DISRUPTIVE INNOVATIONS II

Ten More Things to Stop and Think About

Citi GPS: Global Perspectives & Solutions

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DISRUPTIVE INNOVATIONS II

Ten More Things to Stop and Think About

Kathleen Boyle, CFA
Managing Editor, Citi GPS

Disruptive innovation is a term that was first coined in 1995 by Harvard Business School Professors Clayton Christensen and Joseph Bower and explains how "a market or sector is transformed by introducing simplicity, convenience, accessibility and affordability where complication and high cost are the status quo." For the most part, when people think about disruptive innovation, technology is the first thing that comes to mind — smartphones, flat-screen TVs, MP3 players — things that have come on the market that have totally replaced products that we had and make us think "how did we ever live without this wonderful machine".

But disruption can be so much more than just a better way to listen to music. Disruptive innovation can be found in both products and processes — i.e. how we do something is just as disruptive to the status quo as the new technology that enables us to do it. Going back to the advent of the ATM machine, both the technology itself was disruptive, but so was the process — we no longer had to go to a bank to deposit a check or withdraw cash. In this same vein, mobile phones as a technology were disruptive to fixed telephony, but the ability to conduct banking transactions and to pay for goods and services over this new technology is a change in process that has disrupted many industries.

In this new report, Disruptive Innovations II, we take a look at some new sectors where new products could potentially disrupt a market. Four of the ideas that we highlight are related to themes we introduced in our April 2013 report. Following up on personalized medicine, we analyze the $35 billion opportunity in immunotherapy which uses the patients' immune system to fight cancer cells and has the potential to transform cancer from a deadly disease into a chronic disease akin to HIV. In technology, we progress from 3D printing to 4D printing by adding the dimension of self-assembly to a 3D printer-generated object. In solar technology, we note the recent rapid uptake of solar in Germany and Japan and how new technologies in energy storage are emerging that should remove more of the cost barriers for solar adoption and also reduce the cost of electric vehicles. Finally, in banking we expand our thoughts on mobile payments and look at how mobile payments have digitalized banking in general and raised financial inclusion, especially in emerging markets.

There are also some different areas of innovation in this new report. Typically thought of as a sleepy industry, insurance wouldn't normally be thought of as a place where you would find disruptive innovation. But the latest surge in insurance securitization through the issuance of insurance-linked securities (ILS) has disrupted the market and forced industry players to consider potentially radical changes to their existing strategies. The emergence of digital advertising could breathe life into an industry that was becoming commoditized while farmers are looking to new technologies to greatly enhance productivity in one of society's oldest professions. Other innovations may change how we do basic things in the future: how we drive (possibly with electric vehicles), what we use for cash (digital currency) and who our colleagues are at work (maybe R2D2 and CP3O).

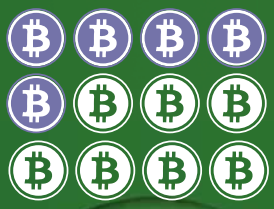
There's big opportunity out there

4D Printing

4D printing takes 3D printing to the next level by directing the object to **change shape and potentially self-assemble**

Digital Banking

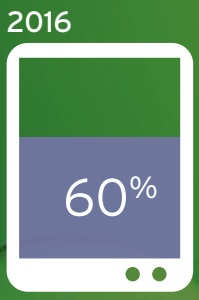
Global **m- payment** volumes are expected to total **$447 billion by 2016**, a **3-year CAGR of 86%**



$5m

Digital Currency (i.e. Bitcoin)

.More than 200 digital currencies exist today, with **12 having marketing capitalizations > $5 million**



Digital Marketing

Real-time bidding-based digital ad spend is expected to reach nearly **60% of total display and mobile spend by 2016**, a 3-yr CAGR of 66%

Electric Vehicles

Introducing a battery operator servicing model could reduce the cost of an **electric car to the $10k** range

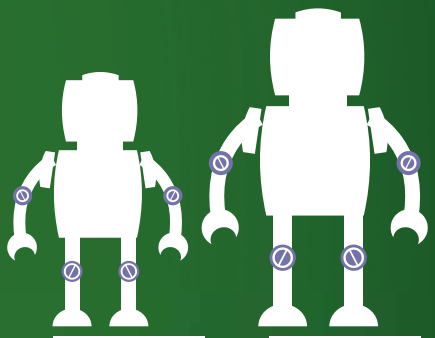
$35 billion

Immunotherapy

Immunotherapy has the potential to **turn cancer into something akin to a chronic disease** – a $35 billion opportunity

Energy Storage

The economic value of energy storage over a 10-year period in the US could be $228 billion, **21% of the $1 trillion global economic benefit**



2012 $25bn

2016E $30bn

Insurance Securitization

Since 2012, the new issue market for insurance -linked securities has grown by 30% per year and **issuance could be $60 billion by 2015**

Robots

The market for industrial robots is forecast to grow with almost **200k units expected to be sold in 2016**

