (fracking, solar); utilities (energy storage); healthcare (generics, biosimilars, telemedicine); education (MOOCs); or finance (ETFs, Robo-Advisors, mobile payments, Bitcoin, peer-to-peer lending, crowdfunding). Many of these are covered in our Citi's Digital Disruptive Innovation series.

Conclusion

Digitization is helping lower the costs and increase the pace and scope of innovation. However, the changing nature of innovation may also be impacting profit pools, investment levels and productivity measures. In most markets, consumers are the ultimate beneficiaries of greater "Abundance", with better products, greater choice and lower costs. This has always been the case - economist William Nordhaus estimated just 3.7% of the social value of US innovations were kept by corporations between 1948 and 2001, with most of the remaining 96.3% going to consumers - but is even more true today.

For corporates and investors, the increased pace of innovation change creates both higher opportunities and increased risks. It makes agility or adaptability even more prized. Rather than defend the status quo, executives can be forced to make decisions and commit resources much more quickly. In some cases share can shift to winner-takes-all or winner-takes-most players. In many markets an ever faster velocity of change risks faster obsolescence, more confusion or just the need to run faster to stay in the same place. We hope the insights contained in this report from Citi's analysts around the world will help clients better navigate these risks and opportunities.

Case Study: Citi Mobile Challenge

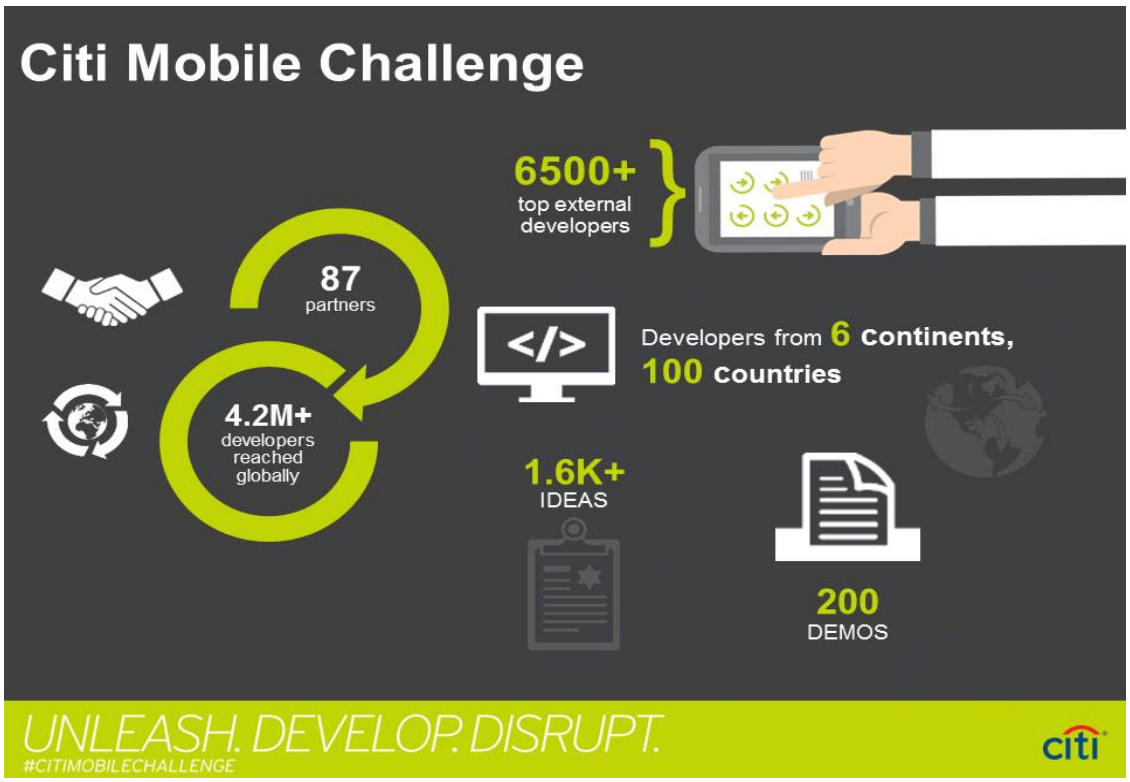
Jorge Ruiz
Global Digital Acceleration Head, Citi

Financial Technology (FinTech) is transforming the way individuals and institutions engage with money. From mobile payment to bitcoins and easy-split billing, 21st century clients expect a world of instant payments and service anytime, anywhere. For the financial industry, this means deepening its engagement with developers and connecting directly with new innovation hubs to integrate new solutions into its digital business all over the world.

The financial services industry is rapidly being pushed toward more digital engagement with clients. However, this is something that Citi, or any other bank, cannot do on its own because of the nature and pace of disruptive innovation across the industry and the world. For its part, Citi created a community to attract developers and other participants, who want to collaborate and add value to this new way of delivering financial services.

Setting out to radically change the way that the world banks, Citi launched the Citi Mobile Challenge. It is a virtual competition designed to accelerate the pace of digital banking innovation by bringing together the world's most talented and creative developers to create cutting-edge applications for Citi's Digital Banking platforms. True to Citi's global DNA, the event is virtual so teams may participate from all over the world. The challenge gathers solutions from a range of participants from established financial institutions to small startups and independent developers from across the globe. Once the Citi Mobile Challenge identifies and evaluates each entry, the top innovations from each finalist group are then incorporated into Citi's platform so it can better attract and engage clients. Citi's ultimate goal is to lead disruptive innovation for the FinTech industry.

Figure 5. Snapshot of the Citi Mobile Challenge



Source: Citi

The Role of Partners

As part of the Mobile Challenge, IBM was invited to collaborate with Citi to work with developers and offer mentoring tutorials as well as providing access to Bluemix — IBM's digital innovation platform. By using a platform of development tools, participants are better able to turn their creative ideas into bankable technology. The IBM Cloud Platform and industry application program interfaces (APIs) enable developers to quickly create mobile solutions for their personal banking clients offering them new services on their mobile devices like never before.

As more companies follow this to drive innovation, the Citi Mobile Challenge is just one example how a firm-wide API strategy can work. Together with our partners, we make APIs available publicly to enable developers to create mashup solutions across multiple corporate platforms, expand our digital assets, reduce product development cycles, introduce external new ideas and increase brand awareness.

As customer expectations change toward their experience with their money, so must banks. With this shift in mind, the Mobile Challenge has built a FinTech ecosystem through partnerships. Uber, Mastercard and IBM are but a few of the partners who have joined Citi on a journey to change the way the world banks.

These partnerships offer two unique advantages. First, shared technology allows FinTech developers to find solutions for the clients that are beyond their core interaction with the bank and instead focus on the way clients live and view their relationship with money. The radical disruption of the financial services industry or *Uberization* of the payment experience, is an example of the shift in client expectations. In many ways, the APIs we provide are like ingredients for a chef. By stocking our pantry with APIs from many open sources, we empower the Mobile Challenge development community to create the most innovative solutions they can. The second advantage reflects the *Uberization* trend by allowing us to create FinTech solutions in partnership other industries. Yesterday's FinTech focused on improving the efficiency and experience of our customers within bank call centers and branches. Tomorrow's FinTech recognizes that our clients – consumer and corporate and government alike – are looking to simplify their lives, not just their next trip to a bank branch or the next time they access the capital markets.

The Demo Days

The Challenge and the Demo Days offer a unique platform for the democratizing FinTech solutions. In exploring the FinTech community, we have found inspiring creativity from large companies and small. On stage at a Demo Day, disruptive solutions are crystalized into 8 short minutes and the best ideas – not the biggest companies – are crowned.

On July 23rd, Citi announced the launch of Citi Mobile Challenge in Asia Pacific, the next chapter of Citi's drive to foster digital and mobile innovation in banking. Selected participants will demonstrate their concepts at events in Bangalore, Hong Kong, Singapore, and Sydney. Citi is enthusiastic to be deepening the engagement with developers and connecting directly with innovation hubs in Asia Pacific to integrate new solutions into digital business in markets all over the world.

1. Autonomous Driving

Ushering in the Era of Driverless Cars & New Mobility

Itay Michaeli
US Auto & Auto Parts Analyst

The auto industry is experiencing several megatrends that will transform mobility as we know it. For the most part, the transformation will prove gradual in an industry characterized by capital intensity and long product cycles. But in some cases, particularly within connectivity and automation, the disruption could spread much faster. Much of what's happening can be boiled down to three major trends:

- **Over the next 5-10 years the vast majority of developed market vehicles will have automated features in some form**. It's critically important to understand that "automated" or "autonomous" cars don't necessarily have to mean *driverless* at first — the key distinction of course being whether the autonomous features require a driver to be present or not. The path will be dictated in steps that are already upon us. For instance, we're already seeing cars being deployed with semi-autonomous features like traffic jam assist and hands-free highway (or autopilot) driving. Around 2018 we should start seeing vehicles sport nearly full automation capabilities in country roads and cities, with the caveat being that the driver stays in the loop (i.e. like today's airplane pilots). The era of driverless cars is probably several years away (2020+) but the technical path to get there is forming rapidly. Disruption and change will occur at many levels. Even before contemplating driverless cars, automated driving and active safety (ADAS) will likely reduce road accidents thereby lowering insurance costs. As automation capabilities increase starting in 2018+, the car will gradually morph into something of a wearable mobile device — even safer and more productive. Once automated driving morphs into full driverless operation, an even greater disruption will ensue — dedicated robotic taxi services, personal driverless cars being loaned out to "taxi" networks, shared ownership, advanced carpooling, new services delivered to occupants and much more.

- **Over the next 10 years the economics of electric vehicles (EVs) will become competitive or even disruptive to internal combustion engines,** as battery costs likely decline to $100-150 per kWh sometime next decade. High capital intensity will dictate this shift to be more linear than automated driving, but this also has the effect of eventually reducing a car's operating costs meaningfully. The EV still has superior operating cost advantages to internal combustion; a cost of $0.02-0.03 mile vs. gas at $0.10-0.15. EVs will be a win for both personal & mobility service vehicles;

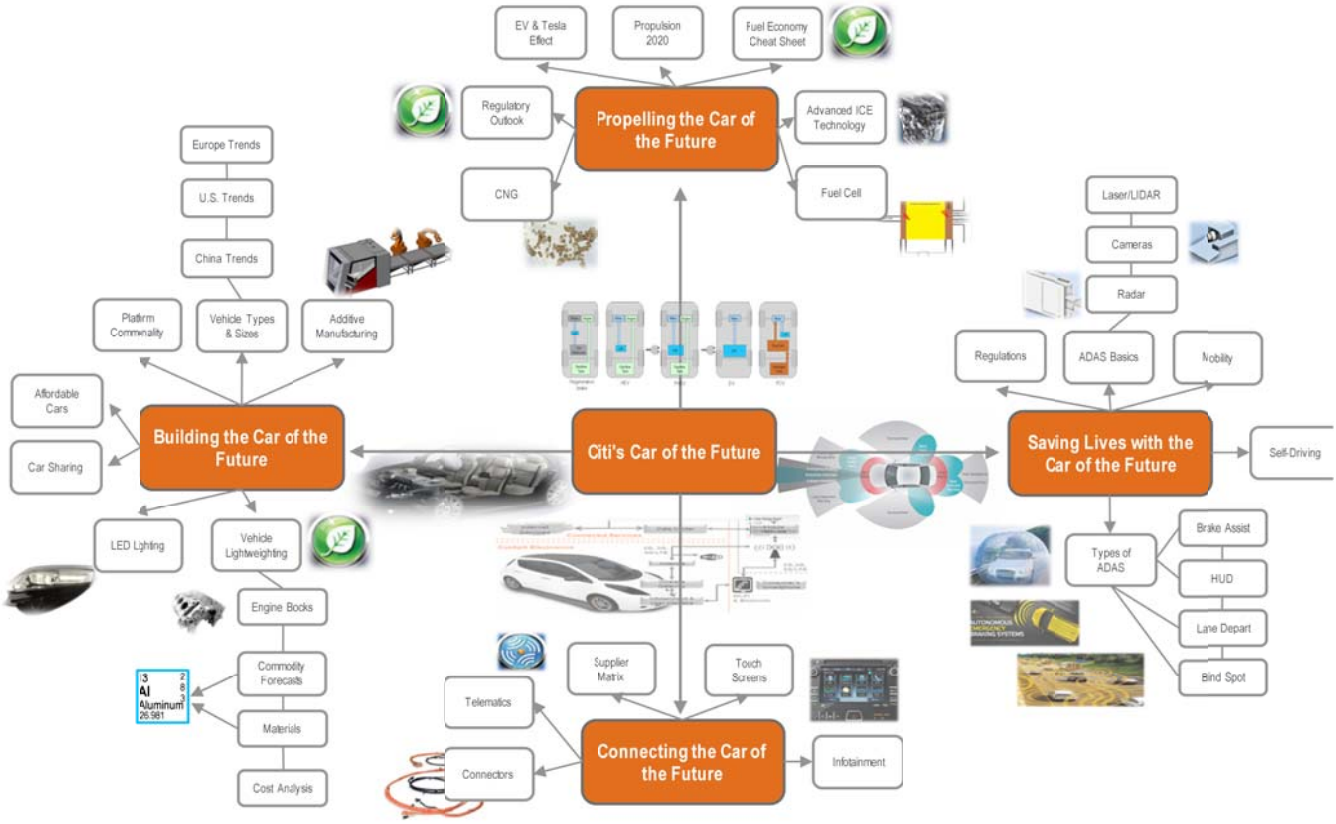
- **Connected cars will turn the automobile into the ultimate wearable mobility device.** Cars will remain fresh even as they age, will offer unprecedented personalization capability as well as tailored service offerings to their occupants. They will become their own sensors on the road by communicating critical information about their surroundings. For the consumer, autonomous connected cars will transform the car into a dynamic office, a living room or both. For automakers these cars will yield opportunities from selling new services, reducing warranty costs and improving residual values. New players will enter the field offering dedicated mobility fleets. The economics of a car will shift from exchanging dollars mostly at point-of-sale to extracting value throughout the car's life, i.e. pay-per-mile services, autonomous driving features sold as subscriptions, personalized advertising as you drive (via augmented reality on the windshield) and data collection.

Figure 6. Leaps of Car Automation

2015-2017	**ADAS + Semi-Autonomous** Adaptive Cruise, Traffic Jam Asst Basic Highway Piloting
2018-2020+	**Advanced Autonomous** Advanced (lane change, cities) Driver Present & Responsible
2020-2030+	**Driverless Era Begins** Robotic Taxis & Personal Cars Capable of Driverless Operation

Source: Citi Research

Figure 7. Car of the Future Schematic



Source: Citi Research

Ushering in the Era of Driverless Cars & Service Mobility

The automated driving era will bring about change and disruption at every level. But clearly the biggest step-function change occurs once we enter the driverless car era. While we may be 5+ years away from truly entering this era, we believe the competitive field will become clearer in the coming 2-3 years as partnerships are formed.

The rise of mobility services will change household vehicle ownership in the future

Mobility services such as Uber and Lyft are growing rapidly and changing certain industry norms by providing simpler and less expensive access to miles. These services are already solving two issues in today's market — serving underserved markets and providing last-mile mobility in cases where owning another car isn't practical. This is yet another megatrend that's just beginning to unfold. While it does not appear that these services are yet shifting consumers away from personal car ownership, they are quickly conditioning consumers to accept the notion of mobility-as-a-service. This will become very important in the coming 5-10 years as we gradually enter the driverless car era. Additional these services are coming at the right time for many consumers – our survey work has long shown 34-45yr old households are highly reluctant to add a second car and this anxiety can be eased by mobility services. The benefits? Easier access to miles for almost everyone, an alternative option for this reluctant to add a second or third car and eliminating grossly underutilized second or third household cars.

Two new forms of driverless cars are likely to emerge: a personally-owned autonomous vehicle and a "robotic taxi" that's owned/managed by a fleet operator

When the era of driverless cars begins in 2020+, we envision two "new forms" of vehicles emerging: (1) a retailed personally-owned autonomous vehicle that's fully capable of driverless operation on–demand (PERSO-AV). As an owner you'll be able to enjoy driving when you want, let the car drive itself when you want and lend the car out to a taxi fleet network in exchange for a fee or even a government incentive. Here too, shared ownership models can flourish — match users based on compatible schedules to see who might be ideal to "split" the purchase of the car; (2) a dedicated mobility car acting as a "robotic taxi" that's owned/managed by a fleet operator (i.e. Uber or Lyft) or the auto manufacturers themselves (FLEET-AV). The split between the two variants will likely be purely demand driven; it's all about how much consumers value personal ownership. Our surveys have and will continue to track consumers' preferences around personal vs. service mobility. However, initially we'd expect FLEET-AVs to lead the way as fleets build their user base and brands to compete. Once FLEET-AV networks are established they could tart borrowing PERSO-AVs from consumers in exchange for a fee or other incentive. This would also de-risk fleets from over-stocking FLEET-AVs in a given market. Both forms of vehicles will be connected and capable of generating revenue streams throughout their useful lives. The first few years of the driverless era might be a soft opening of sorts with test fleets running in select cities. Our base case assumes the driverless market soft opens in 2020-2022 but then ramps up fairly quickly for 2022-2030.

The economics of driverless cars is positive with lower costs in high-density cities and increased efficiency and fuel savings through supply/demand match-ups

The driverless economy should lead to compelling economics, particularly in high dense cities/surroundings where dedicated taxi fleets can be utilized 70%+ in an intelligent manner with multiple occupants. We estimate that, in highly dense cities, driverless taxi services could charge $0.30-$0.55 per mile and still earn 30-50% gross margins, not including any revenue from data collection, advertising and other goods/services (i.e. turning the car into an ecosystem). That would compare to a personal car costing consumers $0.76 per mile in the 2020-2025 time frame. It would also compare favorably to certain modes of public transportation and tradition al taxis. Our rough estimate is that the driverless taxi industry could become a $100 billion plus industry with only a modest penetration of the US by 2030. A connected fleet would allow for fewer cars in operation thereby reducing congestion and pollution. Eventually it could allow for an extremely efficient supply & demand of personal transportation – no more traffic lights, traffic tickets, etc. New services will come about – delivery services that max out not only people capacity but cargo as well. Overnight trips in sleeping cars, cars designed specifically for business meetings, etc. Better matching supply/demand might also yield fuel savings; for example smaller/larger cars could be dispatched specifically for the amount of people requesting a trip – no more wasting a large SUV on a 1 or 2 person pick-up.

Some Key Debates Surrounding the 2030 Industry View

There are a few key debates around the magnitude of disruption posed by driverless cars, at least over the next 5-15 years: (1) how quickly and with what force will consumers abandon personal mobility for service mobility?; and (2) to what extent might driverless cars increase miles driven?

So far, consumers aren't altering their future vehicle plans

How quickly consumers shift from personal to service mobility is clearly the most important question when evaluating future disruption for the traditional automotive industry. The question delves deep into a topic that's very dear to us — household vehicle density, i.e. cars per household. Over the past 5 years we've spent time studying US vehicle density trends using our proprietary Vehicle Density surveys, which ask consumers about future vehicle plans.

At least so far, our surveys have not revealed signs of consumers altering future (2yr) personal mobility plans purely on the basis of new mobility services. This shouldn't be a controversial observation as our survey work appears consistent with recent data shared by Uber which noted that 75% of its Chicago trips were one-way rides, meaning there was another mode of transportation that existed for the user. Additionally 40% of Chicago trips were in previously underserved areas of the city, again suggesting an increase in absolute miles consumption as opposed to a share gain versus personally owned cars.

Driverless cars can raise the amount of miles driven

The car business is ultimately about selling mobility (miles) and a user experience. Driverless cars can raise both the addressable market and transportation share versus other modes of transportation. Of the ~316 million people in the US, ~251 million are of driving age with ~212 million having driver's licenses. That suggests there are ~39 million people of driving age who might not be driving as many miles as they'd like either because of age, disability, location or other factors. So if 40% of this 39 million began driving just 2,000 miles each year, US auto demand would stand to benefit by 0.2 million units, in rough terms.

Strategic Implications to Traditional Automakers

The three major tends described at the beginning of this chapter suggest both good and bad news for traditional global automakers. The good news is that over the next 10-15 years the car business stands to become more profitable (per unit) — new connected car revenues, self-funding ADAS/automated cars, lower EV costs etc. The shift from hardware to software should in theory improve returns. The bad news is that the shift from hardware to software will also reduce historically high barriers to entry.

Our base scenario for 2030 doesn't seem to pose an imminent threat for traditional automakers but it's not a rosy outlook either

Based on our 2030 auto disruption model, we forecast: (1) the US seasonally adjusted annual rate (SAAR) for vehicles stays in the high-15 million unit range by 2030; (2) 17 million vehicles are shed from the road by 2030, net of population growth; (3) the driverless car market exceeds $100 billion; and (4) 2 million driverless fleet vehicles will be replaced every 4 years. Our base 2030 scenario does not seem to pose an imminent financial threat for traditional automakers, but it also isn't a rosy outlook either—arguably a moderately lower SAAR and strong, but flattish, North America earnings power. To pick up on an earlier point—not "losing" in 2030 isn't enough. So what should automakers do?