Precision Agriculture

To support a **population that is growing by ~75 million people per year**, agricultural producers will need to **boost production of key crops by 20%**, on average, over the next decade

Contents

10 Reasons Why Innovation is Like Surfing

Deborah Hopkins
Chief Innovation Officer
Citi Ventures

Four years ago I gave a speech at The International Business Forum (IBF) in Newport Beach, CA on how innovation is like surfing. It was on the eve of Citi Venture's move to Silicon Valley and it seemed an apt metaphor. The metaphor still stands up today, but I figured it could use an update, just in time for summer. Here is the 2014 version:

1. **Waves form a thousand miles out at sea.** It occurred to me back then that trying to harness the disruptive forces happening in the Valley from the other side of the country was a fool's errand. Like trying to catch a wave forming miles off the coast. I had to go to where the wave was - become a member of the community, recruit a Valley-based team who could bring their own networks and know-how to the table and help us sort out the most relevant trends and technologies for Citi. Now in 2014 we are confident that being here, engaged and involved, is the only way to do this effectively. Having the opportunity to see the future form and the chance to ride the wave is invaluable.

2. **It looks easy but it's not.** Watching surfers gracefully yet boldly ride monster waves is breathtaking. You see firsthand how seemingly at ease they are before and after the ride. Onshore there are plenty of high fives but there's also a cool nonchalance about them. It almost makes you think, "I could do that". Until you try it. When you emerge half-drowned, board-scraped, bruised and beaten it becomes clear…this is no amateur sport. It requires endless practice and patience. Innovation is like that too. Done well it seems simple. But underneath the simplicity is an incredible amount of hard work, smart experiments, and spills that require us to get back up on that board and go again.

3. **There are sharks in the water.** For surfers this is always a concern. A dangling foot can be a tempting snack. Innovation is about change. Let's face it, human nature is resistant to change. It feels threatening. It challenges the status quo. It feels incongruent. There is comfort in what we know, what fits into our framework. Even when the disruptive factors are clear, what we know feels safer. At its core, change elicits the fear we will be no longer relevant. When you are the innovator, sharks move in quickly to ridicule, discredit, and challenge the need for change. But that's part of what makes the ride so fun and something to celebrate when you have a good one.

4. **People are watching from the beach.** Surfing competitions always draw a crowd. Like many sports, the crowd cheers the victorious and witnesses the defeated. I remember as a teenager my mother told me about the term "schadenfreude" when she found me sobbing over a hard loss. She told me that others can take joy in watching a David take on a Goliath and fall flat on his face. But like David, innovators know we have a purpose, we believe we can make the world a better place. And we know that the spectators watching us from a comfortable distance may applaud our victories or wince at our defeat.

5. **Most rides are not wildly successful.** Ah, another fact of life in surfing. But one fantastic ride provides the motivation to keep trying. Perfect the approach, the entry into the wave, the footing. Because when it all comes together, the ride is worth all the practice. Innovation is precisely like that. Test, test, test, get it right. Don't get discouraged. Be a maverick. Push the edges a bit further and bingo…it can be the ride of your life.

6. **Storms can provide the best conditions.** Surfers are always on the lookout for the big waves. Often these occur when the weather is wild, and the rest of us are inside. But when Mavericks Invitational Surf Contest is called in Half Moon Bay, CA they come from around the world to try their luck. They courageously enter the raging swells. Innovation can be like that too. Ideas that didn't work before may get their footing in a storm. It takes guts to do something ground-breaking. Timing in surfing and innovation is everything…along with some luck.

7. **You can't practice on land.** Talk to any great surfer and ask him how he chooses the wave to ride. He will say "I know it when I see it." Intuition is something we are all born with. Unfortunately, traditional education usually drums it out of us by requiring evidence to support a thesis. Innovation requires listening, grabbing an inspiration and riding it where it goes. What happens next is the dots connect. For me I literally hear a bell go off when this happens. And then everything just falls into place - right people show up when I need them. You are in the slot….riding the wave.

8. **Surfers hang together in a strong community.** They get energy from each other. They encourage each other to keep going. They learn from others' attempts. They assuage their fears. They share a common understanding of the sacrifices involved, the injuries incurred. Innovators are like that too. Numerous forums exist that bring together change-makers from across multiple industries. We hear from the best, we meet new potential partners, we leave refreshed and reinvigorated to push harder.

9. **Honor the sea and each other.** Surfers love the ocean, the beauty of the waves and the chance for the perfect ride. But they also know it can be deadly. 'Dropping in' on another's ride is uncool and could endanger both riders. It's part of the code. Innovators know this too. We love what we do and we understand the risks inherent in pushing the edges of convention. And we honor our partners, steadfast in the belief that in doing so we can create a winning ride for everyone.