- **Act quickly to partner**. The next few years will likely see key strategic partnerships established, but there might not be enough room for everyone. Because the driverless car industry requires fewer units to serve a given population, a game of musical chairs could ensue where some automakers get involved and others do not, at least at the onset. Consolidation amongst automakers is one way to approach this but our sense is that investors will reward the most points to those automakers who strategically partner to actually participate in the driverless car era. We believe the first few automakers to truly partner with the likes of Uber/Lyft and other emerging players will secure a role in this growing market.

- **Make the math work (because it can):** The profits don't necessarily go away; they merely shift into a different model. Automakers have a large seat at the table as expert manufacturers who also have access to large dealer networks — mass producing quality vehicles and then servicing them is a venture many outside of automotive would probably like to avoid. As driverless networks compete to build scale quickly, getting PERSO-AVs on the road might be faster than a designed-from-scratch FLEE-AV, and in some regions the PERSO-AV probably makes more sense anyway. Replacing 100,000 cars making a $6,000 in variable profits with 75,000 PERSO-AVs earning $12,000 (from higher content) is a net gain. And even FLEET-AVs could be net profit additive versus today's rental car fleet channels, as they would also compete on design and content.

- **Explore Shared-Lux models**: There is little question that driverless cars will likely result in net density declines. However, in some cases there could be partial increases or high-margin offsets. Luxury presence has always been important for automakers, but over the next 5-15 years it could become vital. Let's say I own 2 cars; one is a well-contented crossover and the second a less utilized compact commuter car. Sometime in 2020-2030 I abandon my 2nd car because I now rely on mobility services (Uber/Lyft etc.) for commuting and other trips. The automaker I purchase that 2nd car from just lost $4-6k of variable profit. But I like cars. Nice cars, fast cars. I don't always need them of course—a few long road trips a year, some nights on the town, trips to the beach etc. There are others like me out there. Services could emerge that pair others like me who happen to have compatible schedules for joint car ownership/leasing. Once paired, we split ownership & usage of a luxury driverless car. After one party uses it, the car drives itself to a local dealer who inspects & cleans it before dispatching it to the other owner. For essentially the same money I spent before, I now have access to a dream car that I can call mine precisely when I want it. The luxury car sells with double or more the variable profit of that 2nd car I gave up, so the automaker gains from the transition. I still enjoy immediate mobility freedom from my owned car, have my other day-to-day mobility needs served by the FLEET-AVs and for fun a jointly owned luxury car for those specific use cases.

- **Rethink long-term demand:** The real or perceived threat to automakers from driverless cars might prove something of a blessing in disguise. Historically, chronic global overcapacity has been the biggest problem with the automaker business model. The reasons this story repeats itself is because automakers plan their capacity years in advance and often rely on over-extrapolated demand and/or market share assumptions. If the global automotive industry starts rethinking long-term demand from the lens of a driverless car, it might just be the medicine needed to become capacity disciplined. Of course this is also where the consolidation discussion rolls in. Not every automaker can be a winner in driverless cars and related business models. Investors might welcome an eventual M&A wave, but in the shorter-term what's likely to be viewed as more important is how and whether automaker XYZ is partnering and participating in the driverless car services market.

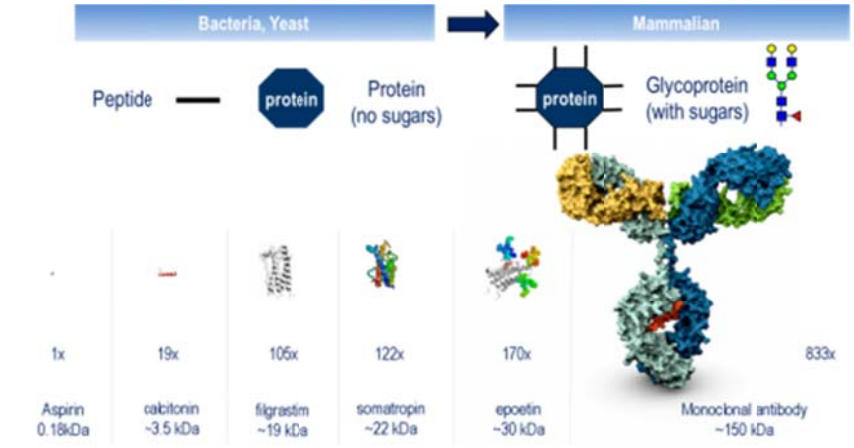
2. Biosimilars

Real, Dangerous and Coming Soon

Andrew Baum, MD
Global Head of Healthcare Research

Up until 15 years ago, pharmaceutical sales were dominated by small molecule drugs, such as aspirin and Viagra, which were synthesized through organic chemistry. However, over the past 10 years, most of the mega-blockbuster drugs have been biologics. These types of drugs, such as monoclonal antibodies, cannot be synthesized through chemistry and instead require genetic engineering. In the manufacturing process, DNA coding for a given protein is inserted into an "expression system" such as a yeast, bacterial or mammalian cell and the desired protein is "expressed" and collected.

Figure 8. Monoclonal Antibodies Are Many Orders of Magnitude More Complex than Simpler Molecules



Source: Citi Research, Company data

Generic competition for biologics introduced in 2009 allows biosimilars into the market

The Hatch-Waxman Act, enacted in 1984, permitted generic versions of small molecules to come to market after the expiration of the patent estate and a pre-defined period of market exclusivity, without the need to demonstrate clinical equivalence, significantly curtailing both the cost and speed of generics development. As a consequence in the US, revenues for an originator small molecule typically fall by 90%+ after as little as six weeks following the launch of generic competition. Until the enactment of the Biologics Price Competition and Innovation Act (BPCIA) and the approval of the 351 (k) pathway in 2009 by the US Food & Drug Administration (FDA), there was no similar pathway for biologic products. The proliferation of novel biologics coupled with premium pricing means that biologics now account for almost 30% of drug spend and that proportion is rising rapidly, aided by the patent expiration of many small molecules.

Six years post BPCIA enactment, why is this an investor concern/ opportunity now? Investor focus on biosimilars has dissipated due to sequential delays caused by regulatory, political and scientific challenges. Our focus on biosimilars is driven by (1) the 2015 US FDA Oncologic Drugs Advisory Committee (DAC) approval of Zarzio, the first 351(k) submission allowing data extrapolation; (2) the enactment of the America Invents Act (AIA) in 2011 allowing biosimilar sponsors and Pharmacy Benefit Managers (PBMs) to potentially rapidly invalidate patents through Inter Partes Review (IPR) and Post Grant Review (PGR); and (3) evidence of increasingly effective pharmacy payer pressure in the US, intensified by the introduction of immunotherapies costing over $150,000/patient per year and

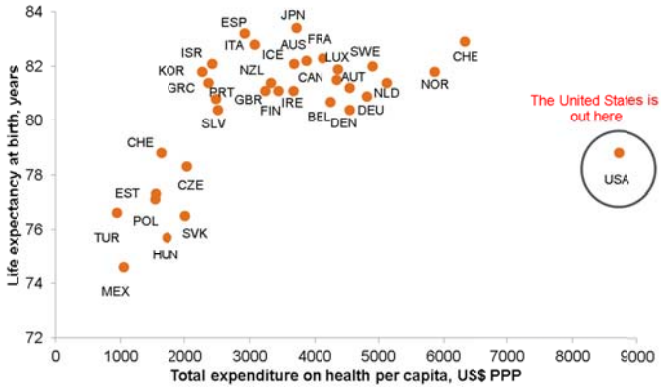
expensive hepatitis C (HCV) cure regimens. Given that biologics account for 30% of total US drug spend and rising, the emergence and utilization of this new generic pathway opens a significant commercial opportunity for biosimilar sponsors and a material risk for biologic innovators.

Biosimilars could provide a 50% savings for global healthcare systems.

We believe that the market materially underestimates the magnitude and the timing of the impact on exposed innovator companies as well as the commercial opportunity for the biosimilar sponsors. We estimate that despite the multiple defensive tactics, innovators will likely lose an aggregate of over $360 billion in revenues over the next ten years, with around $110 billion captured by biosimilar sponsors and the residual helping to alleviate the high and growing cost pressures for both patients and payers associated with the introduction of premium-priced specialty drugs, most notably immunotherapy.

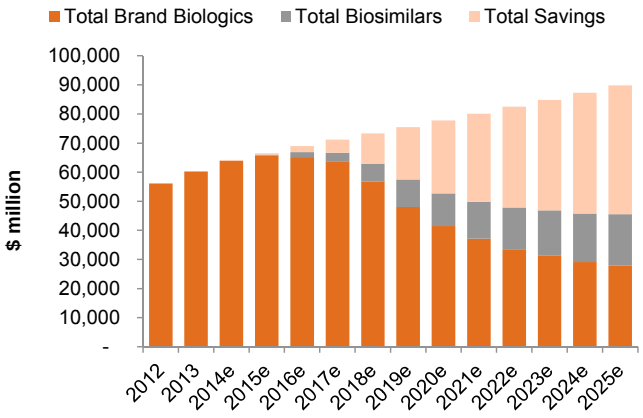
Biosimilar commercial success is an important and necessary "safety valve" in allowing US and EU healthcare budgets to continue to reimburse premium priced highly innovative therapies, such as cancer immunotherapies, in the wake of an aging population. Even as the costs of cancer immunotherapy are only just beginning, many patients in the Western world today are unable to afford or have access to novel biologic therapies leading to excess bankruptcies among cancer patients in the US and 50% under-treatment of severe rheumatoid arthritis patients in EU. Potential commercial failure of biosimilars would likely, ultimately, precipitate a far more punitive reimbursement/access system for innovators in the future. Biosimilars are, we argue, a very necessary "evil" for the industry.

Figure 9. US Healthcare Spend Appears Unsustainable Given Macro-Economic Pressures



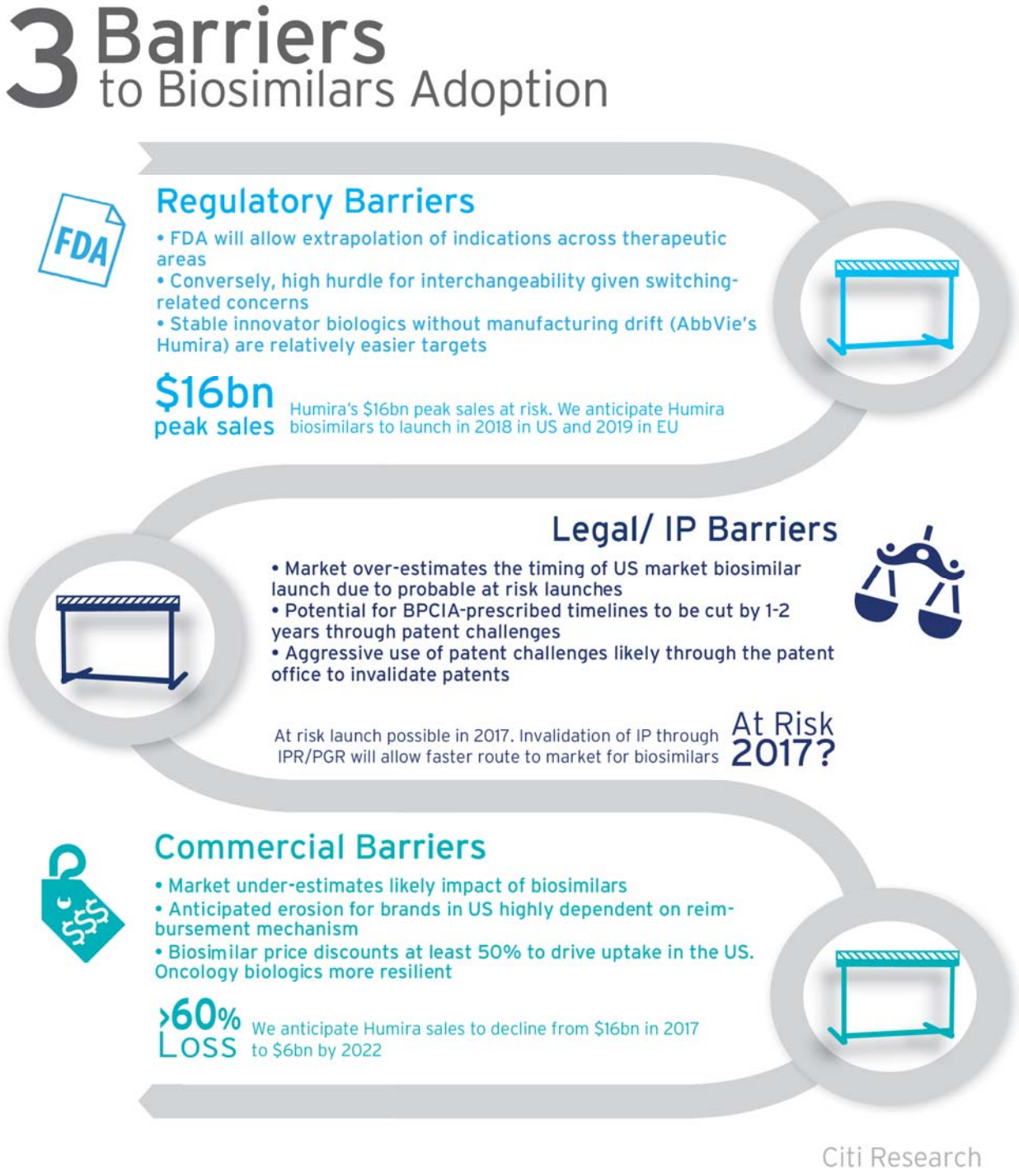
Source: OECD, Citi Research

Figure 10. Biosimilars Will Likely Create ~50% Biologic Savings for Western Healthcare Budgets by 2025E



Note: Savings calculated from assumed global sales of Top 10 biologics in the absence of pricing and share losses from biosimilar introduction.
Source: Citi Research

Figure 11. Barriers to Biosimilars Adoption



Source: Citi Research

Three Barriers to Biosimilars Adoption

1. Regulatory

Consensus underestimates the magnitude of value transfer from biosimilars within the US. Extrapolation and interchangeability are high probability events in the mid-term.

In our view, the market underestimates the willingness of the FDA to approve competitive biosimilar entrants using extrapolation and interchangeability. We anticipate Sandoz's Zarzio launch (a biosimilar of Amgen's Neupogen) will be the first successful approval for a biosimilar in the US under the 351(k) pathway later in 2015. We anticipate this to be followed by approval of Hospira/Celltrion's Remsima (a biosimilar of JNJ's Remicade) in 2015 and Epoetin Retacrit (Amgen's EPO) and Amgen's adalimumab (AbbVie's Humira) in 2016. The recent highly positive FDA approval and commentary for Sandoz's Zarzio was noteworthy for (1) willingness of the FDA to accept EU data and bridging trials; and (2) support for extrapolation of data to broaden indications.

2. Legal/Intellectual Property

Market overestimating US biosimilar launch times. We expect *at risk* launches enabled by ample balance sheets of multinationals.

We believe the market over-estimates the timing of a US market biosimilar launch due to probable *at risk*[9] launches. The risk/reward is clearly favorable for hybrid multinational biosimilar sponsors (i.e., Novartis or Amgen for instance) to launch *at risk,* even prior to the completion of the BPCIA mandated patent exchange procedures. Whilst this carries the risk of triple (punitive) damages, these sums are seldom paid even when infringement is demonstrated. Multinational hybrid biosimilar sponsors have ample balance sheet capacity to absorb the potential risk given the importance of first mover advantage and lack of any 6 month exclusivity period (as with Hatch-Waxman small molecule pathway). Even for the largest biosimilar opportunities such as Humira, the triple damages payment, assuming Sandoz or Amgen launched their biosimilar *at risk*, is likely no more than about $4 billion assuming the district court ruling goes against the biosimilar sponsor in 2018, allowing at least 12 months biosimilar revenues (or about $2 billion). The incentive for biosimilar launches increases further if a biosimilar is deemed interchangeable[10] given the 12 month+ exclusivity period outlined under the BPCIA.

Aggressive patent challenges through the patent office are likely. Separately, we anticipate PBMs, biosimilar and even financial sponsors (such as Hayman Capital) will begin to aggressively request Inter Partes Review and Post Grant Review at the US PTAB (Patent Trial and Appeal Board) to invalidate patents prior to a 351(k) biosimilar filing. PTAB activity not only increases the benefit/risk trade-off while contemplating an *at risk* launch, but also enable biosimilar sponsors to reach favorable legal settlements, where appropriate. Paradoxically, we suspect that aggressive PBMs may actually prove a more active applicant for IPR than individual biosimilar sponsors given estoppel related issues.

[9] "At-risk" generic launches refer to generic pharmaceuticals that are approved by the FDA based on the review of an abbreviated new drug application (ANDA) and are subsequently launched while patent litigation is ongoing. Launching these generics is risky because they can be pulled from the market if courts determine that patents protecting a branded references product are violated or infringed, thus allowing the brand company to seek triple monetary damages.

[10] A biosimilar can be substituted for its reference originator (branded) product at the pharmacy level without the involvement of the healthcare provider who wrote the initial prescription (as is the case or today's generic drugs).

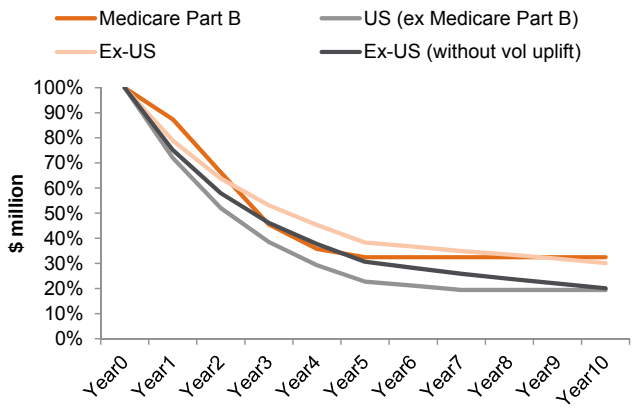
3) Commercial

We anticipate almost 70% revenue erosion for non-oncology brands 5 years post launch, a little slower rate for oncology biologics predominately reimbursed under Medicare Part B

Commercial barriers are the main challenge for biosimilars. The market underestimates the likely impact of biosimilar commercialization. Individual innovator biologics will be subject to differential rates of erosion subject to competitive density and most importantly, predominant reimbursement mechanism (whether they are broadly PBM controlled or non-Medicare Part B vs Medicare Part B vs EU). Oncology originator products will invariably lose market share slower given the improbability of switching. We anticipate US sales of in market US biologics declining >60% between 2017 and 2025 although bio-betters (an improved, but not identical drug in the same class as the existing biopharmaceutical) and re-formulations, negotiated settlements and authorized biosimilars could mitigate the erosion rate for select agents.

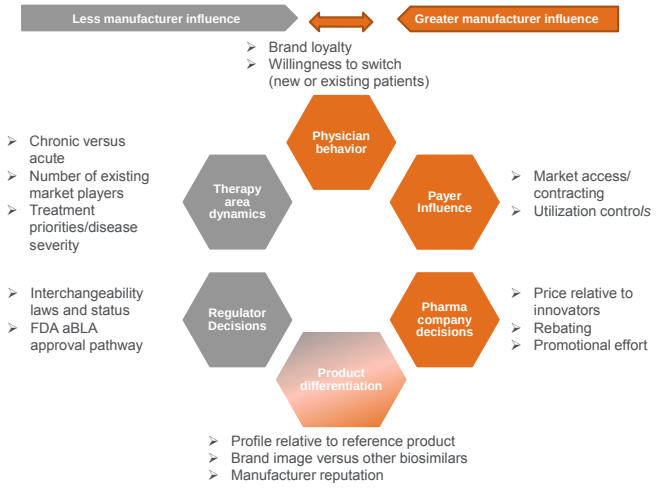
The market underestimates the required magnitude of biosimilar discounts to drive uptake. The analysis, economics and modelling for biosimilar pricing and adoption by segment is complex but critical in gauging the potential impact of bisoimilars in the market. We anticipate biosimilars for drugs covered outside Medicare Part B will need to offer net prices of at least 50% discounts to the brand list price (30% discount to brand net price, assuming 20% brand rebates) in order to offset the rebating power of the innovator product. The anticipated erosion trajectory for innovators in the US market is highly dependent on the dominant route of reimbursement: (1) 'Buy and Bill' Medical Benefit (as with Part B coverage); and (2) Pharmacy Formulary Benefit (as with Part C, D and Commercial Plans). Our anticipated volume and pricing decay assumptions within these three crude channels are shown in 4, although we have overlaid our assumptions with drug specific factors given potential impact of innovator line extensions, formulation changes, biosimilar competitive intensity etc.

Figure 12. Steep Innovator Sales Erosion Likely Driven by Market Share Losses Coupled with Sharp Net Price Erosions. 70% Sales Erosion for Non-Oncology Biologics Within 5 Years.