10. **The search for the perfect wave is endless.** Any surfer will tell you about the ecstasy he feels when he slides into the shore after a killer ride. Everything that came before was worth it. Innovation is like that too. When dots connect and you feel that click of it locking in, you are momentarily invincible. It's a rush. Dude, let's do it again!

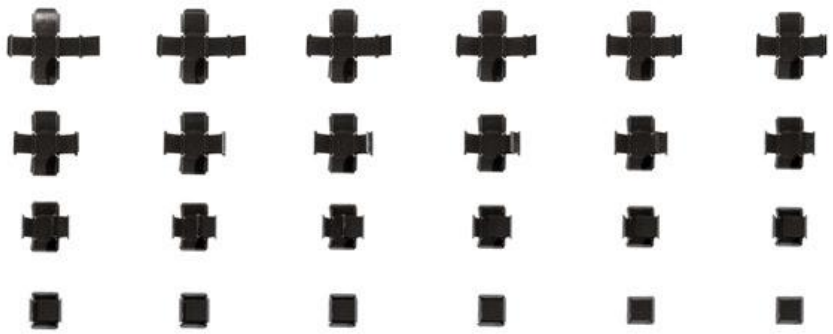
4D Printing

Kenneth Wong, CFA
US IT Hardware and Software Analyst

The industrial world has been continually pushing deeper into the digitization of manufacturing aided by the advancements across technologies such as robotics, computer-aided design software, computer numerical control (CNC) machine tools and 3D printing. It is only natural that the next evolution in the transformation of production centers on the ability of manufactured goods to self-assemble. The concept evangelized by MIT researcher Skylar Tibbits is commonly referred to as 4D printing.

We believe 4D printing has the potential to fundamentally alter the way designers and engineers approach the design, manufacture and interaction with products. The fourth "D" in 4D printing refers to the ability of a static object to change shape and potentially self-assemble over time utilizing different materials which begin to interact with its environment.

Figure 1. Self-folding Cube



Source: MIT& Stratasys

Smart Inputs Must Get Smarter and Better for 4D Printing to Become Reality

4D printing utilizes 3D printing technology….

4D printing utilizes a digital production platform that tightly integrates advanced digital design software with multi-jet 3D printers to manufacture objects in an additive fashion one layer at a time. Computer-aided design (CAD) software allows digital renderings and advanced simulation testing to be conducted on material behavior and the transformative properties of specific designs. While other production processes could also be utilized, 3D printers serve as a critical component in the process. Additive manufacturing (3D printing) allows engineers to design and incorporate structures that are not achievable with traditional manufacturing processes due to the complexity of shape and function. 3D printing also enables designers to use multiple materials simultaneously (i.e., creation of digital materials) which can be natively incorporated into the build in real time. This allows for varying textures, rigidity and material toughness.

….but uses "smart" materials that are programmable and able to change shape

The last and perhaps the most important component, in our view, is the development of "smart" materials that can be "programmed" to change shape with the introduction of an energy source. Currently, one of the most common approaches is the use of absorbent foam like plastic which can be activated with the addition of water (much like expanding foam dinosaurs that grow when you get them wet). Utilizing a 3D printer to build the object layer by layer, intelligence (via more rigid or flexible materials) can be imprinted directly into the actual structure dictating the transformation and the eventual shape of the object.

To Infinity and Beyond…But Not Likely in the Near Future

As it stands today, the potential of 4D printing is both limited and infinite. The concept and many of the technologies associated with 4D printing are still in their infancy which will keep large commercial players from making the significant investments necessary to push the technology forward. At the same time, self-assembly could radically impact a number of industries such as architecture, engineering, furniture makers, healthcare, aerospace, automotive and more.

4D printing for development in remote locations could be a game changer

We believe the potential of 4D printing for development in remote locations is an obvious game changer. 4D printing could potentially allow for large foldable structures that automatically erect in distant, extreme locations that lack traditional construction crews. Self-assembling structures that are tightly folded could also resolve the many logistical problems of delivering large and delicate objects on bumpy space shuttles with limited carry capacity. The technology could also potentially enable medical devices to be implanted into small crevices before transforming to the desired shape.

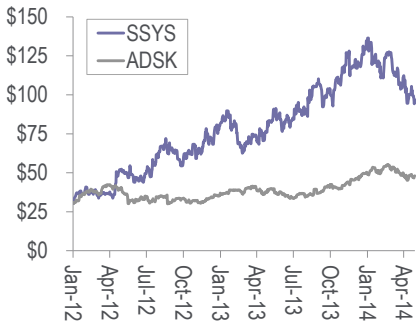
Use of 4D printing could be key in piping and skyscrapers as well as furniture and clothing

Beyond the obvious value of transforming small shapes into large shapes, researchers have also discussed the merits of incorporating the technology into modern day infrastructure such as piping and skyscrapers. Skylar Tibbits spoke of a project that his team is currently working on with pipes that can dynamically expand and contract depending on water flow. Researchers have also expounded on the merits of incorporating fibers into the beams of buildings that can tighten (strengthen) whenever there are significant external vibrations. Some of the simpler consumer concepts that could be conceivable in the near future include self-assembling furniture and clothing that could change its color or hardness based on need could also offer many potential benefits.