Source: Citi Research

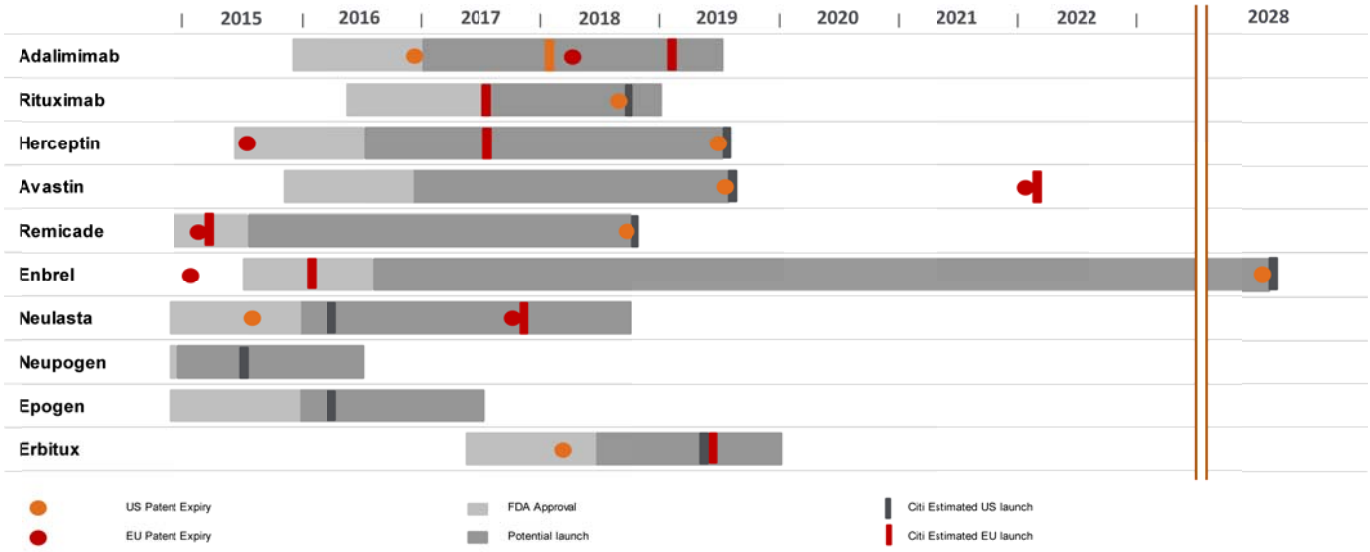
Figure 13. Pharma Companies Influence Biosimilar Performance



Source: Citi Research, ZS Associates

EU likely characterized by heavy innovator price erosion only partly offset by unit growth. Within the EU, there is the potential for an almost 30% volume uplift from increased access to lower price biologics. However, we believe this will be overwhelmed by draconian erosion of innovator biosimilar reimbursement given economic pressures and established reference pricing. We anticipate aggregate EU revenue from key biologics declining from $222 billion to $136 billion over the next 10 years with biosimilars capturing $30 billion, with the residual representing government savings. The analysis, economics and modelling for biosimilar pricing and adoption by segment is complex but critical in gauging the potential impact of biosimilars in the market.

Figure 14. Intellectual Property and BPCIA Uncertainty Leaves Significant Scope for Earlier At Risk Launches Compared to Our Estimates



Source: Citi Research, Company data, USPTO

3. Commercial & Personal Drones

At the Tipping Point

Jeremy David, CFA
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Although the first computers were born out of the military during World War II, it took until the early 1960s before IBM's mainframe computers found their first commercial uses. In the mid to late 1970s, Apple, Atari, Commodore and others started designing and assembling personal computers (PCs) as components became more broadly available. Despite the slow uptake, computers today have infiltrated almost every aspect of daily life.

Drones are likely to be on a similar flight path as computers, though their broad-based adoption is likely to spread much faster. While drones have been known primarily for their use in the US military over the past decade, their commercial adoption is rising outside the US and we believe the market for consumer/personal drones (PDs) is ripe for take-off. The availability of low-cost components (i.e. processors and sensors), many of which were developed for the smartphone market from processors to sensors, and a budding community of drone enthusiasts (to wit, Parrot's AR.Drone Academy has nearly 600,000 registered users, and a recent Kickstarter search for "drones" returned 247 projects) have been key drivers in making personal drones (PDs) a reality.

There are many terms used to describe drones, depending on their applications and the stakeholders involved:

- **Unmanned Aerial Vehicles (UAVs)** is universally synonymous with drones;
- **Unmanned Aircraft Systems (UASs)** is Federal Aviation Administration (FAA) lingo for drones;
- **Remotely Piloted Aircraft (RPA)** is commonly used in the U.S. military to refer to drones;
- **Quadcopter** is a term commonly used in consumer electronics to describe a type of drone that has four electric motors and four rotor blades. The quadcopter design has become popular in consumer electronics due to its mechanical simplicity, despite its relative instability and inefficiency. The DJI Phantom 3, the 3D Robotics Solo and the Rolling Spider from Parrot are all quadcopters. Commercial drones needing to lift loads of several pounds are more likely to be hexacopters (six motors powering six blades) or octocopters (eight motors powering eight blades).

Figure 15. FOX-C8-HD AltiGator OnyxStar

Source: By Zully C3P (via Wikimedia Commons).

Figure 16. Quadcopter (Parrot AR.Drone 2.0)

Source: By Halftermeyer (via Wikimedia Commons)

A $5-$10 Billion Market by 2020, Led by Personal Drones

Uptake of personal drones is likely to outpace commercial drones in the short term

Unlike computers, we believe consumers will embrace personal drones for things like photos and videos before commercial drones become common. Consumer interest for drones is already high, evidenced by the YouTube video for the upcoming launch of Lily, "a flying camera". Since it was posted in May 2015, it has "gone viral", receiving over 7 million views, a strong showing versus GoPro's 18 million views for its launch video of the HERO3+ Black in 2013 and 24 million views for its launch video of the HERO4 in 2014. We believe 10 million personal drones used as flying cameras are likely to be shipped in 2020, at price points ranging from $500-$1,000, many with built-in cameras (especially at the high-end of the price range), equating to a $5-$10 billion market segment five years from now. To arrive at these estimates, we start with the 24 million US households who own a DSLR camera — a likely indicator that they are photo enthusiasts — and we assume that one-third of them will have a flying camera five years from now (arguably, a flying camera may not work for everyone — e.g. photo and video enthusiasts residing in Manhattan), or ~8 million. We then consider the 10 million action sports enthusiasts in the US and assume that 40% of them will have a flying camera five years from now, or ~4 million. These two segments bring the 2020 US installed base of flying cameras to 12 million. We then assume a replacement cycle of ~3 years, leading to a 4 million unit category in annual shipments in the US alone. Assuming the flying camera market is split like the camcorder and action camera market is today (40% of worldwide sales to the US, 60% outside the US) we get to a 10 million unit category by 2020.

We forecast a TAM for the personal drone/flying camera market of $5-$10 billion

To put our estimate of a $5-$10 billion personal drone/ flying camera market in perspective, consider that the DSLR market peaked at $12 billion in 2012, while the camcorder market peaked at $11 billion in 2006 (according to IDC).

Figure 17. Photo and Video Enthusiasts are Likely to be Early Adopters of Personal Drones

Source: HEXO+

Figure 18. Personal Drones/Flying Cameras: Total Addressable Market

Target Segments:	
US Households With DSLR (M)	24
US Action Sports Enthusiasts (M)	10
LT Penetration of Flying Cameras:	
% of DSLR Households	33%
% of Action Sports Enthusiasts	40%
Installed Base of Flying Cameras in the US:	
US Households With DSLR (M)	8
(+) US Action Sports Enthusiasts (M)	4
(=) Owners of Flying Cameras in the US (M)	12
(/) Replacement Cycle (Years)	3
(=) Annual US Shipments of Flying Cameras (M)	4
(/) US Shipments as % of Total for Camcorders (201	40%
(=) WW Shipments of Flying Cameras (M)	**10**

Source: IDC, Citi Research

Although commercial drones have many applications, small package delivery is likely to be the largest

Commercial drones will take-off in a few years once friendlier legislation is enacted in the U.S. Use cases for commercial drones are numerous and include monitoring of construction sites and infrastructure assets such as power plants; crop spraying; film and television; as well as package delivery (especially for first and last mile logistics and for rural deliveries of high value, time sensitive shipments). Amazon Prime Air, Google's Project Wing and the DHL Paketkopter illustrate the potential role drones could fill in package delivery over the next few years.

To build a forecast for the total addressable market for drone deliveries of small packages in the US we focus on the potential of launching drones from fixed locations, but also include the potential for drones to be paired with delivery trucks to launch from mobile locations along more suburban or rural routes, which are further from sortation centers. Domestically, we estimate the potential market size for drone delivery to be over 782 million small packages annually or ~15% of the current ground small package market. To arrive at our estimate, we start with the domestic ground market size of 5.21 billion packages in 2014. We then reduce the market by smaller packages which would be both small enough and light enough to be carried by drone; we estimate this to be ~25% of the total ground market, which is roughly in line with UPS's small sort mix. Finally, we assume that drone deliveries are not suitable for urban centers, which lack individual landing/drop locations (such as front yards or driveways). This assumption reduces the market further to ~60% of the small sort volume.

Our TAM forecast for drone deliveries of small packages in the US is $100 million

Assuming each package delivery drone made 12 deliveries per day for 313 days per year, a fleet of ~200,000 drones would be required to deliver our forecasted 782 million packages annually in the US. Furthermore, assuming a 4 year lifecycle and a $2,000 price tag for a package delivery drone leads us to a $100 million package delivery drone total addressable market (TAM) – a relatively small number. However, this number could become much larger if new business models oriented around drone delivery could emerge, leading to incremental deliveries not fulfilled by companies like UPS today.

Collectively, commercial applications could add a few billion dollars to the Personal Drone TAM of $5-$10 billion by 2020. Note that we exclude military drones (a $6B market in 2014 according to Teal Group) from our estimates.

Figure 19. Commercial Drones TAM (US Package Delivery Only)

Estimated U.S. Ground Package Market in 2014 (millions)	5,210
(x) Percentage of the Small-Sort Packages	25%
(=) Estimated U.S. Small Package Market (millions)	1,303
(x) Percentage of U.S. Population That Drones Can Deliver To	60%
(=) TAM for Drone Delivery (millions of packages)	782
(/) Number of Packages Delivered by a Drone in a Day	12
(/) Number of Days in a Year With Drone Deliveries	313
(=) Required Drone Fleet in the U.S. (millions of units)	0.21
(/) Replacement Cycle of Package Delivery Drones (years)	4
(=) TAM for Package Delivery Drones (millions of units)	0.05
(x) ASP of a Package Delivery Drone	$2,000
(=) TAM for Package Delivery Drones ($B), U.S. Only	**$0.1B**

Source: Citi Research

Venture Funding for Drones is on the Rise

According to CB Insights, there are at least 10 drone companies with $10 million+ in Venture Capital (VC) funding each as of May 2015. These 10 companies – which include 3D Robotics (personal drones), DJI (personal drones), Airware (software and cloud-based solutions for commercial operations of drone fleets) and Skycatch (on demand data capture solutions) – have raised over $300 million. Similar to what we have seen with smartphones and what we are now seeing with wearables, the race is on to develop drone "platforms." Both DJI and 3D Robotics have launched software development kits for third party developers to create new applications for their drones including features such as "follow-me" and preprogrammed flight paths.

Barriers to Adoption – Regulation and Automation – Likely Fade In the Next 2-3 Years

We believe there are two main barriers to adoption: the current regulatory environment and the complexity inherent in flying drones.

Regulations aren't moving as quickly as drone technology which can hinder mass adoption

Not surprisingly, drone technology is moving much faster than regulation. While the FAA Modernization and Reform Act of 2012 allows the use of "model aircrafts" for recreational uses within certain statutory parameters (e.g., fly below 400 feet, keep the aircraft within visual line of sight at all times, don't fly within 5 miles of an airport or near people and stadiums), the lack of a regulatory framework has hindered the potential use of commercial drones in the US. However, recent developments are encouraging:

- Earlier this year, the FAA published a Notice of Proposed Rulemaking to allow the operation of small Unmanned Aircraft Systems in the National Airspace System. A final ruling is due by September 2015 but could be delayed to 2016 or 2017;
- The FAA granted 788 commercial exemptions so far in 2015 vs. a mere 9 in 2014, enabling 797 commercial drone operations by companies including SunPower, Amazon and BNSF Railway (under the current regulatory framework, commercial drone operators require a FAA authorization via the "Section 333" exemption process).

A few countries have been early to regulate commercial drone activities, leapfrogging the US. For example, since April 2012 France, which has over 1,600 registered drone operators as of early 2015, has allowed drone operators to fly their drones beyond visual lines of sight.

Increased automation in drones should help to drive both personal and commercial use

Besides regulation, greater automation is likely to boost both personal and commercial uses. Indeed, flying a drone is not straightforward yet, and is potentially a barrier to mass market adoption. The availability of smart, self-aware drones which do not require a radio controller and which can automatically adjust their flight path and avoid obstacles would boost the adoption of personal drones and enable new drone-based solutions that can be more easily sold to enterprises for future commercial uses. Start-ups HEXO+, AirDog and Lily are developing drones that automatically follow their users and at the 2015 International Consumer Electronics Show, Intel CEO Brian Krzanich demonstrated autonomous drones using Intel's RealSense 3D depth-sensing technology. Furthermore, we believe innovations developed by Google and automakers to make cars autonomous are likely to apply to drones to a large extent.

Digital Imaging Companies Are Potentially Disrupted by Personal Drones

Traditional DSLR/action cam manufacturers could be disrupted by drones with integrated imaging technology

While drone enthusiasts have over the past few years attached their own digital single lens reflex (DSLR) or action cameras to their drones, the resulting drone experience is sub-par as the controls of the DSLR/ action cam and of the drone remain separate. The separate controls also result in a suboptimal system with simple things like an action cam with a 2 hour battery life not being necessary if the drone can only fly for 20 minutes. Drone OEMs are addressing this issue by developing their own imaging technology and integrating it into their drones, a potential disruptive move for digital imaging companies which may not only get shut out of a segment of their market but now have to compete for consumer dollars with a new technology and new OEMs. To wit, we believe GoPro is planning to launch a drone in 2016 because photo and video enthusiasts – who put GoPro on the map along with action sports enthusiasts 4-5 years ago – are flocking to drones.

Connector Manufacturers Are Likely to Benefit from the Broad Adoption of Drones

Given the large amount of connectors and sensors in drones, both industries should benefit from mass adoption of drones for both commercial and personal use

The availability of low cost, high quality and light weight connectors and sensors is one of the major factors behind the availability of low cost drones. Connectors are used in multiple parts of a drone, including the compass, GPS receivers, the camera, the motors and the flight controller to transmit signals within the device as well as to the remote controller. For example, drones typically have a motor for each propeller and the motor is connected by connectors to a circuit board via wires for power and control signals. A drone normally has two main circuit boards (one for processing and communication, and one for motion control) vs. only one for a wearable device like Google Glass, so we expect the connector content in a drone to be 2x the connector content in Google Glass (~2% of the drone BOM vs. ~1% of the Google Glass BOM). Assuming the bill of materials (BOM) of a drone without a built-in camera is ~$250, ~50% of the $500 average selling price, implies the connector content in a drone is ~$5.

As drones become more sophisticated, manufacturers are utilizing a larger number of sensors to make drones safer and more reliable; for example, one of the leading drone manufacturers includes 30 sensors in their typical drone and is adding more to improve the user experience. Sensing applications in drones include GPS, pressure sensor, biaxial/ triaxial accelerometers and gyro sensors. One of the key sensing applications is a combination of an optical flow sensor and an echo-location sensor which enables low-flying drones to detect and dodge obstacles such as trees, buildings and humans. The sensing applications in drones are similar to smartphones and high end wearable devices like Google Glass, but with higher requirement on weight and water resistance. As a result, we expect the sensor content in a drone to be 1.5x the sensor content in Google Glass (~4-5% of the drone BOM vs. ~3% of the Google Glass BOM). Assuming the bill of materials (BOM) of a drone without a built-in camera is ~$250, ~50% of the $500 average selling price (ASP), implies the sensor content in a drone is ~$12.

With TE Connectivity the primary connector company in consumer end-markets, we believe it will benefit from the increasing use of drones. Amphenol also has sophisticated technologies that could be utilized in both consumer and commercial drones.

4. Floating LNG

Bringing "Stranded" Gas Ashore

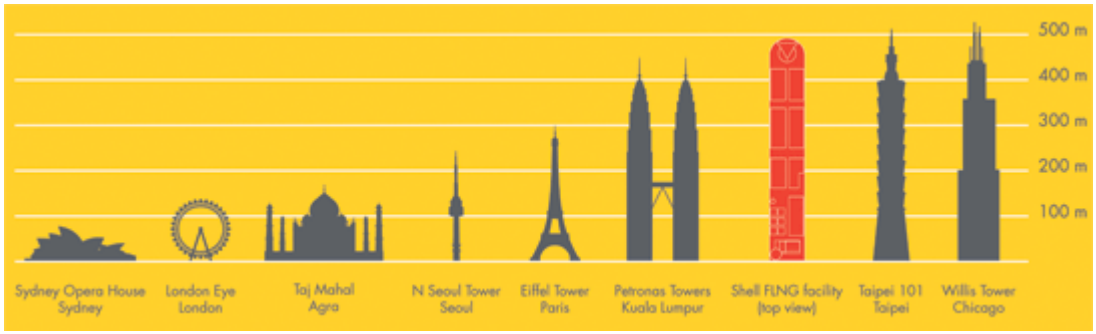
Seth M Kleinman
Head of Energy Strategy

While a large percentage of innovations highlighted in his report entirely computer based or fairly small, as in the case of drones, Floating Liquefied Natural Gas (FLNG) is neither a computer-based technology (though it will clearly be a very data intensive process), nor it is small. It is the siting of a natural gas liquefaction plant on a ship; a very big ship. When finished, Shell's Prelude FLNG vessel, currently under construction in a South Korean Shipyard, will be the largest offshore facility ever constructed and is set to cost more than $12 billion. At 488 meters long and 74 meters wide it will weigh more than 600,000 tons fully ballasted, more than six times the weight of the world's biggest aircraft carrier, The USS Theodore Roosevelt.

The first FLNG vessel is expected online in 1Q 2016

Prelude FLNG is set to start production in 2017; perhaps by the first half of 2017 but base expectations are for the second half of the year. The world's first FLNG project is expected to be Malaysia's PFLNG which will come online in the first quarter of 2016 yet it is the open-sea Prelude FLNG which should be the world's first view at this potentially disruptive technology for the global energy industry. Petronas' FLNG2 is the only other FLNG project currently under construction but another 5-10 projects are currently being reviewed.

Figure 20. Shell's FLNG Facility Will be the Biggest Offshore Facility Ever Constructed



Source: Shell

FLNG allows on-site natural gas conversion allowing previously stranded assets to be brought to market

Converting natural gas to its liquid form involves stripping the gas of unwanted components, extracting valuable components such as natural gas liquids (NGLs) and then freezing it to about −162 °C (−260 °F). This process reduces the gas' volume to roughly 1/600th of its previous state, and facilitates transportation by ship; something that is simply uneconomic without the reduction in volume. Liquefied Natural Gas (LNG) has been transported by ship since the middle of the last century, but until now the liquefying of the gas has always been done at a purpose built land-based facility. These are expensive facilities and companies have had to use economies of scale to reduce unit costs, meaning that small offshore gas fields, which cannot justify the construction of a purpose built LNG facility, are effectively 'stranded' at sea. FLNG, if it fulfills its promise, will provide a means to bring these previously stranded finds to market. This would open up another vast tranche of hydrocarbon supply just as fracking has done with shale over the last two decades.

FLNG May Hold to Key to Tapping the Vast Resource Base of "Stranded Gas" – What is the Potential?

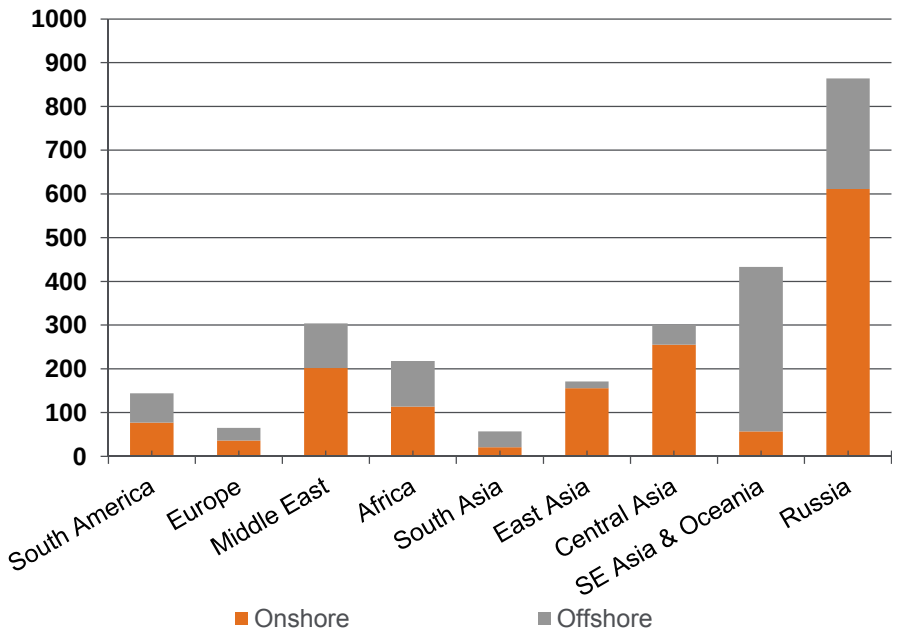
Developing untapped gas resources would lower gas price and increase gas usage in power generation

The world is becoming increasingly gas prone with gas discoveries outweighing oil discoveries by a large factor. Yet to date, gas development has been limited by a confluence of factors — the cost of developing gas for local markets, expensive international transportation solutions given high political and economic costs of pipelines and high and rising LNG development costs, elevated liquids prices and geopolitical barriers (Iran, Iraq) to name a few — so cheaper gas (vs oil) has lagged, keeping the potential for usage in the power sector at bay. This is where FLNG could potentially be so disruptive, the ability to develop a currently untapped resource, which can help meet the vast amount of untapped demand locally and globally along the world's coasts. Additionally, the growth of floating re-gasification terminals in addition to on-ship generation can provide a platform for this "stranded" gas to be brought to areas that have been starved of electricity generation. Last year's report on distributed power from General Electric highlighted this potential, with annual distributed power generation additions expected to rise from 142GW in 2012 to 200GW by 2020.