Figure 2. Strand of Self-folding Smart Material

Source: MIT, Stratasys

Figure 3. Stock Price for SSYS & ADSK



Source: Citi Research, Factset

Research is being done by academics and corporates to develop 4D printing for commercial use

Early Supporters, Stratasys and Autodesk Best Positioned to Benefit

As is the case with cutting edge research projects, financial support has largely come from academia and government grants. Research is currently being conducted at a number of higher education institutions. At the forefront is the MIT Self-assembly Lab lead by Skylar Tibbits and his team. The US Army recently contributed $855K, split between Harvard, University of Illinois and University of Pittsburgh to help advance projects focused on "4D printing."

Autodesk has been working on a project known as Cyborg, which is a cloud based CAD solution that integrates advanced digital design tools for modeling with cloud-based simulation and rendering services. The platform allows for the programming of matter into a CAD design to enable transformational engineering. Autodesk is also working closely with Mr. Tibbit's team at MIT to better understand and optimize folding sequences on a broader scale.

Stratasys has also gotten involved with Mr. Tibbit's team which is utilizing Objet Connex 3-D printers to combine a range of materials such as rubber and plastics with a water-absorbable material which is currently under development. With the help of simulation software, researchers can strategically place the water absorbent material to "code" specific transformations. The material is currently under development for research purposes only and is not available commercially, but as interest for smart materials accelerates, we believe early innovators such as Stratasys are the most likely to benefit.

Who is at Risk?

At this stage we find it difficult to clearly call out specific industries which would be negatively impacted since the concept is still a research project in the early incubation stage. Moreover, 4D printing is a manufacturing process, much like the assembly line, injection molding and 3D printing which can be adopted by any forward thinking industrial company.

Since the 4D printing model utilizes 3D printing as a foundational manufacturing process, we believe sectors that could lose out from the mainstream adoption of 4D printing (and 3D printing by default) would include machine tools (used to manufacture dies and molds), plastic injection molding companies and possible suppliers of foundry equipment. All are examples of the more traditional forms of subtractive manufacturing which could be displaced in the digital world of 4D printing.

What Needs to Go Right before 4D Printing Becomes a Reality

Barriers to 4D printing are the same as 3D initially

4D printing research is extremely early and the concept remains so cutting edge at the moment that concrete real-world applications have yet to surface, limiting the commercial viability of the technology for the time being. Beyond the lack of a "killer app," 4D printing must still clear a number of hurdles:

- **Improvement in 3D printers** – Quantity and quality are the criteria required of real world capital equipment. While not quite on par with traditional tooling, today's 3D printers have largely addressed quality and precision concerns and 3D printed parts have found their way into jet engines and medical devices. However, speed remains a significant issue. Industrial users commonly highlight build speeds that are 1000x slower than traditional manufacturing methods. We feel that unless the underlying 3D printing technology can meaningfully close that speed gap, mainstream adoption of 4D printing will be limited to academia and very specific use cases thus limiting its commercial potential.

- **Better materials** – Many of the materials currently used in 3D printers do not have the same structural integrity of traditional manufacturing methods (partly due to specific print processes). New "smart" materials are also needed to enable more applications. Materials that can react with different "energy" sources are needed and materials that can better withstand time, pressure and the elements are required for real world structures. The industry will need large materials development companies such as 3M to be more involved to legitimize the cause.
- **Reimagining the design process** – 4D printing will likely encounter the same issues that the 3D printing industry is currently facing. Critics often highlight the limitations of the technology relative to how effectively it can be used to reproduce existing goods. As is the case with 3D printing (largely because the concept utilizes the technology), the underlying value is the ability to create what currently is not possible. 3D printed products, like Invisalign braces, would be nearly impossible to mass produce with existing manufacturing processes due to the uniqueness of each individual mold.

Digital Banking

Ronit Ghose
Global Head of Banks Research

Simon Ho, CFA
Head of Asian Regional Banks Research

Digital-banking includes a disruptive mix of heterogeneous players, with opportunities for efficiency improvements, revenue share changes and new business areas created

Banking and digitization are two sides of the same coin. An industry which is dominated by information and where the products and services are in a sense "virtual" is ideally suited to the digital revolution. Many large banks today already have a larger payroll of IT staff and software developers than the largest stand-alone IT companies. The latest phase in the global banking sector's ongoing digital revolution is the current mobile banking wave. The ubiquity of smart phones in developed markets (DM) and mobiles in emerging markets (EM) is creating opportunities and disruptions across many axes:

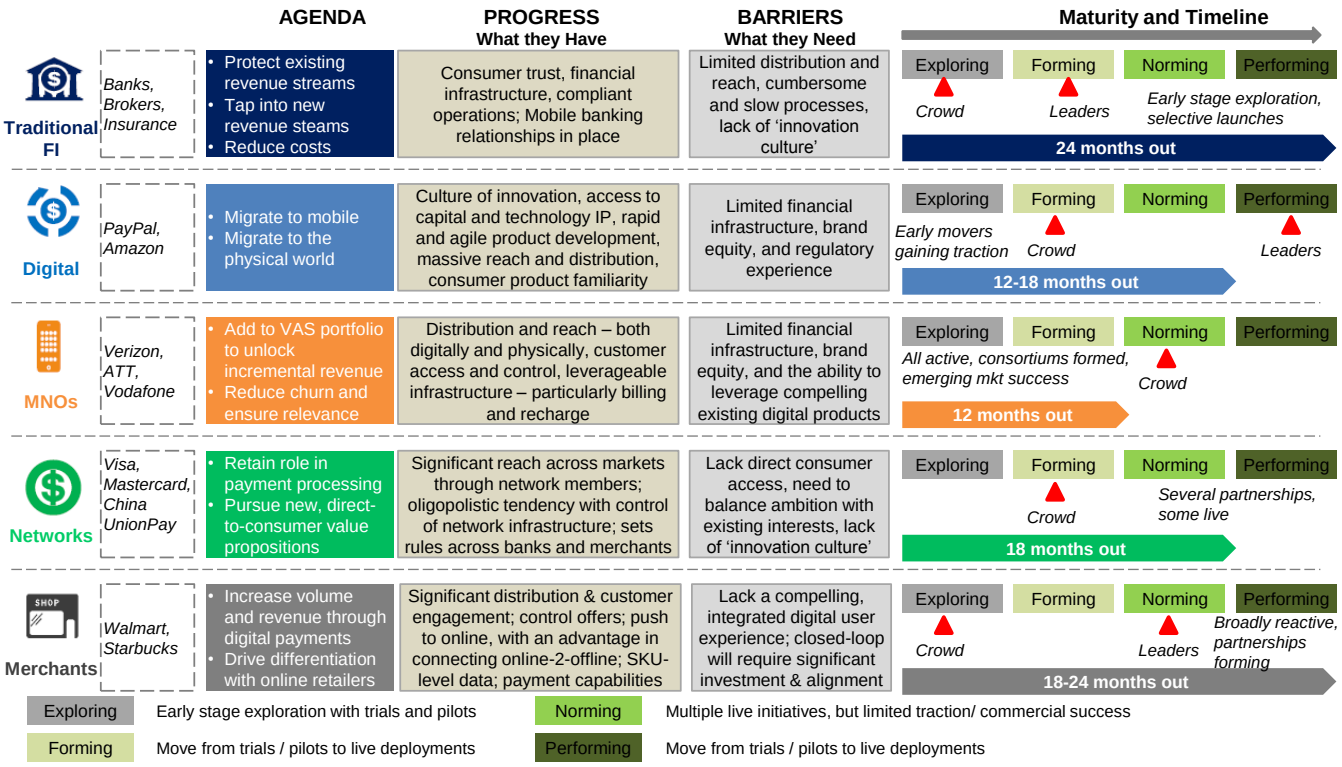
1. Incumbent commercial banks in developed markets can use digital to boost efficiency via the reduction of branch networks and staffing levels. The Nordic region is a good example, with the likes of Norway, Finland and Sweden operating at branch per population densities 2x or more below DM peers such as the UK;

2. Online commerce companies such as PayPal can disintermediate traditional banks in the e-commerce and now m-commerce space;

3. In emerging markets, non-bank players such as telecom operators can reach new, previously unbanked consumer markets, such as M-PESA in Kenya.

The bottom line: competition from digital players, mobile operators and payment providers is eating away at the potential banking revenue pool, especially in terms of future upside growth in EM consumer banking and payments; while on the cost side, greater digitization and increased m-banking adoption can help lower costs.

Figure 4. Diverse Set of Market Players Competing for a Lion's Share of the Mobile Banking Pie



Source: Citi Mobile Analytics Team

The Growth in Mobile Payments in the Digital Age I

Mobile payments have expanded at a fast pace in the last few years, driven by the global uptake of mobile phones, replacing physical wallets. Players like PayPal and Amazon have been early entrants in the m-commerce space following their success in e-commerce. In order to capitalize on the evolving mobile wallet technology, payment providers like Visa and Mastercard have also launched versions of their mobile wallet called 'V.me' and 'Masterpass' respectively that directly compete with physical credit cards.

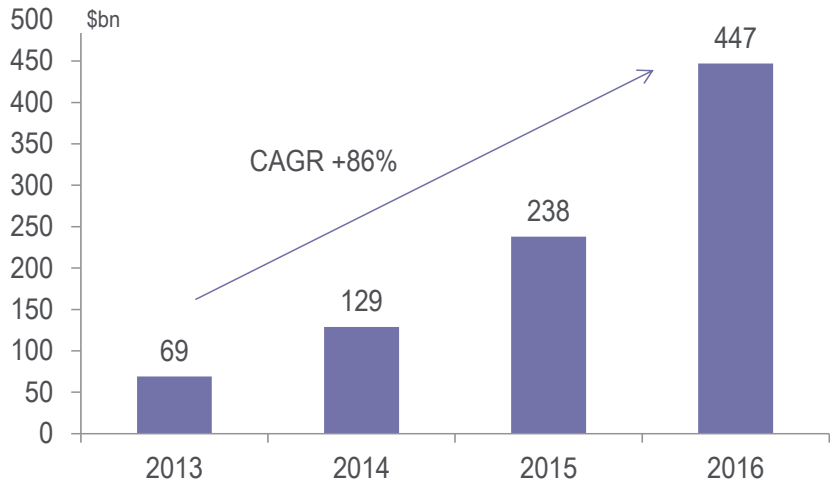
Citi expects m-payments to grow at 86% CAGR till 2016 across 27 key markets

According to a study across 27 key markets by Citi's Mobile Analytics Team, global m-payment volumes are expected to total $447 billion by 2016, growing at a CAGR of 86% between 2013 and 2016 led by increasing consumer acceptance. Increased demand is likely to be driven by unmet banking needs and payment convenience.

US, Japan, China to have highest mobile banking penetration in 2016

Developed markets including the US and Japan are expected to have the highest mobile payment volumes by 2016 owing to stronger penetration of smartphones and customer acceptability. Amongst developing markets, we expect China to lead mobile payments with CAGR of 84% due to higher unbanked population and cash intensity

Figure 5. Global Mobile Payments Volume Forecasts



Source: Citi Mobile Analytics Team

M-payments can be split based on 'how' and 'to whom' payments are being made

The way we purchase goods has changed dramatically with the proliferation of new payments ecosystems. Mobile payments can be segregated into 3 types:-

- **Remote Mobile Payment** – consumers do not interact directly with merchant's physical point-of-sale (POS) but instead use mobile browsers, SMS or dedicated apps to make payments remotely. Commonly driven by m-commerce, bill pay and mobile recharge.
- **Proximity Mobile Payment** – consumer needs to be physically located at retailers' store during the transaction. Proximity payments rely on bar codes, QR codes, or chip-enabled payment technologies like near field communication (NFC).
- **Peer-to-Peer Payment** – allows individuals to pay one-another through a third party where payments can be processed using an e-mail address, phone number or account ID internationally. PayPal is a leader with its Internet payment network.

Where do Opportunities Lie: The EM vs. DM Question?

Users expect feature rich mobile products, e-wallets in developed markets; banks have co-opted digital banking within the existing banking structure, so far ….

Developed markets are characterized by their high degree of technological advancement, wider acceptance of m-commerce, higher banking penetration and an organized retail market. Mobile players offer feature-rich mobile products to entice tech savvy customers seeing opportunities in proximity and remote payment. Developments in digital banking in DM have largely taken place within the auspices of the incumbent banking system, especially in Europe where banks are typically multi-product financial institutions.

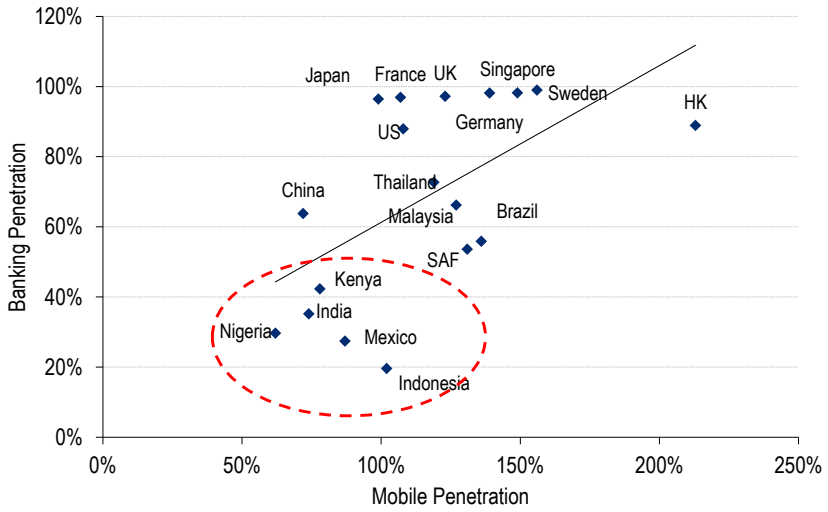
.. financial inclusion and broadening of the bankable population to new demographics is a key driver in emerging markets

Overall, digital money is a bigger opportunity for new entrants in EMs vs DMs, and hence a bigger disruptive threat to EM consumer banking. This is due to relatively superior mobile and dealer network penetration compared to traditional financial systems, including commercial banks. Mobile operators and technology companies may create new m-payments and m-banking markets cutting out traditional banks that have yet to enter markets where an informal economy may be the norm.