52% of global natural gas reserves are effectively stranded

Stranded gas as defined by the US Geological Survey (USGS) is "natural gas in discovered conventional gas and oil fields that is currently not commercially producible for either physical or economic reasons" of which their 2013 study put at 52% of proven ex-North America natural gas reserves. In other words about half the gas in the world is effectively stranded. This estimate was for 2009 and put the stranded gas total at 2.9-k tcf (or ~3.2-k tcf if using 52% of 2014 reserves) which is an enormous volume of gas; 2014 global gas production was 34-tcf making it around 85 years supply of current gas production. Fracking opened up commercial opportunities for shale oil and gas reserves that the industry had known about for decades but had not bothered to pursue; FLNG has the potential to repeat this for stranded gas reserves.

Figure 21. Stranded Gas Reserves (tcf)



Source: USGS

The biggest offshore stranded gas reserves are located in South-East Asia and Oceania, making FLNG an ideal fit given the proximity to the key Asian demand centers. Offshore areas in the Middle East, Africa and Europe all have roughly 100-tcf of stranded gas as well. Just as with shale, the resource is huge and widely distributed.

Lowering Costs and the Environmental Impact

FLNG is expected to lower costs for the LNG industry and have a lighter environmental footprint

Proponents of FLNG stress two other significant benefits including lowering costs for the LNG industry (now more important than ever given oil prices are down by half from a year-ago) and a lighter environmental footprint.

Building the FLNG vessel in a shipyard may well prove less expensive than building an LNG facility in remote locales such as Australia's North West Shelf or Papua New Guinea, where virtually all the workers and materials will need to be expensively imported; though a quick review of the economics of Prelude indicate that it is hardly a game-changer on that front, at least this first time around.

Citi estimates the final costs of Prelude in the $13-$15 billion range. At 3.5 million tonnes per annum (mtpa) of LNG production this indicates a mid-range cost/mtpa of $3.9bn/mtpa. As can be seen in Figure 22 below this is not particularly low in comparison to other large scale LNG projects in the same country.

Figure 22. Australian LNG Projects Cost and Size Overview

Project	Capacity (mtpa)	Final Budget (bln $)	Cost (bln $)/Mtpa	First Production
Darwin LNG	3.6	1.5	0.4	1Q'06
GLNG	7.8	18.5	2.4	3Q'15
QCLNG	8	20.4	2.6	4Q'14
PNG LNG	6.9	19.0	2.8	2Q'14
Gorgon LNG	15.6	54.0	3.5	2H'15
Wheatstone LNG	8.9	32.4	3.6	4Q'16
Prelude LNG	3.6	14.0	3.9	2H'17
Ichthys	8.4	37.0	4.4	1Q'17

Source: Company Reports and Citi Research estimates

The $/mtpa comparison misses the fact that Prelude is significantly smaller than the other projects, both in terms of mtpa but also in terms of the size of the gas field. This is the key feature of FLNG — that it will allow the commercialization of offshore gas fields that otherwise would have remained uneconomic.

The extraordinary technical challenges of positioning all of the heavy equipment on a ship add to the cost. Though Shell's FLNG vessel is huge, it is still about one-quarter the size of a land based facility of similar capacity. Reducing the square-footage sufficiently to fit on a ship involves stacking the units vertically; essentially translating the 2-D land-based layout into a 3-D ship-based one. Prelude will, for example, have the operating plant stacked above the LNG storage tanks, and will utilize cold seawater sucked from 150 meter below sea level as a medium for chilling the gas in order to save space on deck.

Although initially build costs for FLNG vessels are high, they are expected to fall as more are built

This is the first vessel of its type to be produced however, and future vessels are certain to gain the benefits of the lessons leant. This means that costs may well come down in a meaningful way. Furthermore, an FLNG vessel can, at least in theory, be reused. Once the current gas reservoir has been exploited, the vessel can simply move on to the next project; this means that unit capital costs may fall significantly once the vessel gets redeployed.

There are two distinct types of FLNG, near-shore and open-sea

Although we have focused so far on the large open-sea option being pursued by Shell, there are really two distinct concepts for FLNG: near-shore and open-sea. The first also consists of liquefaction units on board a ship, either a new build or converted existing LNG carrier, moored in a port or near the coast in benign sea conditions which would allow LNG carriers to moor alongside the FLNG unit, load up and depart for export markets. These vessels will be both smaller in size and have a smaller production capacity than the open sea option. This approach is a major advance for the LNG industry, but is more of step-change than a game-changer. The key advantages of this approach are reduced cost and environmental impact by avoiding the requirement to construct large bespoke onshore facilities. PFLNG 1, the world's first near-shore vessel is scheduled for completion for the end of 2015 and Malaysia's Petronas is scheduled to start operations in the Kanowit field 112 miles from Malaysia's coast early next year. PFLNG 1 will have production capacity of 1.2-mtpa and is designed to operate in water depth of 70-200 meters for 20 years while accommodating up to 150 workers. It is expected to cost ~$2.3 billion putting the cost/mtpa at $1.9-bln/mtpa.

Both of these options are being hailed as a means of reducing the environmental impact of LNG facilities. They will both avoid occupying large amounts of water front acreage as well as reducing the need for pipelines and associated impact on the marine environment.

What Could Go Wrong?

Technical issues in operations will have to be overcome for FLNG to be successful

The risks to FLNG are both technical and economic. Operating an enormous vessel of such technical complexity in sometimes extremely adverse weather conditions has never been done before. For FLNG to fulfill its potential it will have to manage this, and overcome the technical issues that will inevitably surface once it has transitioned from theory to practice, without blowing out the economics of the project. Land-based LNG relied on economies of scale to overcome the expensive nature of the process; FLNG will not have that option.

The technical challenges will be great in number. The FLNG vessel will have to handle the removal of impurities and liquids from the gas stream, coping not only with the variable nature of gas from the first field at the first location, but - if FLNG is truly to fulfill its promise - from the next location when the ship is moved on. Transferring the LNG from one floating structure to another using flexible hoses in bad weather is no simple manner.

From an economics perspective, FLNG will have to prove its reliability and cost effectiveness

FLNG was sanctioned during a period of high oil prices and hence high LNG prices (given oil indexation). Citi believes that the days of $100/bbl oil are a thing of the past, albeit recent past. FLNG is being promoted as one means of the LNG industry adapting to a low-price world. Yet it will have to prove its reliability and cost effectiveness. If it does, then the companies involved in the construction of land based LNG facilities that do not translate into FLNG construction are the clear losers. As are local governments that have hitherto benefitted from the tax revenue gleaned from these very expensive land-based engineering & construction projects.

To truly appreciate the big picture impact of FLNG though involves seeing it as a chain of technologies, from floating production, storage and offtake facilities (FPSO's) that facilitated production from deepwater oil reserves and started up in the late 1970s but now number almost 300 globally, to fracking and low-cost solar panels and wind turbines and now FLNG. Each of these has unlocked new horizons in global energy supplies, and is shifting the world from being energy constrained, to becoming one of energy abundance.

5. Machine Learning and Artificial Intelligence

Peter Chalif
Head of Structured Trading, Citi Municipal Securities

Not Quite Science Fiction….Yet

Machine learning (ML) and artificial intelligence (AI) have fallen short of the promises of computer scientists and the fantasy of science fiction, at least so far. Machine learning is the use of computer algorithms to recognize patterns in data and turning that data into knowledge. At its simplest, ML is a combination of statistical techniques put into a framework to understand and generalize information. Artificial intelligence includes multiple fields, but here it specifically refers to an extension of ML where computers can make decisions or provide specific conclusions. Where necessary we will separate ML and AI, but in most cases use MLAI to represent their combined use.

Introduction

The ability analyze and learn from data and make good decisions towards a goal when given a mechanism to implement those decisions is the disruptive capacity of MLAI

MLAI has transitioned out of the lab in the last few years into greater use, and will continue to do so in the coming years. ML and AI make other things possible; they are foundational technologies leveraged across other innovations including many that are disruptive themselves. The disruptive capacity of MLAI is its ability to analyze and learn from data, and make good decisions towards a goal when given a mechanism to implement those decisions. These abilities encroach on work done by employed people. The benefits and disruptive nature of MLAI described will not be the plot of apocalyptic movie scripts, but rather the impact on business and employment.[11]

What is innovative and disruptive about MLAI now and in the future is the variety of problems it can address and how accessible a tool it is becoming. MLAI is constructive; better analytics means a business can deliver a better product or service, allocate resources more optimally, and reduce cost. It is a tool that is now accessible by everyday people; not just computer scientists. MLAI can be applied to problems of greater complexity and less specificity as it improves and these improvements increase the benefits and potential profitability of businesses and individuals that use it, generating a virtuous cycle of implementation, investment, improvement, and expanded use. That virtuous cycle results in a more vicious cycle where human expertise is replaced at successively higher levels of complexity and intelligence. Most of us have figured out how to use Google's search technologies to our advantage, and IBM's Watson, Apple's Siri, and systems like them promise to be even easier. Natural language processing can provide an interface to advanced MLAI most people can use, bringing advanced MLAI to many more fields.

Defining Intelligence – Human or Machine

What is intelligence and therefore what are machine learning and artificial intelligence? There is a difference between consciousness and intelligence, and this article will focus solely on intelligence. To paraphrase a definition from Pei Wang, as discussed by Goertzel in "Artificial General Intelligence"[12] Intelligence is the ability

[11] For a discussion of other risks inherent in AI see Barratt, J. (2013) "Our Final Invention"

[12] The exact quote "Intelligence is the ability to work and adapt to the environment with insufficient knowledge and resources."
Goertzel, B. (2007) "Artificial General Intelligence". Another definition "Intelligence is the ability to achieve complex goals in complex environments" adds the need for complexity, but removes the resource constraints. Goertzel, B. (2006) "The Hidden Pattern".

to make good decisions in a time and knowledge constrained environment. A "good" decision in this context means one that brings the decider closer to a goal. That goal may be simple or complex, tightly defined or abstract. AI is, therefore, the ability of machines to make good decisions given a goal with time and knowledge constraints. More precisely, AI is simply the ability for a machine to use *some* information and *some* amount of time to make a good decision, not necessarily make "the same decision a person would".

AI does not mean consciousness, it simply means the ability of a machine to make good decisions across multiple domains and manage knowledge and decision making

Humans have a strong emotional reaction to losing our mental superiority. Few would say "that isn't running" about a cheetah, or "that isn't climbing" about a chimpanzee or a cat up a tree. Machines have matched or surpassed human abilities in some areas once considered hallmarks of human intelligence, such as theorem proving, chess, Jeopardy, antenna design, and analyses of consumer buying patterns and financial reporting. But these accomplishments are discounted and machines' abilities written off as an expensive parlor trick. There is a running joke in the computer field, "AI is everything machines can't do yet." MLAI's ability to make good decisions in a resource constrained environment is no more a parlor trick than a person's ability to make good decisions. Skeptics will point out that usually those fields and problems are narrow in scope, otherwise known as *narrow AI*. They are right, but the techniques developed are increasingly abstract and applicable to multiple domains, and, therefore, closer to artificial *general* intelligence. Artificial general intelligence *does not mean consciousness,* it simply means the ability of a machine to make good decisions across multiple domains and manage knowledge and decision making in a general way.

If we had unlimited time and unlimited knowledge, either generally or within a specific domain, the concept of intelligence would be irrelevant. We would know every possible path, its outcome, and always be able to make a good decision. When planning a vacation, given knowledge of every possible experience you could optimize your time for "maximum enjoyment". Similarly, if you knew every outcome of every trade in the markets, the market response to that trade, and had infinite time to compute it all you could easily optimize for "maximum profit". Unfortunately, we don't have infinite knowledge or infinite time, and that's where intelligence comes in — human or machine.

Why MLAI is Changing Things Now

Algorithms are being developed that utilize the intersection of improved access, expanding computing capacity and an explosion in the availability of data

Each day MLAI can handle increased complexity, and develop more general algorithms. The intersection of improved accessibility, rapidly expanding computing capacity and an explosion in the availability of data make this possible. While these changes are the cause of the expanded use of MLAI, they do not fully explain the disruptive result. Algorithms are being developed that utilize this intersection of improvement, for example, hierarchical temporal memory developed by Dileep George in 2008. Hierarchical temporal memory is a technique for training machines to recognize patterns over time and is based on how the human neocortex may perform.[13] Other projects such as OpenCog combine multiple algorithms into a single platform and results in more general abilities.[14]

[13] George, Dileep (2008) "How the Brain Might Work: A Hierarchical and Temporal Model for Learning and Recognition"
[14] Hart, D.; Goertzel, B (2008) "OpenCog: A Software Framework for Integrative Artificial General Intelligence"

MLAI is a foundational technology, one that other technologies can leverage, including many of the topics described in this edition of GPS. As a foundational technology the value of MLAI is significantly increased, attracting greater investment which results in faster development. Some examples of innovative technologies that leverage MLAI are found in other sections of this Citi GPS report and described in the "MLAI Leverage" table in Figure 23. Computing capacity, the sophistication of generally applicable algorithms and the accessibility of both bespoke and off-the-shelf MLAI solutions combine to create a rapidly increasing value proposition. MLAI is a viable solution to many competitive pressures including efficiency improvements, headcount reductions, technology developments and understanding clients.

Why MLAI is Disruptive

MLAI can produce insights in real-time against datasets of staggering size and complexity

Most companies regardless of size analyze their data enough to draw some level of inference from it. The sandwich shop that has its staff arrive at 10am to prep for an 11am open is clearly familiar with the concept that "most people want lunch at about noon". From a casual glance at sales data, any manager could tell you that the turkey club sells the most. What they might not be able to tell you is on days the turkey sells out what the alternative is and therefore what to make instead. This is where MLAI enters as a potential solution, especially in more complex businesses. In complex businesses with large amounts of data, machine learning can provide insight people cannot. Machines can produce insights in real-time against datasets of staggering size and complexity that would take an army of employees with spreadsheets decades to perform. MLAI is already at a level where it is difficult for people to compete against a highly customized algorithm in an isolated domain with large amounts of data or dimensions to that data. Those domains may be financial markets, consumer retail, or other industries where data and decision making are critical. The more complex and abstract a problem that MLAI can address the more valuable and more disruptive it becomes.

Goals may be short term in nature, for example, "baby steps into the elevator", "sell more widgets this month", or "trade bonds at a profit today". Other goals are long term — "obtain a job that pays enough to support a family", or "build a company that is resilient to market stresses and can outlive my tenure". A problem may require different amounts of intelligence to analyze, and then solve. People do not possess the ability to deal with infinite complexity; we use symbols, generalization, and abstraction to handle more complex problems in visual, auditory, tactile and conceptual domains. Machines use the same techniques that humans do to address complexity: symbols, generalization and abstraction, and they can now solve problems with meaningful levels of complexity in multiple domains such as finance, consumer patterns, and medical or veterinary diagnosis.

Machines are now solving problems that previously were managed manually

As cited in Rise of the Robots by Martin Ford,[15] an aptly named article "Let's try and not have a human do it"[16] describes how Facebook automated server maintenance. Ford describes the situation as no longer creating the number of jobs people would expect since machines are doing a lot of the work. As Ford points out the work isn't just programmatic; machines are solving problems that previously were managed manually. Machines can manage the servers efficiently given appropriate objective functions, data and a mechanism through which to implement decisions. Economists will point out the loss of server maintenance jobs results in new jobs developing server maintenance software. True, but the jobs created are fewer, and require more education, greater expertise and investment. That same process is

[15] Ford, M (2015) "Rise of the Robots"
[16] Heath, N. "Let's Try and Not Have A Human Do It" ZDNet, November 25, 2013.

happening throughout the technology and other industries. The result is greater opportunity for fewer people who have a more valuable skill set. The closer machines get to general intelligence the more automation will creep up the human employment value chain.

MLAI is disruptive as jobs performing analysis and making decisions based on those analytics are replaced by machines

Businesses perform many analyses each day of varying complexity in order to make decisions, most of which are performed by people. MLAI is disruptive due to the loss of jobs performing analysis and making decisions based on those analytics. There is also a loss of jobs in the review of transactions or other data, for example compliance reviews of trading desks. The jobs lost and replaced by technology are no longer entry level, physical labor or semi-skilled work. The jobs lost will be those where humans currently have the upper hand: those that require knowledge of data, analysis, and what we generally consider a human only skill of "understanding" or "learning what data means". The losses will include jobs that are currently considered moderately skilled, including ones that require a college degree.

The virtuous cycle of MLAI quickly turns into a vicious cycle ultimately leading to a reduction in the need for moderately and lower skilled workers

Some of the equity trading algorithms incorporate MLAI techniques even if they don't consider what they are doing MLAI. The algorithmic trading business model is also growing in fixed income markets. While there are specific challenges in different asset classes and different industries, the techniques are adaptable and will improve over time as business models and people also adapt. The virtuous cycle: use MLAI => adapt business model or industry structure => more MLAI is possible; again turns vicious: use MLAI to an advantage => business models and competitors adapt => invest in more sophisticated MLAI to compete =>reduction in need for moderately and lower skilled workers.

The CEO of a company could soon ask a machine "What are my greatest risks?" and in return getting not only a reasonable and valid answer, but probably better analytics and insight than they do presently. The path to get there has both straightforward and complex requirements. Centralizing datasets and financial calculators are two of the most straightforward prerequisites. Ensuring the machine understands that "risk" in the financial world is a more complex requirement, as risk takes numerous forms, i.e. market, credit, liquidity, and taxability. Machines' ability to analyze nonlinear dynamics in large data sets and the ability to correlate exogenous factors and language based information will likely lead to significantly better analytics.

MLAIs need for customized input and pre-analysis by humans is decreasing

Given the mortgage portfolio of a large bank, an advanced MLAI in the future may flag risks like a large number of interest only loans and their reset risk after an article in Forbes.[17] The mechanism might be through correlation of the words "risk", "interest only", and "reset" combined with the bank's loan data. A more advanced MLAI solution might include deeper understanding of the definitions of the words above. There are algorithms available that can probably perform reasonably well already given the right input, customized data management, and work by people similar to that which went into Watson's Jeopardy. MLAI's need for customized input and pre-analysis by humans is decreasing, and with that machine's inexorable climb up the employment value chain.

[17] Myer, L. "Beware The Interest-Only Mortgage" Forbes.com, June 6, 2005.

Machines can handle more than seven variables, the limit for human working memory

There's another reason MLAI may be able to contribute significantly greater insight than people: the magic number seven. Humans can manage about seven variables at once in their working memory.[18] Above that the brain starts grouping variables together, forming correlations, or storing perceived patterns, right or wrong. All of those types of learning come with a loss of granularity or a formation of bias. In reviewing sales data across different products, a manager might see several receipts in a row where bubble gum and blue jeans were bought together and start to recognize it as a pattern. Each time they see the two together they may get false confirmation the pattern makes sense and make up a reason, for example, "the person buying new jeans has a date tonight and is, therefore, also buying gum". In reality, it might be that the person is sixteen and teenagers tend to buy those items. The store manager could easily have missed that correlation if age it didn't happen to be one of the top seven variables they considered. Machines wouldn't miss it, and probably wouldn't suffer from the human trap of confirmation bias either. When you ask a machine "what products do people buy?" if it responds with "sixteen-year-olds are buying gum and jeans", and knows the definitions of *sixteen*, *buy*, *gum*, and *jeans*, what more could a human add to "understanding" the data? As more data is available, with faster computers and better algorithms that handle greater levels of complexity, it is only a short time later that "how do I increase sales?" returns "Pay Miley to tweet a photo with this gum wearing these jeans".

Who is Impacted?

Ability to adapt, use MLAI to advantage and creative, non-machine replicable skill sets are winners

The result of MLAI disruption is a change in the winners and "more challenged" of an industry, management hierarchy, and people. Winners: companies that use MLAI to their advantage, managers who move functions to machine only or machine enhanced strategies, and people who are creative or produce results beyond the current capabilities of a machine. Those that will be more challenged: companies that don't optimize their data platform and can't use MLAI, managers that are unable to adapt, and employees whose skill set is manual processing with spreadsheet copy/paste or equivalent skill sets.

47% of US employment may be at risk from automation…

In "The Future of Employment"[19], authors Carl Frey and Michael Osborne provide a deep and compelling analysis of how employment may change through computerization and arrive at the conclusion that "47% of U.S. Employment may be at risk". Most consider this a surprising and rather alarmist conclusion. It may, in fact, be too conservative. The paper contains a chart of sectors of employment, the number of employees as determined by the Bureau of Labor Statistics, and the probability of "computerization". In reviewing the chart, categories such as Management and Business are given a low risk of computerization, when as shown above large sections of management may be automated as MLAI improves.

…and this number could actually be higher as MLAI improves in management and business functions

Also in Frey and Osborne's paper, "Computer, Science, and Engineering" fields are given a low probability of computerization, which is true for the more sophisticated jobs, but not for the areas that saw the greatest increases in employment. The late 1990s and 2000s brought significant growth in employment in fields like programming and software design, and also less sophisticated jobs in maintenance and repair. The Facebook example above shows the striation quite clearly, and less sophisticated jobs will plateau and then fall. As software development becomes increasingly abstract even some programming jobs will be at risk. The use of software development kits (SDKs), software as service models, common AI libraries

[18] Miller, G. A. (1956). "The magical number seven, plus or minus two: Some limits on our capacity for processing information". Psychological Review 63

[19] Frey, C.; Osborne, M. "The Future of Employment: How Susceptible Are Jobs To Computerisation?"

and other components are all reducing the need for individual programmers to write their own versions of commonly solved problems. The virtuous and vicious cycles are extremely clear in technology. Improved hardware capacity leads to faster and more general algorithms, which leads to better engineering, more hardware capacity and improved MLAI. Improved MLAI can improve engineering, optimization, and maintenance, and will make entry level and less sophisticated technology jobs obsolete.

Andy Feng and Georg Graetz acknowledge the change taking place in disruptive technologies, continuous improvement and their impact on employment in a recent paper[20] *emphasis added*:

"Routine" vs. "non-routine" tasks could be a differentiator

'In a seminal paper, Autor, Levy, and Murnane (2003, henceforth ALM) categorize tasks as routine and non-routine and document a shift of employment out of routine tasks. They call a task routine "if it can be accomplished by machines following explicit programmed rules." In contrast, non-routine tasks are "tasks for which rules are not sufficiently well understood to be specified in computer code and executed by machines." The authors cite a 2013 report by Frey and Osbourne (2013) which demonstrates that recent technological progress of many non-routine tasks can be automated after all, including driving a car, parts of legal research, and some types of medical diagnosis. The authors therefore advocate a task framework that accommodates the possibility that machine capabilities constantly expand,

> *"…our model suggests that automation will lead to a continuing displacement of workers in the middle of the distribution, with the growth in low skill jobs more and more dominating that of high skill jobs. The term 'middle' will refer to increasingly skilled workers over time, as machines move into increasingly complex, training-intensive tasks."*

Conclusion

Dozens of companies are working to make MLAI accessible, from the long brilliant labs of IBM to Google and its staggering talent acquisitions[21] to startups of all types and sizes. They are doing so due to perceived social and potential financial benefits. Those benefits are real, present, and disruptive. Some will succeed, some will not. Some will perfect their techniques in less complex domains, for example, the ad servers that show me "Portillo ski vacation!" every time I go to a web page. Others will succeed in developing technologies that are broader and more general in their ability to achieve intelligence in multiple domains. Some are taking "moon shots" at "natural language search", with high probabilities of success given the financial resources and talented people committed. Understanding of natural language requires intelligence in learning what words mean, and the ability to recognize that meaning in many contexts. "Natural language search" is a thin euphemism for MLAI.

[20] Feng, A.; Graetz, G.(2015) "Rise of the Machines: The Effects of Labor Saving Innovations on Jobs and Wages"

[21] Google recently purchased/hired: DeepMind, DarkBlue Labs, Boston Dynamics, Vision Factory, Oxford University, Ray Kurzweil, Geoffrey Hinton all of whom have/are well respected practitioners or theorists

MLAI is here, it continues to improve, and it is increasingly disruptive through direct impact and as a building block for other innovative technologies. These disruptions occur through multiple effects, but primarily the ability of MLAI to learn from data and make good decisions. For the first time, machines are taking mental work from people and not just manual labor. The result is a direct impact on employment and therefore the economy, and those effects is here and growing.

Figure 23. ML/AI Leverage

Disruptive Technology	Machine Learning Use/Impact
Autonomous Driving	Autonomous driving is possible in part due to the pattern recognition and analytics provided by MLAI. Driving is a great example of the need to "make good decisions in a knowledge and time constrained environment". It is also an example where machines will probably make better decisions than most humans, especially on the NJ Turnpike.
Drones	Much like autonomous driving, drones are not just a success of hardware but MLAI, used for everything from object recognition to path optimization and in-flight decision making.
Floating LNG	GE's Industrial Internet[22] makes the case for rapid and accelerating change due to a variety of factors, including the optimization of energy delivery and resource optimization using a combination of sensors, public APIs, and machine learning.
Marketplace banking, P2P lending	Multiple firms use machine learning to determine credit worthiness by learning which data points are most important
Public APIs / The Internet of Things	Seen primarily as input to MLAI, for example learning the habits of drivers based on different timings of street lights. Public APIs have the potential to provide vast quantities of data to MLAI, but also the the opportunity for MLAIs to exchange knowledge. An MLAI running in New York City could teach what it learned about driving patterns to a new instance of itself running in Los Angeles.
Robo-Advisors	Currently, Robo-Advisors generally target static or dynamic investment mixes based on basic analysis. Given that some retail and institutionally available structured products and certain quant based hedge funds use machine learning to drive or assist their investment it is probable Robo-Advisors will move toward that as well.
Sharing Economy	ML is used in the retail space to analyze consumer behavior and to optimize everything from inventory management to shelf layout. In the sharing economy, consumer and provider preference will equally important.
Virtual Reality	MLAI + Virtual Reality = Science Fiction that isn't likely to be fiction for long. Products such as MetaPro, MagicLeap, and Oculus are all racing towards consumer viability in this space.

Source: Citi Research

[22] Evans P; Annunziata M (2012) "Industrial Internet: Pushing the Boundaries of Minds and Machines", General Electric.

6. Marketplace Banking

Digital Disruption is Here to Stay

Simon Ho
Head of Asian Regional Banks Research

Mark May
US Internet Analyst

A whole range of new digital players —ranging from peer-to-peer (P2P) lending and foreign exchange (FX) to insurance and investing — have emerged in the past several years. Not all of these have the potential for significant disruption, but the commonality across them is their value proposition of cheaper fees and pricing — in theory being achieved through lower operating costs (no physical network/agents), directly matching buyers and sellers — and a great user experience.

These new digital models have gained traction and momentum albeit off a low base but their overall size is still relatively small and so the disruptive impact today is happening only around the edges of banks' business.

However, customer behavior is digitizing and technology is improving exponentially — the playing field is changing very rapidly and some of these new digital models will continue to growth, evolved and expand into adjacent market. For example, we forecast the addressable market for P2P players such as Lending Club and its peers is $254 billion (8% of consumer credit in the US). Lending Club has already evolved from just consumer credit and P2P lending into SME lending and now about 80% of lenders are institutional investors. Charles Schwab, a traditional incumbent, has entered the Robo-Advisor market and estimates the market potential to be $400 billion in coming years — a 20 fold rise from current size.

P2P Lending

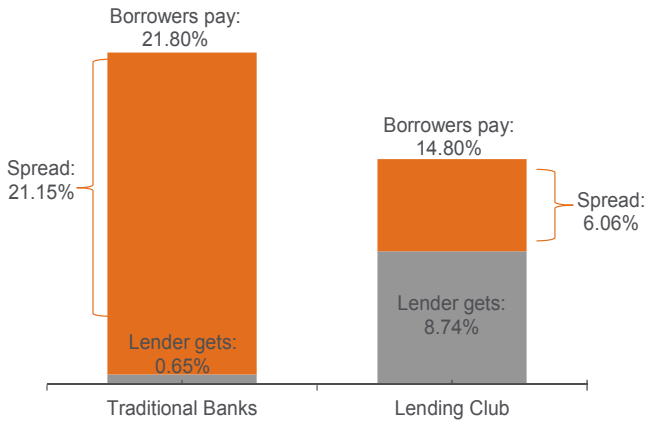
Online marketplace lending amongst individuals without traditional financial institutions

Peer-to-peer lending refers to lending money amongst individuals without going through traditional financial institutions. Potential borrowers and lenders are brought together on a digital platform that facilitates scrutiny of the borrower and subsequent exchange of money. In its early days, the model helped address borrowing needs of customer segments that were not ordinarily serviced by traditional banks (possibly due to smaller ticket size or poor credit rating). But with increased convenience, potentially lower borrowing costs and shorter processing time, this model has been gaining prominence in recent years, chipping away at banks' lending and deposits.

Borrower:
(i) lower borrowing costs and quicker,
(ii) assists in financial inclusion.
Lender:
(i) higher returns,
(ii) diversify investments.

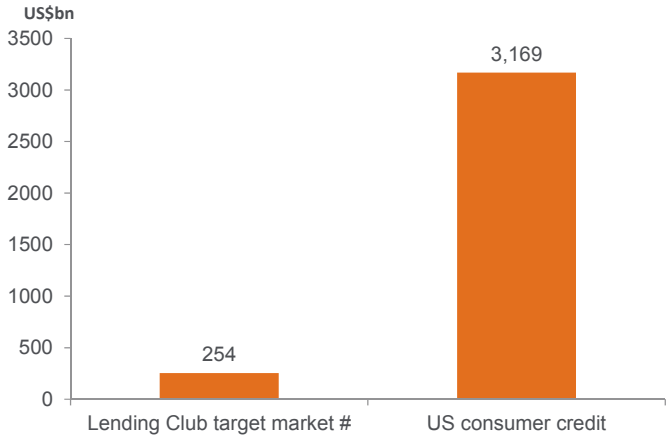
- **Value proposition:** Apart from faster processing times and lower borrowing costs (due to branchless model), P2P lenders help service customer segments that are not ordinarily viable for banks. On the other hand, lenders enjoy higher returns versus other traditional bank products and have the opportunity to diversify their investments (as a single lender can choose to invest in multiple projects, thereby funding only a part of the whole project and diversifying his risk).

Figure 24. Interest Spreads at Traditional Banks vs. Lending Club



*Based on responses of 21,347 borrowers in a survey conducted by Lending Club from April 2014-April 2015.
Source: Company Reports, Citi Research

Figure 25. US Consumer Credit vs. Lending Club Target Market



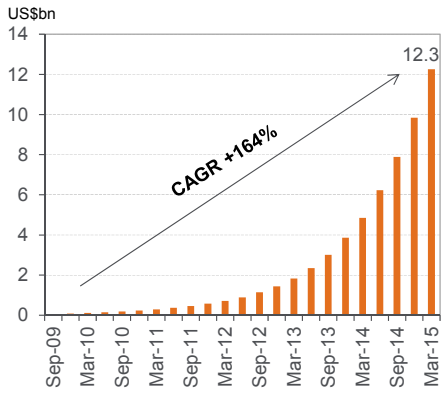
Note: # based on Citi's estimate after considering US revolving consumer credit ($882bn) and loans make to small business ($298bn)
Source: Havers, Citi Research estimates

Addressable market is $3.2 trillion in the US, comprising card loans, student loans and loans to small and medium businesses

- **Market Size:** Prominent P2P platforms in the West are Lending Club and Prosper in the US and Zopa in the UK. They currently account for a miniscule share in the total credit pie (<1% of US and UK consumer lending), but they have been growing exponentially – Lending Club and Prosper originated loans of nearly $6 billion in 2014 alone. In Asia, P2P lenders have been scaling up loans in China, with total originations exceeding that in the West at $90 billion.

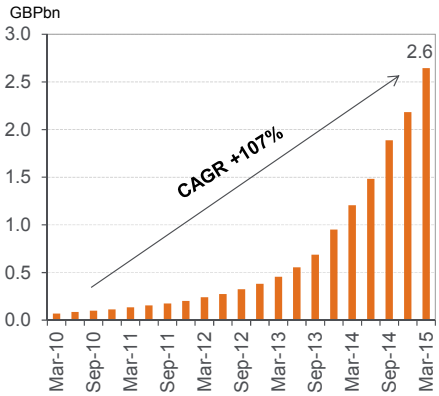
The addressable market for P2P lending potentially includes revolving credit card loans, student loans and loans to small and medium businesses. We estimate in the US, this market totals $3.2 trillion, of which $1.3 trillion is held by commercial banks and the rest by non-bank financial institutions. We estimate the addressable market for Lending Club's and its peers is about $254 billion – a whopping 8% of US total consumer credit market.

Figure 26. US P2P Finance Cumulative Lending



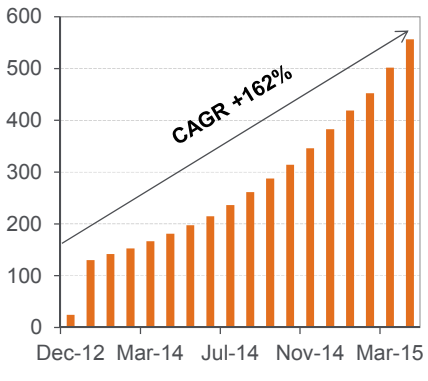
Note Represents Aggregate of Lending Club and Prosper
Source: Company Reports, Citi Research

Figure 27. UK P2P Finance Association Members Cumulative Lending



Source: P2P Finance Association

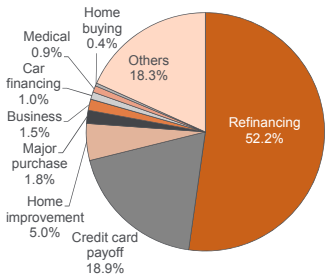
Figure 28. China P2P Finance Cumulative Lending



Source: Wangdaizhijia

- **How it works:** Potential borrowers submit applications on the digital platform, similar to any traditional loan application. The platform staff then verifies the borrowers' information (such as credit history and revenue sources) and assesses loan risk, before setting a grade and an interest rate. Potential lenders review available applications and select the borrowers they want to fund. Once confirmed, the website passes the money from the lender to the borrower. Subsequently the platform also facilitates repayments from the borrower to the lender. On Lending Club's platform, nearly 80% of lending volumes now come from institutional investors like hedge funds and other businesses entities.
- **Type of loans**: Primarily unsecured consumer loans for refinancing, credit card payoffs, and home improvements with durations of 3-5 years. A few P2P lenders like Funding Circle in the UK specialize in lending to small businesses only.
- **Revenue model:** P2P platforms generate revenue from origination fees charged to borrowers (usually 1-5% of loan granted) and service fees charged to lenders (usually 1% per year of principal borrowed).
- **Secondary market:** Key players in the US and UK offer secondary markets where lenders can liquidate current outstanding loans.
- **Counterparty risks:** Unlike banks, P2P marketplaces do not undertake any risk in case of borrower default as they do not lend or borrow directly and also do not set aside any capital reserve. All risks are borne by the lender. However, a few P2P lenders, particularly in the UK, feature protection funds designed to compensate lenders exposed to loan defaults.

Figure 29. Lending Club Loan by Type (2014)



Source: Company Reports and Citi Research

Figure 30. Key Players in US and UK P2P Lending Space

Company	Target customers	Economics	Transacted volume	Avg Loan Size	Avg Interest Rate	Avg Return to Lender	Historical Bad Debts
Lending Club (US)	Individuals and small institutions	Earns 1-5% as origination fee from the borrower depending on loan grade, tenure. Lenders pay a service fee of 1% for each repayment received from the borrower	Originated over $9.3 billion loans since 2007. Growth in recent years has been strong with loans originated in 2014 totaling $4.4 billion	$14,000	13.19%	5.0 - 8.7%	5.10%
Prosper (US)	Individuals	Earns 1-5% as origination fee from the borrower depending on loan grade, tenure. Lenders pay a service fee of 1% per year. for outstanding principal balance of loan	Originated over $3 billion loans after starting in 2006. Originations in 2014 exceeded $1.6 billion.	$11,400	15.30%	9.33%	6.60%
Zopa (UK)	Individuals and business	Borrowers pay an origination fee of 1.2% - 4.4%, while lenders pay an annual fee of 1.0% on the amount they lend.	Lent more than £847 million to over 107,000 UK borrowers since its founding in 2005.	£ 7,500	8.00%	5.00%	1.79%
Funding Circle (UK) *also available in US	Small businesses	Borrowers pay 2-5% as origination fees. Lenders pay an annual 1% service fees on loan outstanding for each loan	£630m lent to more than 40,000 British businesses	£15,000	10.90%	6.30%	1.50%

Source: Company websites and Citi Research

Still Relatively New in Asia, but Significant Market Potential

With exception of China, P2P lending is very new and mostly in developed Asia

- **Potential market across Asia:** P2P lending is relatively new and small across Asia with the exception of China which has seen an explosion of P2P lending in the past few years with over 1,800 platforms and nearly $70 billion in loan originations since 2014. In the rest of the region, start-up P2P lenders are mostly in developed Asia where consumers are better banked and credit information is more readily available. Digital infrastructure is more mature in developed Asia and so it is easier to replicate the highly automated and online P2P lending models seen in the US and UK. P2P lending marketplaces in the region include Society One in Australia, Monexo in Hong Kong, Money Auction/Pop Funding in Korea and Faircent in India. While most of these are focused on unsecured consumer lending, a handful of P2P lenders (such as MicroGraam in India and MEKAR in Indonesia) are also engaged in socially responsible lending to the unbanked, aimed at increasing financial inclusion.

China's hybrid P2P model more applicable in emerging markets today

- In China, the P2P lending model is mostly a hybrid offline-online model, where investors are sourced online but loan acquisition is done offline either by partnering with non-bank financial institutions or by the platform's own agents or staff. Due to the lack of credit information, P2P lenders have to rely on offline traditional credit assessment methods in China. We believe the rest of emerging Asia may have to follow China's hybrid model if P2P lending were to develop these digitally less advanced countries. But eventually, we believe P2P lending will have to migrate to a pure online model in order to gain a sustainable competitive advantage over traditional banks and financial institutions.

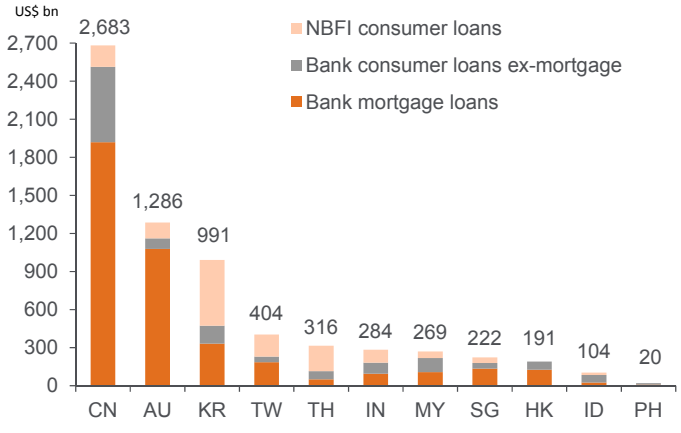
Us$6.5bn of consumer credit potentially up for grabs even before counting the underbanked segment

- In the coming years, we believe P2P lending will disintermediate a portion of the existing consumer credit and small business lending in Asia. We estimate that there is $6.8 billion of consumer credit in Asia ex Japan, which overall accounts for 38% of GDP and 32% of total loans in the banking system – not an insignificant size. Our consumer credit figure includes mortgage lending, consumer credit (e.g., credit cards, personal loans) and also lending by non-bank financial institutions.

Higher yielding lending most susceptible, mortgages in HK and SG unattractive

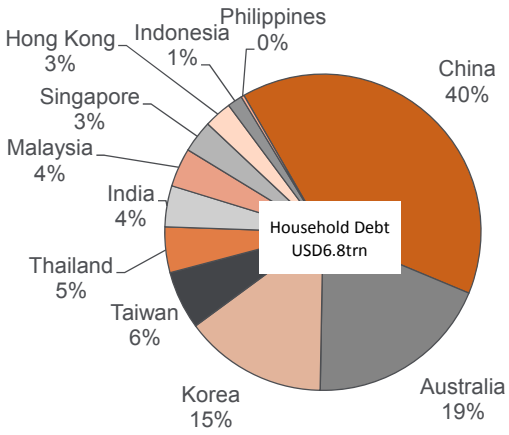
- Not all types of consumer credit will be disintermediated – higher yielding unsecured consumer credit will be more susceptible in general whilst low-yielding mortgages in HK and Singapore will be unattractive for lenders. In underbanked countries, the potential addressable market could be significantly larger than our figures which ignore future potential as banking penetration deepens. In China for example, a leading non-bank financial institution estimates the potential market for unsecured small business lending is around Rmb20 trillion ($3.2trn), this is larger than the existing stock of consumer lending in the country of Rmb16trn ($2.6trn). We believe this potential is enormous in countries like the Philippines, India and Indonesia where even the official penetration of consumer credit is very low at only just 10-15% of GDP.