Our recent GPS Opinion piece, "Getting Ready for Digital Money" highlights that with half the world's adult population lacking access to formal financial services, the digitization of money is one of the top items on government's agendas all over the world. The financial inclusion agenda can become an additional growth driver.

Many large emerging markets, including India, Indonesia, Kenya, Mexico and Nigeria, boast mobile phone penetration that is several times banking penetration.

Figure 6. Mobile Penetration vs. Banking Penetration for Major Global Markets



Source: Citi Research, GSMA Intelligence, World Bank; Mobile penetration shows SIM penetration per 100 people; Banking penetration shows bank accounts per 100 people (Age 15+Yrs)

China as a middle-income and increasing wealthy but tightly regulated, relatively plain vanilla banking market faces some unique challenges. Disintermediation is also happening in m-payments: Tencent's WeChat has been trying to expand into off-line purchases. The Internet is also changing brokerage sector.

If China follows the pace of disintermediation the US witnessed in the 1970s, i.e., 10% of customer funds flowed to money market funds (MMFs) over five years, net interest income growth could be reduced to 3% pa. But disintermediation could be faster in China today with better technology and information. If disintermediation happens at double this speed, net interest income could be contracting 5% pa.

Global Comparison: M-Banking and M-Payments

Asia highly diverse from m-payment/m-commerce leaders in North Asia to new disruptive players in larger EMs

1. ASIA - diverse set of markets with different payment ecosystems

- Technologically advanced countries like Japan and South Korea are leaders in m-payment with evolved m-commerce and drive adoption of proximity payment.
- Taiwan and Hong Kong are expected to see increasing adoption of mobile payments due to high smart phone penetration.
- Markets like China, India and Thailand with a large prepaid customer base, unbanked population are likely to drive P2P volumes, remote payments.

2. EUROPE – high mobile penetration, diverse mobile services offerings

- Mobile banking is already commonplace and remote payment adoption is expected to increase with growing m-commerce.
- France, Poland and UK are already witnessing significant interest in contactless payments via trials and initiatives.

Non-bank digital players are important in m-commerce and m-payments in North America

3. NORTH AMERICA – strong influence of digital players, sophisticated market dynamics between market participants and tech-savvy consumers

- Influence of digital players (like Google, Apple) likely to create opportunities for remote and proximity payments via use of NFC technology.
- M-Commerce likely to grow, with PayPal already dominating a large share.

4. LATAM/AFRICA – high cash intensity and unbanked population, large prepaid base

- Mobile payment initiatives primarily targeted at unbanked population.
- Brazil likely to see faster adoption of remote payment as a result of quicker m-commerce adoption.

East Africa is the leader in use of m-payments to expand the banked population: M-PESA a financial inclusion case study

- Kenya poster-child for use of m-payments to expand into non-banked population (Safaricom/M-PESA).

Citi along-with Imperial College London, recently published a Digital Money Readiness Index that tracked the readiness for key markets on various stages of digital money adoption. Starting from the incipient stage, markets move to the emerging stage and then to the in-transition stage and finally to the materially ready stage, as they remove barriers on the adoption of digital commerce.

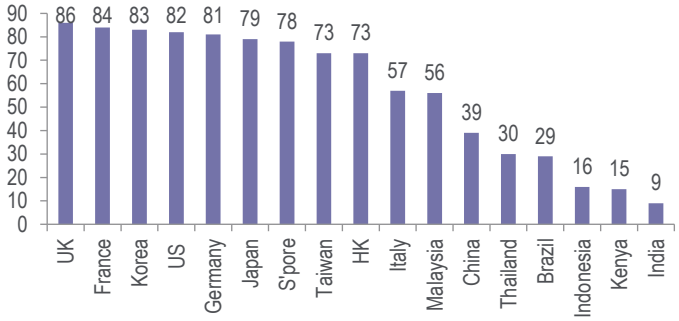
Figure 7. Markets Classified on Digital Money Readiness Index

Incipient	Emerging	In-Transition	Materially Ready
Russia	Thailand	Korea	Sweden
Nigeria	Mexico	Spain	Norway
Egypt	India	Malaysia	Germany
Argentina	China	Chile	UK
Pakistan	Indonesia	South Africa	US
	Kenya	Italy	Australia
	Peru	Brazil	Canada