Figure 31. Asia Household Debt in US$ (2014)



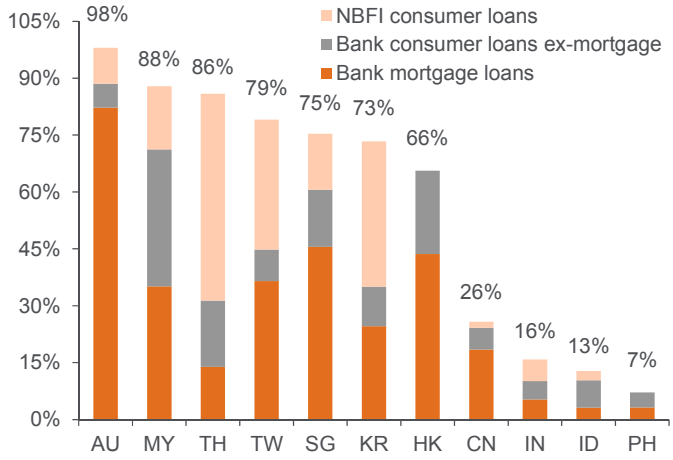
Source: Central Bank & Statistical Office Websites, CEIC, Citi Research

Figure 32. Asia Household Debt Mix by Country (2014)



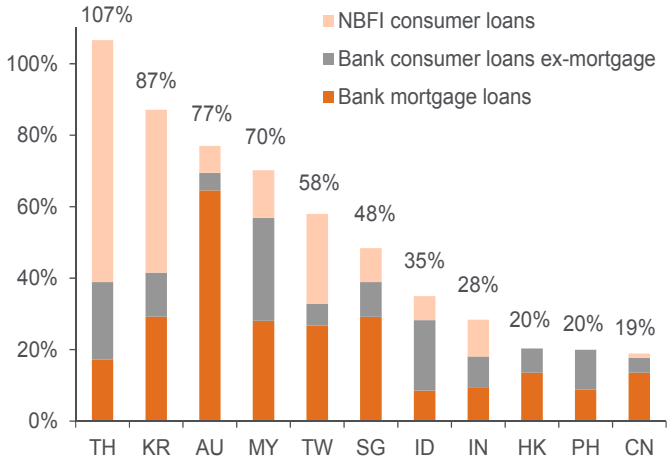
Source: Central Bank & Statistical Office Websites, CEIC, Citi Research

Figure 33. Asia Household Debt as Percent of GDP (2014)



Source: Central Bank & Statistical Office Websites, CEIC, Citi Research

Figure 34. Asia Household Debt as Percent of Banking Loans (2014)



Source: Central Bank & Statistical Office Websites, CEIC, Citi Research

Figure 35. Asia Household Debt

Figures in USD bn (2014)	Bank Mortgage Loans	Bank Consumer Loans ex-Mortgage	Non-Bank Consumer Loans	Total Household Debt	Total Household Debt as Percent of GDP
China	1,919	594	170	2,683	26%
Australia	1,078	83	125	1,286	98%
Korea	333	140	518	991	73%
Taiwan	187	42	175	404	79%
Thailand	51	64	201	316	86%
India	95	87	103	284	16%
Malaysia	108	110	51	269	88%
Singapore	134	45	44	222	75%
Hong Kong	127	64	n.a.	191	66%
Indonesia	26	59	20	104	13%
Philippines	9	11	n.a.	20	7%
Asia Pacific x-JP	4,065	1,299	1,406	6,771	38%

Note: NBFI consumer loans include:
- in Korea: loans from non-bank depository corp., mutual credits, credit union, other financial corporations and pension funds;
- in Taiwan: credit cooperatives, Chunghwa Post, insurance & pension funds;
- in Thailand: personal loan companies, co-operatives, insurance & securities companies.

Source: Citi Research

Crowdfunding

Small investors pool their resources online to extend micro loans

Crowdfunding is the approach of raising funds from a large number of people, facilitated by the rise of online platforms that help match borrowers with lenders. Crowdfunding can operate in various formats: (1) donation/reward crowdfunding where people investment simply because they believe in the cause, rewards may be offered, (2) debt crowdfunding where investors receive money back with interest (also called P2P lending) and (3) equity crowdfunding where people invest in an opportunity in exchange for an equity share in the venture.

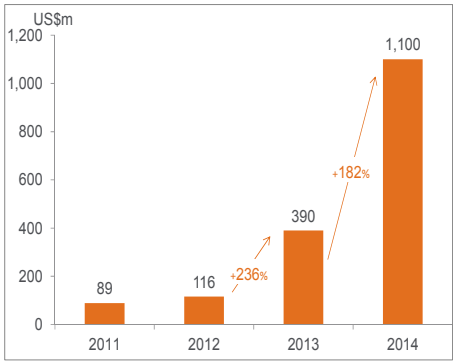
(i) quick & easier to tap global audience, (ii) fund unconventional projects, (iii) diversify investor base

Value proposition: Crowdfunding provides an alternative to traditional private equity and bank loans, offering benefits such as: (1) quick and easier access to capital for individuals/startups from a global audience, (2) finance ideas that may not appeal to conventional investors, (3) diversify investor base (and control) as it allows for more people to be involved with smaller investment amounts and (4) create brand awareness for the business even before it launches.

Global equity crowdfunding US$1.1bn vs PE backed buyout deals of US$332bn

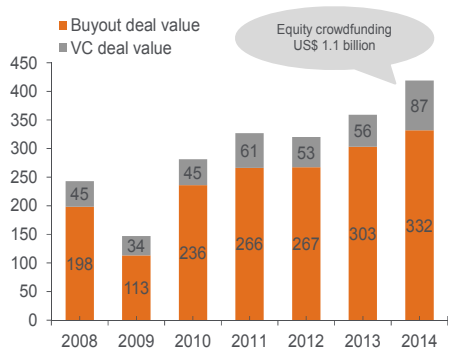
Market size: Crowdfunding is a fairly new sector and is mostly a developed world phenomenon, with the largest number of crowdfunding platforms in US (over 300). But the industry has been gathering momentum with entrepreneurial talent globally. According to Massolution, a research firm specialized in crowdsourcing industries, crowdfunding grew to over $16.2 billion in 2014 (equity crowdfunding – $1.1bn, debt crowdfunding – $11.1bn). Like most startups, absolute numbers for equity crowdfunding are still small, but the industry has grown multifold from $89 million in 2011 to $1.1 billion in 2014, growing 182% in 2014 (see Figure 36). In comparison, private equity backed buyout and venture capital deals totaled nearly $420 billion in 2014 (see Figure 37).

Figure 36. Equity Crowdfunding



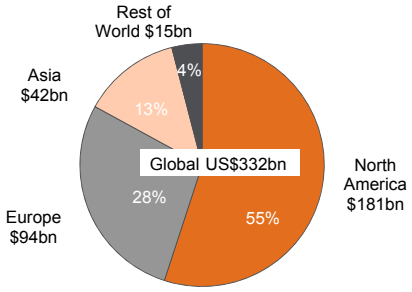
Source: Massolution, Citi Research

Figure 37. Global Private Equity-Backed Buyout and Venture Capital Deal Value



Source: Preqin, Massolution, Citi Research

Figure 38. Private Equity-Backed Buyout Deal Value by Region (2014)



Source: Preqin, Citi Research

- **How it works**: An online platform allows fundraisers to create an effective pitch for the project detailing the project idea, amount needed and financial targets. The platform, after due scrutiny, then launches the campaign online, which usually last 4-6 weeks. Potential investors choose desired campaigns and contribute online. On completion of required period, if the campaign has been able to raise the minimum funding threshold, investment/donations raised are transferred to the borrower, else returned back to investors.

- **Revenue model:** Crowdfunding platforms charge close to 5% of the amount raised via successful campaigns as fees. In addition, borrowers also pay 2-3% as payment processing fees to the online party responsible for coordinating the funds from different investors.
- **Type of projects funded:** Crowdfunding usually helps small startup projects raise funds for almost any purpose. Depending on the type of project, there are a host of different online platforms available. For instance in order to crowdfund projects for a personal cause, Kickstarter or Indiegogo can be used, while CircleUp is better suited for funding consumer product projects.

Figure 39. Crowdfunding Players in the US and UK

Company	Model	Type of funding	Economics	Transacted volume
Kickstarter (US)	Donation-based	Funding for creative projects such as art, comics, music and fashion.	Successful projects pay 5% of funds raised to Kickstarter and an additional 3-5% to the payment processors.	Funded close to 85,000 success projects with total dollar pledges of $1.46 billion to date.
Circle Up (US)	Equity-based	Funds consumer product companies with more than $1 million in revenue for the current fiscal year	Charges a percent of capital raised from the online campaign if successful.	Founded in 2012, the company has helped more than 40 small businesses raise nearly $30 million of funding.
Crowdfunder (UK)	Equity-based	Funding from individuals/VCs to startup entrepreneurs in any field	Charges the borrower a 5% fee if the project is successful along with a flat monthly fee. Additionally payment processors charge 2% for coordinating funds	Raised over $165.9 million to date for nearly 25,000 companies.
Crowdcube (UK)	Equity and debt-based	Helps fund British businesses across industries. The platform also allows for venture funding.	Borrowers pay 5% of funds raised on successful completion of campaigns along with a regular flat fee. Payment processors further charge 1-3% of funds processed.	Successfully funded over £80 million to nearly 250 businesses since 2010.
Kiva (US)	Non-profit based lending	Kiva does not lend directly to individuals. Instead it works with field partners, who help screen borrowers, post loan requests, disburse loans and collect repayments	Non-profit organization funded through donations/grants. Field partners however charge a nominal fee to the borrower for overheads.	Founded in 2005, Kiva has helped raise over $700 million in loans

Source: Company websites, Citi Research

Equity and debt crowdfunding is regulated

- **Regulated?:** Debt and equity crowdfunding are currently regulated in the US and UK, which helps set rules for who can invest and how much can be invested. Donation/reward crowdfunding is currently unregulated.
- **Traditional business friend or foe:** While crowdfunding is clearly changing the way individuals/businesses raise capital, nibbling at the PE/investment bank pie, they are not necessarily a threat. On the contrary, Private Equity (PE) and Venture Capital (VC) firms are using crowdfunding as a means to source deals and vet initial public reaction to the business idea before investing their own money. Moreover crowdfunding also helps fund borrowing needs of those who would not be serviced traditionally.

Disruptive impact on PE/VC firms minimal in current form

Potential market across Asia: Crowdfunding (especially equity-based), is a relatively new concept in Asia, with few players like FundedHere in Singapore and Opportune in Korea. But regulators are actively looking at this space to encourage financial innovation and address regulatory grey areas – for example, Singapore has recently concluded a public consultation on its paper related to facilitating equity crowdfunding while India and Malaysia have issued consultation papers on the same. However, equity crowdfunding as it sits in its current form (matching small size capital needs for personal startups) is not a significant disruptive threat to traditional PE or VC firms, which usually tend to deal in larger ticket sizes and also offer management advice to startups in their initial phase. In fact traditional PE firms are today using crowdfunding as a means to sourcing deals and test initial public responses to new business ideas.

7. Public API

The Foundation for Everything Connecting to Everything

Walter H Pritchard, CFA
US Software Analyst

"Everything connecting to everything", it seems like a reality for the ~3 billion global smart phone users who do everything from "hailing" taxis with an Uber app) to paying for groceries with ApplePay). These connections are enabled by the application program interface (API), a basic building block of software that is in the midst of an explosion driven by the convergence of device proliferation, ubiquitous connectivity and reams of data being generated.

The API enables software applications to interface with other resources such as sensors, services, content and data

The API, in technical terms, is a set of computer programming instructions and standards that enables software applications to interface with other resources. APIs enable a software developer to connect to sensors, services, content and data in a standard (easy) and secure way, enabling these elements to interact. APIs have existed internally within software for decades and this activity has likely accelerated significantly in the last several years. However, what is changing is these APIs are now being made available publicly or "semi-publicly" (to customers / partners) in ways that significantly increase their utility.

Ultimately, APIs enable outcomes such as greater reach for emerging competitors, massively increased volumes of interactions in a digital supply chain and automation in previously manual business process. As a result, we believe APIs will drive disruption across many industries as they allow many-to-many connections between constituents in a marketplace, without needing the position of traditional incumbents that have served as facilitators or gatekeepers in a marketplace.

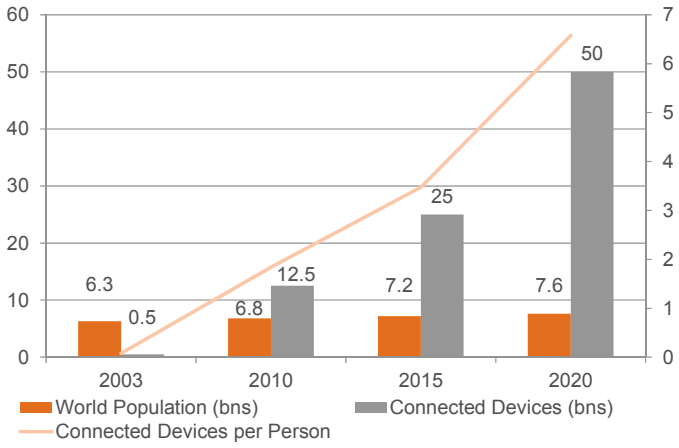
The Smartphone Was the Early Catalyst

The roots of API are with the Internet but the smartphone has been the real drive

We'd argue the renaissance of the API can be traced back to the birth of the modern smartphone, although the roots of the public API were established gradually along with the evolution of the public Internet. The classical early public API-enable scenario is the "map mash-up" that is ubiquitous today such as traffic information and the location of restaurants plotted on a map. In these examples, the location of a user comes from API connectivity to GPS chips in phones, traffic data comes through API from companies such as INRIX, Google or HERE (Nokia) and restaurant location and information from a Yelp API. A developer "mashes up" this information in a mobile app. The ease in which a developer can "call" this information has significantly lowered the barriers to writing applications with higher utility. Prior to the public API, the integration of this information was done in a "one-off" fashion, which took significant time.

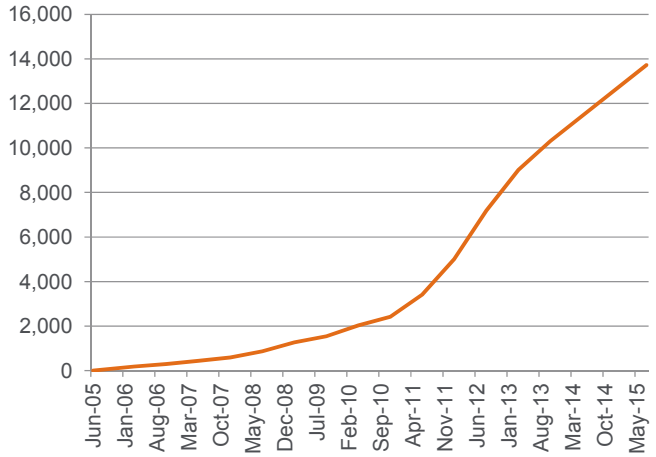
The iPhone announcement at the beginning of 2007 and the ensuing volume of devices that has shipped in the intervening time with high sensor density (location, movement, camera, etc.) plus the demand for mobile commerce has brought with it an explosion in technology innovation. In the most recent version of Apple's iOS operating system there are 4,000 APIs that can be leveraged by developers with new capabilities ranging from enabling developers to use ApplePay to direct camera control in app to device handoff (activity can be started on one device and resumed on another). At the same time, there has been an intense effort globally to digitize information, much of which is now publicly available. For example, the goal of the White House Open Data Initiative, implemented through an Executive Order in May 2013, is to make all public data, from the US federal government and other governments around the world, machine readable by 2016.

Figure 40. As the Number of Internet-Enabled Devices Expands, APIs Will be the Connective Tissues that Links Them to One Another



Source: Cisco

Figure 41. Similar to the Adoption Curve of Smart Devices, APIs Have Increased at Nearly an Exponential Rate



Source: Programmable Web

Use cases for APIs have now moved past the smartphone to other applications in the consumer market

Use cases enabled by APIs have now proliferated well beyond the smartphone. The pure "public" API scenarios are in the consumer market, where nearly all devices that consumers interact with have an API-enabled version now available. Home automation is a key example, where light bulbs, alarm systems, cameras, appliances and other devices can be connected and controlled. Each device has an API than enables granular control.

Consumer Scenarios More Obvious; Business Scenarios Could have Significant Impact

The use of APIs in consumer is obvious but there are non-technology markets that benefit as well

We could go on and on with consumer examples and in the near-term, it is likely that consumer scenarios are likely to be the most obvious. However, we see examples of how APIs could change the dynamics in many other industries. Below we focus on emerging scenarios in "non-technology" markets that might not be in the realm of what investors are considering, but could be equally impactful.

Figure 42. APIs Have the Potential to Disrupt Nearly Every Industry

Industry	API Value	Examples	Market Impact
Agriculture	Integrating real-time data (micro-weather, soil properties, etc.) into planting, maintianing, harvesting	Conservis, Granular, GroMAX	Higher crop yields, differentiatin of offerings
Agriculture	Connection of external electronics, diagnostic information, real-time performance (speed, braking, acceleration)	Open XC, Ford Sync, BMW iDrive	Differentiated experience impacts competitive landscape, raises barriers to entry in auto repair, new business models for insurance
Construction	Better understanding of construction material properties during design (BIM)	BiMsie API,. John Deere SPI	More efficient building design and better energy efficiency
Data Services	Automated look-up of data previously done manually	DnB, Verisk Prometrix, Experian Connect	Expands reach for service providers previously reliant on manual query of data
Call Center/Customer Service	Integration of ubiquitous voice, video, chat capability with location and situational awareness	Twillo, NetworkedHelpDesk	Differentiated customer experience, lower costs
Financial Services	Basic account information, credit card/ACH payments	Most banks, Square, Connect, Stripe, ApplePay, Yodlee, Prosper API	Seamless payments, personal financial information aggregation, peer to peer lending
Government/Education	Access to digitized government/academic information	G-8 Open Data Initiative, NIH Data	New business models around collecting/aggregating and analyzing freely available information
Healthcare	Population data, patient data through Electronic Health Records system	Kaiser Interchange, Inovalon, SMART standard, Microsoft Health Cloud	Competitive advantage for those that integrate data, expands reach for service providers previously reliant on manual query of data, disruption for EHR vendors that established competitive barriers with proprietary interfaces
Hospitality	Realtime data to price hotel rooms	Gogobot, Stayful	Better profitability from pricing hotel rooms real-time
Industrial	Timely maintenance of equipment, optimization of routing, fleet management	John Deere API, AEMP (telematics) API, Fleetmatics, Octopart API	Cost savings for operators, improved safety, competitive differentiation for equipment/machinery makers
Oil & Gas Exploration	Pipeline monitoring, access to operational and pricing data, employee/operator location	OPIS, iWell, Fleetmatics, Field Squared	Imprved safety, environmental regulatory compliance/monitoring, real-time asset visibility
Publishing/Content	Search and access to content	The Guardian Data Store	Easier discovery of content, broader content distribution
Retail	eCommerce, pricing, stock, warehouse inventory, loyalty, package delivery, information	Amazon API, Walgreens Photo Kiosk API	Increased competition, new revenue opportunities for retailers that make data available
Utilities	Visibility for consumers of their energy consumption, baselining of consumption across buildings, communication of consumption information between utilities and electricity providers, connection to appliances, transmission equipment and smart meters	Utility API (First Utility UK), EcoSCADA, Open ADR	New entrants drive increased competition for incumbents, better energy efficiency and demand management, less service interruptions at peak loads

Source: Citi Research

Design/"Ownership" of the API is Strategic High Ground

Liberal use of API at no cost has driven an explosion in applications and other integrations

While the technical process by which an API is designed, published and connected to is relatively simple, the business implications are not. At a high-level, the creator of the API defines how it can be used and holds the strategic high ground as its API is adopted. At the same time, if business terms for use of the API are onerous or generally unfavorable to those that use it, adoption is likely to be hindered. For example, some firms are very liberal with the use of their API at no cost, allowing any application developer access to its API so long as the application is registered with the firm. This has driven an explosion in applications and other integrations and at times a market-leading position for the firm. Similarly, Apple had previously been criticized for being very restrictive in terms of how developers could use APIs, but in iOS 8, the company has reversed course. In the social networking industry, Facebook, LinkedIn, Twitter and Google have all become more restrictive with API access. For example, they have focused on an end-to-end experience in mobility by not allowing third-party clients to access data or publishing to their platforms.

We see several models for monetizing APIs across various industries and monetization may differ for incumbents versus new entrants to markets. In some cases, monetization will be direct as a good or service is sold through API, even as a primary channel. While there are many direct monetization strategies in the technology industry, this business model holds in "old world" industries as well. The first example that comes to mind here is data/business service players, even incumbents, can significantly expand access to their service through publishing an

API that can be incorporated into other business applications. A credit check from Experian or business information look-up from Dun and Bradstreet (DnB) can be directly fed into a system a lender might use, in order to speed up the loan qualification process. In this case, Experian and DnB are paid for a lookup the same way they would when this information is requested through fax or mail delivery. At the same time, in these markets, public APIs and the digitization of government information have made it easier to obtain some of the same information that a service like DnB might have been a sole source on in the past. We see direct monetization in financial services (e.g. clearing of payments), publishing (e.g. selling of content from library) and retail (e.g. purchasing from mobile device or third-party system).

More often than not, it is likely the API monetization is indirect as an incumbent augments an existing product or service or a new entrant uses an API to differentiate a new service. Almost all the examples noted above in Figure 42 use indirect monetization. This may come in the form of delivering data (weather and seed information to a piece of agricultural machinery), offering transparency into inventory in retail (to encourage purchasing from this retailer), robust product information (to make it easy to design a part of material into a BIM-enabled construction project) and opening up of car electronics (to offer differentiated experience like connecting music through online service or automated maintenance scheduling with a goal of selling more cars).

Opening the Business through API Will Not Be Optional

The forces outlined above (device/sensor proliferation, growth in online commerce and data creation/digitization) are touching nearly all markets. Supply chains, both traditional and digital, will be opened up, as new competitors use the API as a competitive advantage. A new entrant, such as First Utility, can use deregulation to its advantage by having closer connections with customers of incumbents and better information to price energy versus incumbents. First Utility's basis for competition starts with its systems "ingesting" a prospect's electricity usage information from its competitor and then showing this customer how much money it could save based on its unique usage pattern.

Incumbents, at first, can resist the change catalyzed by the API, especially in markets where their current market share or the regulation environment protects them. There are no barriers to incumbents embracing this disruptive innovation other than their ability to gather sufficient technology expertise and have a willingness to change their business models. However, it is likely the API is an equalizing force that lowers the barriers to entry in many markets. The innovative incumbents will be those that leverage their market share to build a network through an API, either to monetize directly or indirectly.

Inhibitors: Security / Governance and "Ownership" of API Still in Early Stages

Inhibitors to API growth include business practices and design architecture

While APIs have driven change in many industries already, there are inhibitors to this trend. Automated connection of systems and enablement of a business process purely between two machines has potentially catastrophic consequences if not done in a secure and governed way. There are business practices, technology best practices and design architectures that need to be followed. Also, there are certain interactions that may be technically possible, but will take time to happen. For example, the exchange of patient medical information has considerable regulatory implications and as a result, API-enablement here has been slow to gain traction. At the same time, access to patient population data through API (such as Kaiser's Interchange), has seen significant uptake. We expect time and maturity of technology will likely help reduce this inhibitor.

In addition to real and perceived challenges around security, there are also unsettled issues around whether APIs are protected as intellectual property. A recent case in the U.S. federal court system has pit Oracle against Google over whether Google's "copying" of APIs in Oracle's Java software fall under traditional copyright law. Depending on the outcome of this case, the freedom to innovate around APIs could be hindered.

8. Robo-Advisors

Rise of the Machines: Robo Revolution

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Initiatives such as internet / mobile banking and online trading and investment platforms have been widely accepted by users, and shown significant growth. Newer initiatives such as crowdfunding, peer-to-peer lending and mobile payments appear to be gaining traction. In contrast, Wealth Management has remained quite 'low-tech' and high touch. It has been focused on the wealthier, 'baby boomer' generation, providing bespoke, face to face, expensive customer service.

We believe change is coming. Automated investment / advice services, so-called Robo-Advisors, are a key new Disruptive Innovation.

What are Robo-Advisors?

We define Robo-Advisors as automated investment management providers, usually based online, that provide investment portfolio management services with limited or no human contact. Robo Advisor services are typically, or typically have:

- **Questionnaire-led:** Investors fill out a series of short questions, designed to identify their investment horizon, goals, style, risk appetite etc. Based on the results of this questionnaire, the Robo-Advisor will suggest a model portfolio/asset allocation for the investor
- **Low, or no advisory fees:** Typical fees range from zero to 0.5%, with some providers stretching up to 1.0% for lower value accounts.
- **Low cost investment products:** Exchange traded funds (ETFs) are most often used by Robo-Advisors, helping to keep the overall cost of investment down for end investors.
- **Limited human contact:** Limited to phone calls/email/web chat, etc.

Key technologies

In robo-advice, the traditional role filled by the financial advisor – 'handholding', regular updates and meetings, investment allocation / portfolio rebalancing, etc. — is now fulfilled through a combination of algorithm-driven decisions, and 'smart' tech. Some of the key technologies offered by Robo-Advisors include:

- **Mobile App**: offering a simple, graphical snapshot of the client's portfolio, and a dashboard of functions / information, charting options etc.;
- **Smart Interactions:** e.g. automated messages or emails when the market turns, or customers show increased frequency of log-ins (potentially a sign of 'jitters');
- **Automatic tax-loss harvesting:** i.e. selling a security that has lost value to offset a gain on another security, and then replacing the sold security with a similar one to keep the portfolio allocation in the right place.

Market Position

Filling a vacancy

We see Robo-Advisors filling a gap between face-to-face high touch, traditional wealth management and financial advice services and online, execution-only investment and trading platforms. So far, Robo-Advisors are more established in the US than in Europe. Companies such as Betterment (launched 2010) and Wealthfront (2011) now manage around $2 billion in assets, respectively, with the US Robo-Advice market currently managing about $19 billion of assets under management. We see the growth of robo-advice in the US continuing, even accelerating from here, and spreading also into other regions, such as the UK and Europe.

Case Study: UK

Regulation = Catalyst

Following the implementation of the investment advice recommendations of the UK Retail Distribution Review on 31 December 2012, the availability of 'free' investment advice to the mass market investor has disappeared.

Threat at the 'lower value' end

Robo-advice offerings should, in our view, offer a useful solution to investors whose wealth levels preclude them from seeking more costly high-touch investment advice, and / or are not comfortable with, or are unhappy with the relative cost of, online execution-only investment platforms.

How Big Could This Be?

Still small, with parallels to the past

Industry estimates put the size of the robo-advice market at end 2014 somewhere between $14 billion and $19 billion of assets under management. While imprecise, this growth is impressive given this figure was essentially zero in 2012.

We believe parallels can be drawn with history, and the growth in a similarly disruptive innovation of its time — the online investment platform industry: Charles Schwab saw its assets under management grow to $10 billion over its first 10 years, and added almost another $200 billion over the next 10. We see potential for robo-advice to follow a similar path.

Industry estimates of the potential size of this market vary wildly

There is no consensus on the likely future size of the Robo-Advisor market:

- **US: $300 billion by end 2016, $2.2 trillion by end 2020.** In a June 2015 study looking just at the US robo-advised market (i.e. excluding virtual advice services where there is a human advisor) consulting firm A.T. Kearney projected Robo-Advised assets of $0.3 trillion by end 2016, and $2.2 trillion by end 2020. It projected broadly equal contributions to growth from shifts from non-invested assets (e.g. cash deposits) and invested assets (equities, mutual funds, pension accounts, credit market instruments).

- **Global: $13.5 trillion total addressable market.** In a June 2015 report, McKinsey estimated the potential value of personal financial assets that could be served by virtual advice at $13.5 trillion, split into $6.4 trillion in North America, $3.4 trillion Asia, $3.3 trillion Europe, $0.4 trillion Australia and $0.1 trillion Latin America. This assumes that 25% of affluent households ($100k to $1 million in financial assets) and 10% of high net worth households ($1to $30 million) are prime candidates for virtual advice. Once again, this is a figure for all virtual advice, not just robo-advice.

- **Global: $14 billion end 2014, $255 billion by end 2019.** In its September 2014 report, Swiss firm MyPrivateBanking Research estimated that global asset under management managed by Robo-Advisors would reach $14 billion by end 2014, with 83% managed in the US. Within five years, the firm forecasted robo-advised assets could grow to $255 billion.

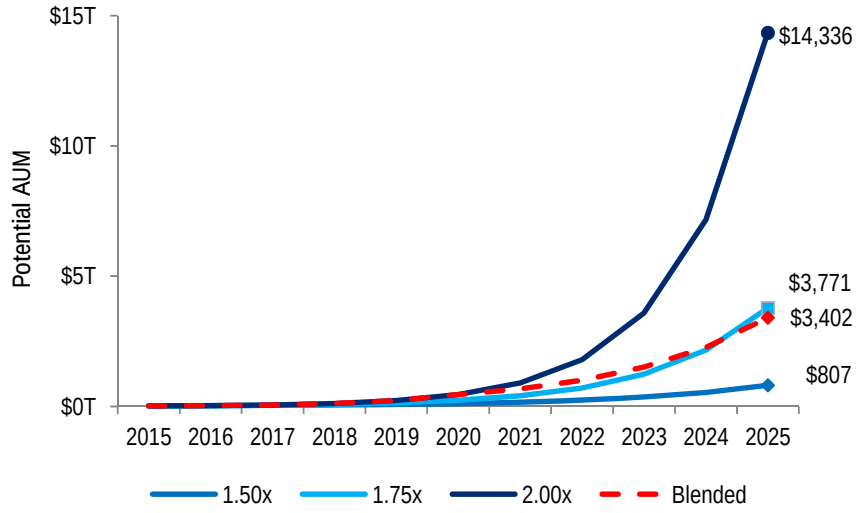
- **Citi: Up to $5 trillion over the next 5 to 10 years.** Based on the distribution of younger individuals within the population, and the net investable wealth those individuals hold, we estimate the Target Addressable Market for Robo-Advisors could be $1 to $5 trillion over the next 5 to 10 years. Most of this in the US, but within this we estimate $500 billion in the UK.

At present, some of the larger players (including Betterment and Wealthfront) are doubling their AUM on an annual basis, and our discussions point to $2 billion in assets as the level of critical mass where asset growth becomes more consistent and robust.

In Figure 43 we look at potential growth rates for Robo Advisor AUM. We start with end-2014 Robo Advisor AUM of $14 billion, and plot different trajectories. While 2x growth is likely unsustainable long term, we plot annual growth rates of 1.5x-2x, as well as a blended growth rate of 2x for the first 5 years and 1.5x thereafter.

We expect the blended growth to be the most likely outcome. This reaches $448 billion by end 2020 and $3.4 trillion by end 2025, consistent with our $1-$5 trillion target for 5-10 years.

Figure 43. Potential Growth Trajectories for US Robo Advsed AUM, Staring at $14B, end-2014



Source: Citi Research

Barriers to Adoption – or the Risks to Robo

While Robo-Advisors pose a threat (or at least disruption) to various business models within the Asset Management space, multiple factors could slow their ability to take share, including:

- **Untested through the cycle:** Robo-advice has only really been around since 2012, and the algorithms employed by automated online investment tools have not been tested through a crisis, or bear market environment. Investors may be comfortable with allocating their investments to a Robo-Advisor and passive/index-tracking funds in good times, but when markets fall, the appeals of human, active management may suddenly re-assert themselves.

- **Start up vs. Incumbent:** We see Robo-Advisors posing the greatest competitive and substitution threat at the lower value end of the advice sector. If larger incumbent platforms/broker-dealers can commandeer, rather than be replaced by, this new market segment, this could reduce the disruptive impact of Robo-Advice.

- **Fear of passive outperformance over active:** Robo-Advisors typically allocate client portfolios to ETFs, helping to keep the total cost of investment as low as possible. Investors' "comfort level" with ETFs and passive funds could be a key barrier to adoption of the robo-advice model. Or, if active fund managers can start to demonstrate significantly superior investment performance to passive funds, this could also delay uptake of robo-advice.

- **Cyber Security threats:** Following a number of data breaches in 2014 (Target, Lowe's, Sony, J.P. Morgan Chase), firms across all industries are increasingly focused on protecting their information. Given the direct impact to an individual's financial security, a breach of Robo-Advisor data would dampen growth, we believe.

- **Customer loyalty:** We are yet to see if brand loyalty is maintained following one of the above risks. While "ease-of-use" and the ability to increase/decrease account size quickly is a benefit during Bull markets, it likely makes assets less sticky and prone to outflows if relative performance (to other Robos or Active) is poor.

- **Wealth sits in the "wrong" demographic:** To date, start-up ventures such as Nutmeg in the UK; Wealthfront, Betterment, Hedgeable in the US; have been most successful with the younger demographic and have gained less traction with more affluent, older individuals. According to Betterment, 75% of its customers are less than 50 years old, and its average client is a 30-something professional earning $150k a year. At Wealthfront, 90% of customers are less than 50 years old, and 60% less than 35 years old.

Figure 44. Robo Advisors – SWOT Analysis

Strengths	Weaknesses
• Low cost, highly scalable, solid margins	• Subject to glitches/cyber attacks
• Can be a tool unsed by a Financial Adviser or do-it-yourself investor	• Challenges around tactical allocations
• Easy to use, understand	• Uncertainty around cash sweep/economics
• Better returns (supposedly) vs. passive/index	• Not yet tested 'through the cycle'
Opportunites	**Threats**
• Huge AUM target addressable market	• Can be copied and replicated without additional fees
• Essentially a lower fee TDF/Asset Allocation Fund	Unless offering a continued service (rebalancing)
• Millenials want online products	• Pushback from tenured Finanial Advisors
• Rising affluence in younger generations	• Fiduciary responsibility?

Source: Citi Research

Not all Robo-Advisor platforms will survive and thrive. The US alone has seen over 200 launches in this space.

Our View of the Future

Disruption risk

We expect the competitive impact of pure Robo-Advisors to be focused in specific segments of the financial advice client base:

- Lower value accounts, and/or individuals with straight forward investment needs
- Younger, more tech-savvy and price-sensitive clients

But the future is hybrid?

For the rest of the wealth management industry, rather than seeing Robo- as a direct substitution / competition for financial advisors, we think it more likely that an online offering will become subsumed into the 'normal' offering for financial advisors and wealth managers.

Longer term, wealth managers adopting a 'hybrid' virtual and in-person advice model should be able to improve the productivity and reach of their financial advisors network, and improve the operating efficiency of their business, without removing the bespoke nature of complex financial advice.

Web-meetings, more frequent digital rather than face to face contact, should – in our view – become more prevalent within the wealth management / financial advice industry as the millennial generation matures and grows in both age and wealth.

Passive vs. Active.

Robo-Advisors typically allocate client portfolios to passive funds and ETFs, helping to keep the total cost of investment for its users as low as possible. As such, we see significant growth of robo-advice as explicitly negative for future allocations, and so future net flows, to traditional active asset managers. We see this as yet another factor pushing investors towards passive, and away from active fund management options.

9. Sharing Economy

Assessing the Threat Level

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The 'sharing economy' – which is sometimes also referred to as the 'peer economy', the 'on-demand economy', 'collaborative consumption', and other similar terms – has been a disruptive trend not only for the consumer Internet sector in general but for several specific industry verticals. You only have to ask a taxi driver in San Francisco or a hotelier in Paris to get a sense for how disruptive sharing economy businesses like Uber and Airbnb have been for large and, presumably, well-established industries.

There are several definitions of the sharing economy but they tend to leverage the Internet as a transaction platform, rely on trust and safety and are the result of mostly individuals driving the virtual economy

What is the sharing economy? There are several definitions, and little consensus. Many consider online e-commerce marketplaces like eBay to be the earliest representation of the sharing economy. In these early instances, individuals began to leverage online marketplaces to buy and sell from other individuals. These models share many of the same attributes of what are today more commonly thought of as leading shared economy businesses. They leverage the Internet as the transaction platform, they rely on trust and safety, they are the result of mostly individuals (not large businesses) driving the virtual economy and they benefit from the network effects that are derived by scaling both buyers and sellers in the marketplace. They also often involve taking an under-utilized asset and making it more productive, either by fully monetizing (selling) it or by renting it.

What has sparked the rise of the sharing economy? Several factors likely gave rise to the more recent acceleration in the development and use of sharing economy services including:

1. **Entrepreneurs:** The consumer Internet sector is now 15-20 years old and while the early Web 1.0 companies were often founded by relatively inexperienced entrepreneurs that had to experiment with new Internet-based technologies and business models, today's entrepreneurs benefit from experience and/or from the trials and errors of the companies that came before them. For instance, Uber's founder and CEO Travel Kalanick founded his first company in 1998 and Uber, which was his third company, was founded in 2009. The importance of entrepreneurialism is not just relevant for the sharing economy companies themselves but also for the active participants within the sharing economies. The rise of entrepreneurialism in general is a driving force for these businesses (e.g., part- and full-time Uber drivers, Airbnb hosts, etc.).

2. **Technology Costs:** With the development of scaled cloud solutions such as Amazon's AWS, it has become far cheaper and easier for entrepreneurs to launch and scale large online businesses.

3. **Trust & Safety:** Over the last 15-20 years of the consumer Internet sector's existence, even the average Internet user has become more trusting of conducting business over the Internet. Payment solutions such as PayPal have played a role, as have social networks like Facebook that have established greater confidence in building online personas and in online sharing.

4. **Social Networks:** The emergence of social networks like Facebook and LinkedIn over the last 5-7 years has created networks of likeminded consumers that are ready to transact and, like mentioned previously, has resulted in greater confidence in online sharing and transacting. With social networks, the mainstream consumer has gained trust in interacting with and conducting business with relative strangers online.

5. **Mobile Internet:** Many of the largest sharing economy businesses are mobile-only or mobile-mostly companies (i.e., the majority of their transactions occurred on their mobile app). The adoption of smartphones and the development of faster mobile data access networks have been key drivers of the sharing economy for a few reasons, including 1) the ability for new companies (startups) to more freely innovate and compete with incumbent desktop/Web-based companies; 2) the ability to transact remotely when you're on the go; and 3) the ability to layer on important location data as well as to more seamlessly leverage new data such as photos.

The Current State of the Sharing Economy

The size of the sharing economy could be up to $335 billion by 2025

The sharing economy is much more than a concept. While no reliable estimates exist for the size of the sharing economy, PWC did estimate last year that global revenue from "the five most prominent sharing economy sectors – peer-to-peer (P2P) finance, online staffing, P2P accommodation, car sharing and music/video streaming – could rise to $335 billion by 2025, up from just $15 billion today." These are global estimates. While US-based companies like Uber and Airbnb seem to capture many of the headlines related to the sharing economy, the trend is certainly not contained to the US For instance, the Chinese ride-sharing app Didi Kuaidi recently announced it had raised $2 billion in its latest funding round – bringing its total funding since inception to $3.4 billion. There are many more examples of sharing economy businesses that are prospering around the world.

From an individual company or vertical industry perspective, there are already several examples of companies that have embraced the sharing economy model and have, as a result, developed large and disruptive companies. Uber is reported to be on track to generate $10 billion in gross bookings and $2 billion in net revenue this year, and Airbnb is reported to be on track to generate at least $900 million in net revenue this year, up meaningfully from ~$500 million in 2014 and $250 million in 2013. While the two poster children for this movement are Airbnb and Uber, there are many other examples of companies that are disrupting traditional industries by leveraging the sharing economy.

- Ride sharing – Uber, Lyft, Didi, Ola, Sidecar, etc.
- Car sharing – ZipCar, RelayRides, Sidecar, Getaround
- Accommodations sharing – Airbnb, onefinestay, etc.
- Labor/task sharing – TaskRabbit, Zaarly, Mechanical Turk, Exec, etc.
- Wi-Fi sharing – Fon, Joikusoft, etc.
- E-Commerce/Apparel sharing – Poshmark, Rent the Runway, Rentoid, etc.
- Space sharing – WeWork, LiquidSpace, etc.
- Other – DogVacay, etc.

Airbnb & the Sharing Accommodations Economy

Airbnb is a primary example of the sharing economy

Few companies represent the sharing economy more so than Airbnb. Founded in 2008 by Brian Chesky, Joe Gebbia and Nathan Blecharczyk and initially called "AirBed & Breakfast", Airbnb today already has more than 1.2 million rental listings in more than 34,000 cities across more than 190 countries worldwide. At a high level, Airbnb operates an online marketplace model, whereby it connects hosts and renters/travelers and takes a transaction fee for matching this supply and demand and for enabling the transactions. Like most sharing economy marketplaces, Airbnb does not own any inventory (assets/rooms).

Airbnb has considerable scale

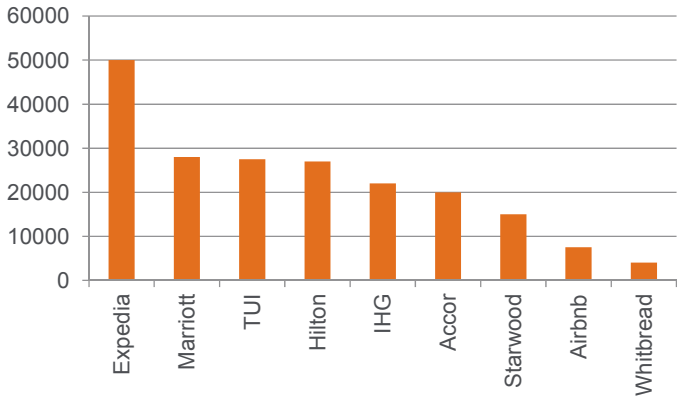
Airbnb has gained considerable scale with over 1.2 million listings, compared to around 15.5 million hotel rooms globally. The idea (using B&Bs, renting a spare room or temporarily vacant home) is not new, but technology has overcome some barriers and created distribution leverage. Customer and host feedback help to create confidence in the product and drive usage and it has built scale and traction with consumers and accommodation providers alike.

A recent Wall Street Journal article[23] reported that Airbnb management expects over $900 million in revenues in 2015. This number reflects the company revenues and not the gross value of accommodation services provided. Airbnb charges both the buyer and seller, adding 6-12% commissions to consumer's invoices and charging 3% administration fees to the host. If we assume the midpoint of this range (12%) this implies the group would achieve gross bookings of around $7.5 billion in 2015 or about 1% market share (Euromonitor estimates the global lodging market at $713 billion).

Airbnb's forecasts for 2020 assume $10bn in revenues or 8% of market share.

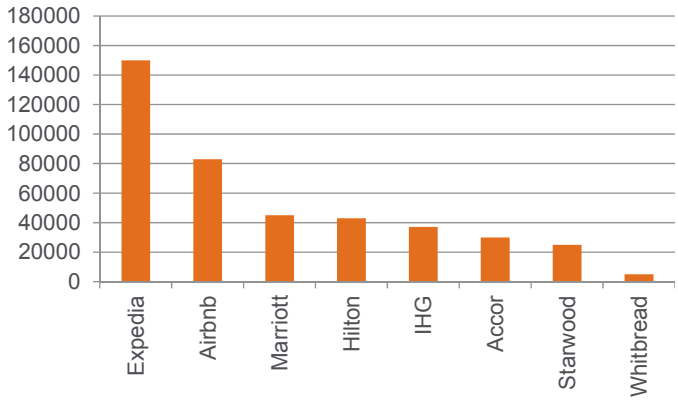
According to the Wall Street Journal article, Airbnb management is targeting $10 billion in revenues by 2020. Assuming a similar commission structure this would imply around $83 billion of bookings in that year or a 9% share according to Euromonitor estimates for market size at that point ($910m). Figure 46 presents a scenario for some key industry players at that point. We assume here that the major online travel agencies (OTAs) continue to grow at 25% per year and that the global hotel groups grow at 10% per year.

Figure 45. 2014 Bookings ($m)



Source: Company Data, WSJ article for Airbnb 2015E

Figure 46. 2020 Bookings Scenario



Source: 2014 Company data with stated growth % discussed above applied, WSJ article for Airbnb

[23] " The Secret Math of Airbnb's $24 Billion Valuation," WSJ, June 17, 2015

How Much of a Threat is the Sharing Economy?

The sharing economy has helped fill the void of hotel room scarcity in large markets

In part we see this strong growth as a pro-cyclical phenomenon. Occupancy has been strong in big cities and many hotels are effectively full. Rising room rates have created white space at certain price points. The sharing economy has helped to fill this void. Arguably hotel room rates should be stronger given the strong demand but are not growing as fast given this incremental capacity.

As a result we acknowledge that the sharing economy may have had some impact in big cities like New York, London and Paris – where revenue per available room (RevPAR) growth is slowing. However we do not think this is entirely due to the sharing economy but also to increased hotel capacity (up mid-single digits in London and New York), weaker inbound tourist flows in New York and London and a weak local economy in France.

Figure 47. RevPAR Growth – Selected Markets

RevPAR growth	NY	London	Paris	Americas	Europe
2009	-26.3%	-3.9%	-12.4%	-16.9%	-16.7%
2010	12.9%	11.7%	10.7%	6.2%	9.9%
2011	6.0%	8.4%	14.3%	8.2%	5.8%
2012	6.1%	1.9%	8.5%	6.3%	4.8%
2013	4.1%	0.6%	1.7%	5.2%	1.7%
2014	2.3%	3.3%	1.1%	7.6%	5.8%
2015 YTD	-4.8%	0.0%	-1.2%	6.5%	10.5%

Source: STR

There is little clear evidence about the impact of the sharing economy on hotels. Boston University completed a study in 2013 that was updated in early 2015. Through its detailed analysis of the Austin, Texas hotel market it formed the following conclusions about the impact of Airbnb: (1) Each 10% increase in the Airbnb market leads to a 0.37% decrease in hotel room revenue. (2) 76% of Airbnb properties are outside the main hotel districts. (3) The impact on Airbnb is magnified as we move down the price tiers. (4) The impact on Independent hotels is larger.

We also consider the growth implied by the group's own projections. As discussed above, Airbnb is projected to grow from a 1% share to 9% share over the next 5 years, based on company statistics as reported in the Wall Street Journal. This raises the specter of significant new capacity coming into the market. However we think this is an oversimplification.

An October 2014 report into the impact of Airbnb in New York by the NY Attorney General shed some light on the business. The report, *Airbnb in the City*, draws on anonymized data on 497,322 private stays in 35,354 unique places. The report concludes that Airbnb is significantly exposed to large-scale operators, finding that 6% of the hosts made 37% of the revenue in the review period. The report also found that 38% of revenue in 2013 was from properties rented for more than half the year, suggesting that these are not ordinarily occupied by residents. These "commercial" hosts are also growing in importance.

This "commercial" capacity worries us less than the informal capacity that Airbnb is known for. We argue that commercial operators will be sensitive to an economic return and therefore this capacity will be self-limiting. We also think that many of these hosts could have already existed and simply switched their distribution channels. This would contrast with hosts who are letting spare rooms in their primary residence to earn supplementary income. These amateur operators are likely to be less focused on an economic return and could possibly add significant incremental capacity at little cost – a more significant threat to overall market capacity in our view.

Assuming about 40% of expected growth calculated above comes from existing capacity the implication is that Airbnb's model is adding only about 1% per year to global lodging capacity. Given the current over demand position in the US and European hotel markets we do not see this as a significant threat however it does cause us to think that the hotel cycle may now be closer to supply/demand balance than we had previously thought.

A Bigger Threat to Online Travel Agents (OTAs)?

Shared economy company Airbnb is a bigger threat to online travel agents than hotel chains

Based on the WSJ numbers, the suggested growth of Airbnb would add another scale player into the lodging distribution mix, one that could challenge the OTA's in scale terms. As Airbnb continues to grow its "commercial" base we think it could increasingly compete with OTAs and offer a much more cost effective distribution model for small and independent hotels – after all it charges 9-15% of room revenues compared to up to 25% for OTAs. In addition, given the costs of operating a website and interfacing with OTAs, the Airbnb approach could become a more cost effective and simpler to operate alternative for small to medium sized lodging providers.

In this context we think the growth of the sharing economy model may not be such a threat to the hotel industry. Smaller operators may find they have a cheaper form of distribution and the large branded chains can refocus on what they are good at and use their scale to drive distribution.

Public Policy and Safety issues

For all the strong growth we note a number of challenges over the legality of some listings, tax compliance and fire safety compliance. These challenges revolve around the use of residential premises for commercial use and for short time periods. Local laws may prohibit certain types of residential property being let for short periods.

The broader issue that a number of City authorities are facing is that residents could be squeezed out of city centers if residential units are substantially used for short term lets. The higher return available from short term lets may also push up property prices further exacerbating the problem. This has broader public policy ramifications and authorities in, for example, New York and Paris appear to be tightening up the supervision and compliance with local laws as a result.

We also see issues with regard to fire safety compliance. There is currently no way of knowing for sure whether the dwelling has appropriate fire-safety measures and escape routes in place or if smoke detector devices are appropriately fitted. Contrast that with the large global hotel chains which are required to enforce strict compliance with local fire codes.

We don't expect these issues to be resolved quickly and in the meantime publicity of these issues could deter participation by hosts and travelers alike. On balance, we think the path of the sharing economy is unlikely to be significantly impeded by legislation and rather we see some evidence that authorities are amending rules to allow this activity to continue. For example in London the government has removed restrictions on homeowners letting their properties for periods of under 3 months. Amsterdam also recently passed a home sharing friendly law that permits residents to rent out their homes for up to 2 months of the year.

10. Virtual & Augmented Reality

What Do We Really See?

Kota Ezawa
Japanese Industrial & Consumer Electronics Analyst

We have already recently seen Virtual Reality/Augmented Reality (VR/AR) escape its previous confines as a toy for hard-core gamers. We now expect VR/AR to forge an intimate presence in people's lives in a variety of work situations and also in the field of such entertainment as movies and games, with users obtaining assistance with things such as vehicle navigation and daily lifestyle information. We see the market for hardware, networks, software & content and services reaching $200 billion by 2020. This suggests that VR/AR developers are not aiming for the technology to be confined to devices such as goggles and eyewear. The related markets are broad in scope: in addition to infrastructure and devices that display virtual information and allow users to hear, touch, and communicate with them, there is a market for content and software for sound and graphics for virtual spaces and information to be built out on these devices and infrastructure and one for service industries related to acts of consumption that are mediated by these experiences in virtual reality. We believe destructive creation, in which merchandise and experiences in existing and inconvenient reality are swiftly replaced, is striving to happen.

Figure 48. AR: You Can Touch 3D Hologram

Source: 123RF

Figure 49. VR: Project Morpheus – Wearing Google

Source: 2015 Sony Computer Entertainment, Inc.

Figure 50. AR: Overlay CG on the Real view

Source: Pioneer Corporation

Figure 51. VR: You Experience Totally Different World in VR

Source: 123RF

What is VR?

VR visualizes using two displays so that it appears computer graphics are being viewed with both left and right eyes. Users don goggle-type displays that completely cover their fields of vision, so they feel, illusorily, as if they have placed themselves in an artificial space. As users turn their heads to the right, in tandem with this the images move smoothly rightward into the field of vision. If users look upward, the skies open up, studded with stars. If users don headphones they can hear the sounds of a virtual world (sometimes birds chirping and sometimes machine guns and combat aircraft), and they completely lose confidence in the knowledge of where they are.

What can users do?

The key characteristic of VR is that users truly feel as if they have placed themselves in a virtual space. Viewing high-resolution computer graphics in 3D, users are enveloped in a sense of reality that differs from the feeling of "really being there" or of a powerful performance. This is generally known as immersion. By drawing users into virtual spaces and information, the experience is changed into one in which games or movie-watching become highly immersive. This has lots of applications in the commercial sphere alone, and we expect ramp-ups to be relatively rapid in areas such as remote medicine, military drills and pilot training, simulators for auto driving instruction, etc. Leading candidates for future VR adoption includes as participation in meetings from remote locations and business discussions.

What is AR?

Augmented Reality (AR) resembles VR but it is not necessary for users to immerse themselves in virtual spaces. Indeed, it can be used by overlaying the requisite information on the scenery (field of vision) in the current world, with computer graphics being used while users are aware of the current world. In AR, it is possible for users to view objects, people and information such as words and arrows created by computer graphics as real-life images that appear to have risen up in real space. Unlike in VR, users view AR images and information such as computer graphics while remaining aware of the real-world space, so they are expected to use AR while walking in real spaces, riding in vehicles, and engaging in communication.

Prospects for Virtual and Augmented Reality

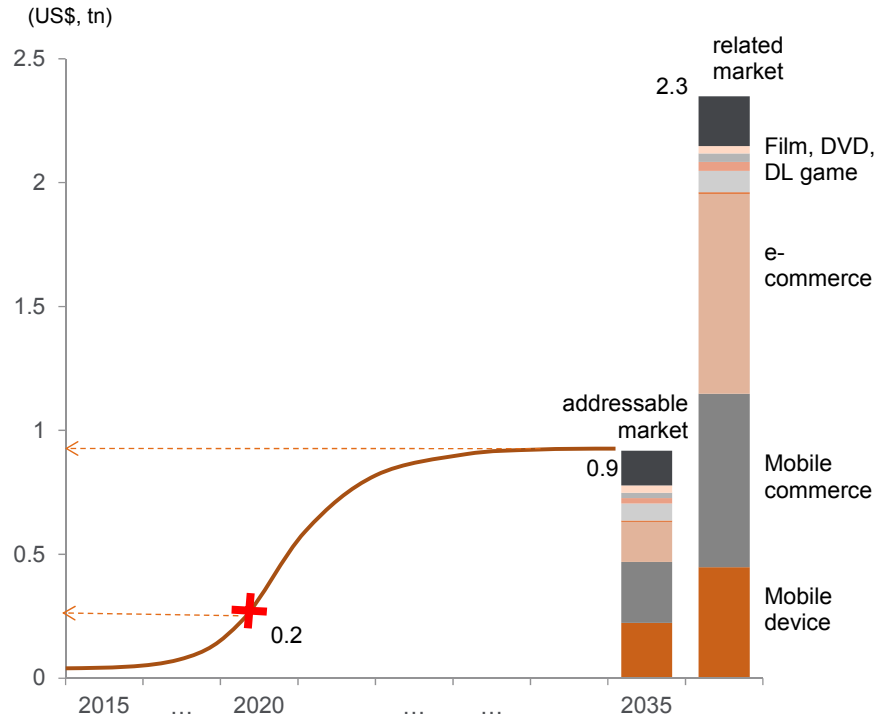
VR/AR prospects

The leading market for VR is games and images that look to pursue the most intimate experiential development, using the sense of immersion. Both the gaming and imaging industries have been taking the lead for a while in the creation of visuals that create this immersive sense via the technological evolution of VR. We think VR using 3D goggles could engender significant innovation in the way content is created, watched, and played. Games and movies can only be experienced in one place but they match well with VR. We also think there is considerable potential for the use of VR in amusement parks and theme parks. However, we think that AR has greater commercial potential and envisage the market growing larger than that for VR. Moreover, AR is delineated on the skein of a real space, so placement precision and the quality of the sensor response, for instance, need to be at an even higher level than in VR. As a consequence, we think the hardware devices such as smart eyeglass frames that realize AR will form larger markets than VR ones. After hardware, we are most optimistic about consumer markets and think AR here has the potential to be a major constituent element of contemporary mobile commerce. Moreover, we would expect the information itself that is overlaid and displayed as AR on real spaces to form a major constituent element of the market value. That is, we envisage a structure whereby the user puts on an eyeglass-style device and spends money because he or she obtains information in front of their eyes about the degree of popularity of a product and how well it has sold to date. We also think advertisements might be displayed. It is not easy to make projections of the size of the markets for these constituent elements but the main constituents are in our view likely to be hardware, commercial services, and entertainment services and we note the potential for rapid market expansion.

Estimating market scale

We feel the VR/AR market is one with a long tail and that it is not easy to estimate market scale. Taking a big picture view, we think AR has the properties required to substitute for the current smartphone market and that VR has the properties required to substitute for the current game and movie industries. VR game applications are the field where we think the obstacles to diffusion are lowest and here we expect 2016, when makers of major game machines such as Sony and Microsoft are slated to announce goggle-like game terminals, to be the year VR takes off in earnest. Taking this as the starting point and envisioning the spread of VR/AR over the next decade, we see the end-market reaching $200 billion in the first five years.

Figure 52. VR/AR Market Potential



Source: Citi Research

Changing our world

By projecting virtual objects or people in real space through the use of AR, it has become possible to intuitively convey images of objects or people that previously had to be imagined. By superimposing 3D computer-generated imagery over real-time images, AR allows users to view and touch objects from different angles in an almost realistic fashion and to use a gyroscope to adjust views and aspects. This not only offers greater convenience, it may also affect human sensibility. Put another way, humanity's desire to own material things and infrastructure could wane and the importance of objects existing physically before one's eyes could also diminish.

In the world of AR, it is also possible to superimpose text, statistics or other information forms over real-life images or background scenes. We believe this will bring life changes similar to those triggered by the birth of the Internet. As this technology not only allows explanations of immediate events/phenomena even where there is no prior memory or knowledge, it also makes it possible to obtain information to augment existing knowledge such as up-to-date information and

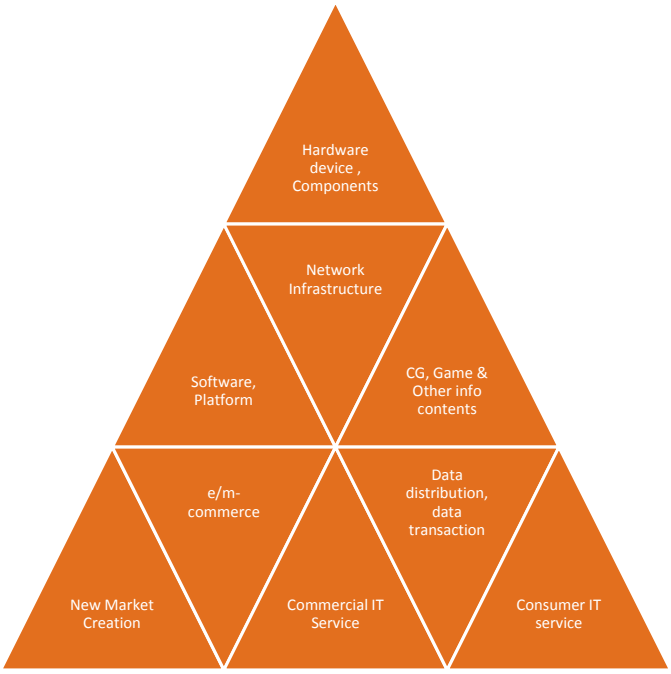
statistics (support ratings, sales, traffic news, etc.). Customizing such information to an individual's needs also appears feasible, especially when linked to profiles, data sets and productivity applications relevant to that user.

The use of VR can simulate environments that give the impression almost of a novel scene. Using a headset or similar device, the VR visitor normally stands in a certain space, or in some cases sits in a chair or lies on a bed. VR not only includes sight and sound, but if sensors corresponding to each of the five senses are applied to the body, the overall virtual experience can deliver a level of awareness that transcends the physical body. For the user, VR heightens the perception of being physically present in a non-physical world, a perception that is created as the user's awareness of physical self is transformed by being immersed in a virtual space. We believe the use of VR in entertainment applications such as games and movies will deliver a relatively more realistic experience. The field has attracted a wide range of participants, including hardware makers, software makers, content developers, retailers, and service providers.

Broad range of participating industries, including hardware, software, content, retail, and services

As VR/AR has the potential to replace parts of many existing industries, the range of related technologies, businesses, and companies is wide. Hardware not only encompasses displays for visual content and headphones for sound, but also includes key electronic components—sensors such as accelerometers and gyro sensors—which ensure that images adjust as the user's head position (line of sight) changes. As with goggle- and eyeglass-type headsets, we believe the importance of sensors is likely to come to the fore when VR/AR advances to include hand and feet wearables. In the creation of highly immersive games or movie content, we feel technical quality will play a central role overall. Finally, an industry to manage such platforms is indispensable. We surmise that such a role could be performed by the retail industry, which handles e-commerce and that a variety of service industries will broaden business breadth by bringing on board VR/AR. In business scenarios, an example application is field service, where a technician could have reference material displayed while making a repair and even a "walk-through" of a repair superimposed through AR in the field.

Figure 53. AR/VR Supply Chain



Source: Citi Research

Figure 54. AR/VR Related Company List

Hardware	Components		Semiconductor	Network Infrastructure	SW, CG, Contents	Commerce	IT Servece
· Microsoft (Hololens)	· Sony	· TE Connectivity	· STMicro	· IBM	· IBM · Microsoft	· Amazon	· Gamification
· Google	· Chicony	· Amphenol	· Asahi Kasei	· Fujitsu	· salesforce.com	· Alibaba	· IBM
· Facebook (Oculus)	· Japan Display	· Sensata	· Sony	· NEC	· Adobe	· Walmart	· Fujitsu
· Sony (Project Morpheus)	· AUO	· LG Display	· NVIDIA	· Verizon/ AT&T	· Autodesk		· NEC
· Samsung	· Samsung	· AMD	· Intel	· NTT/ KDDI/ Softbank	· Oracle · SAP		· Oracle
· HTC · GoPro			· Qualcomm	· China Mobile	· Disney · Fox		· Infosys
· Apple							· SAP

Source: Citi Research

Which Companies are in the VR/AR Market?

Apple

Apple is considered both a Hardware and possibly a Mobile Commerce company, recently purchased Metaio, which develops AR tools that use 3D tracking capable devices (e.g. iPads and iPhones) for development and deployment of AR apps. We believe Apple's next generation iPhone 7 (expected in 2016) to include dual cameras that would enable AR images. It's possible that Apple could use Metaio's AR creation tools to introduce unique AR features to Maps and other apps. A use case would be an app that lets you point your phone at a street to see what businesses are nearby, or a restaurant's exterior to see the menu or specials.

IBM

IBM likely falls into the Software and Commerce categories. The company has unveiled several mobile applications that leverage their AR technology patents. Some of the examples are 1)a personal mobile shopping app enabling consumers to pan across store shelves and receive personalized product information, recommendations and coupons; 2) a mobile maintenance, repair and operations (MRO) prototype system designed to help manufacturers and companies supplying

and maintaining high-value machinery in sectors such as aerospace, oil & gas and shipping to aid field engineers to accurately locate equipment, provide them with critical information and receive real-time visual support from supervising experts based remotely and 3) helping data center administrators find and manage assets.

Connector companies

Our total addressable market (TAM) analysis indicates VR/AR applications can contribute 2% and 4% in incremental demand to the connector and sensor total market respectively. We believe Amphenol, TE Connectivity and Sensata will both benefit from the increasing use of VR/AR devices. TE Connectivity is currently the largest connector company in the consumer device end market. Amphenol could benefit give its long tradition in the Apple supply chain and we also believe Sensata could benefit from AR application in industrial segment.

AMD

AMD seeks to leverage its strengths in the core PC gaming segment into VR market. In March 2015, AMD announced its “LiquidVR” virtual reality technology initiative. AMD’s LiquidVR software development kit helps developers effectively combine AMD’s graphics processing unit with its virtual reality software to enhance user experience with features such as low latency and high refresh rates. We believe it will be another 3 to 5 years before virtual reality represents a more meaningful portion of AMD’s revenue as the industry is still nascent.

Sony

Sony has announced a virtual reality headset called “Project Morpheus”. It is expected to be used to enjoy content (mainly games) on the PlayStation platform and also for 3D video.

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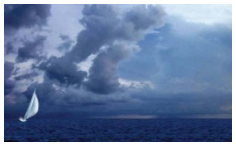

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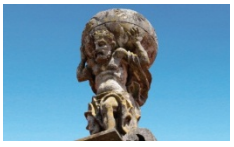

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REGULATION

The proliferation of novel biologics coupled with premium pricing means that biologics now account for almost 30% of total drug spend — and that proportion is rising rapidly. / Regulation approved by the US FDA paved the way to approval of biosimilars, whose commercial success is an important and necessary "safety valve" in allowing US and EU healthcare budgets to continue to reimburse premium highly innovative therapies in the wake of an aging population.

TECHNOLOGY

Machine learning and artificial intelligence (ML& AI) have fallen short of the promises of computer scientists and the fantasy of science fiction. / However, ML & AI is here now, it continues to improve and it is increasingly disruptive through direct impact and as a building block for other innovative technologies. These disruptions occur primarily because of the ability of ML & AI to learn from data and make good decisions.