Source: Citi Research

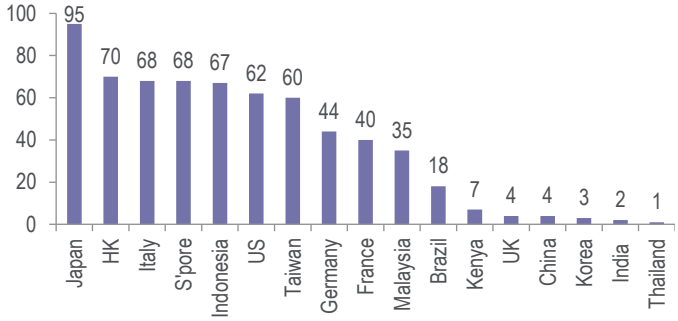
DEVELOPED MARKETS: Higher internet penetration, Customer acceptability to e-commerce / m-commerce, Organized retail

Figure 8. Internet Penetration (%)



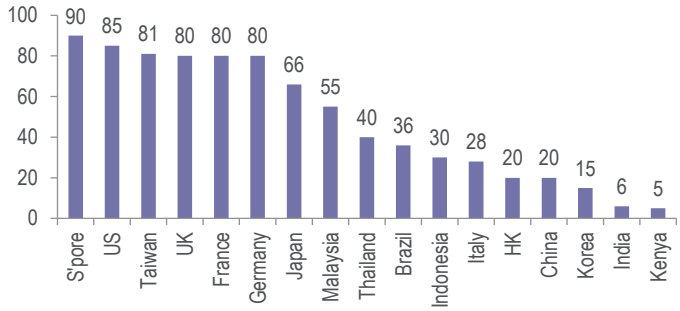
Source: Citi Mobile Analytics Team

Figure 9. 3G Penetration (%)



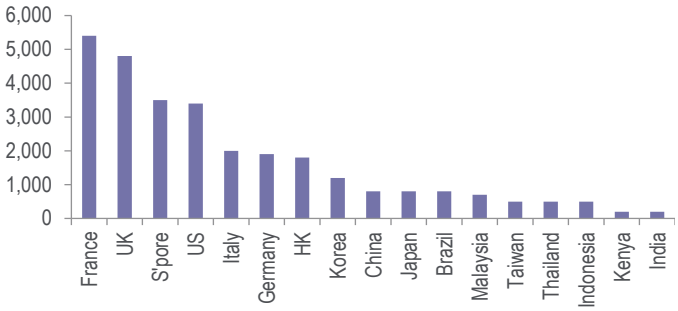
Source: Citi Mobile Analytics Team

Figure 10. Organized Retail (%)



Source: Citi Mobile Analytics Team

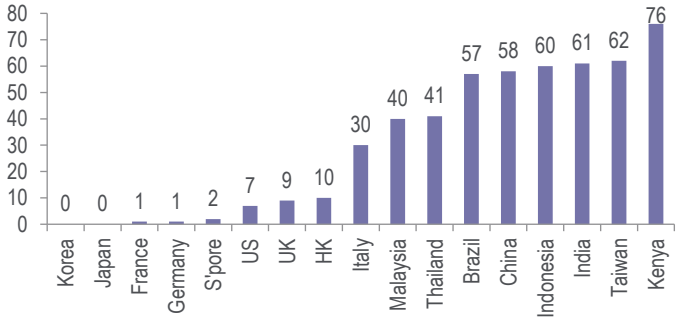
Figure 11. Card Spend per Capita



Source: Citi Mobile Analytics Team

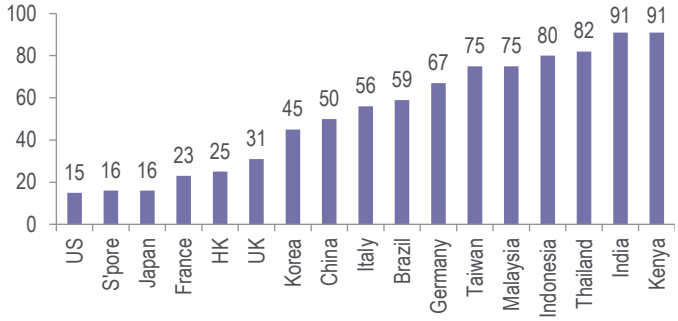
EMERGING MARKETS: Unbanked population, High cash intensity, Long handset replacement cycles and fewer POS per capita

Figure 12. Unbanked Population (%)



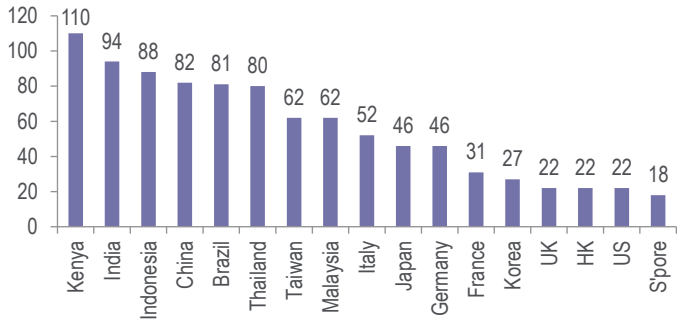
Source: Citi Mobile Analytics Team

Figure 13. Cash Intensity (%)



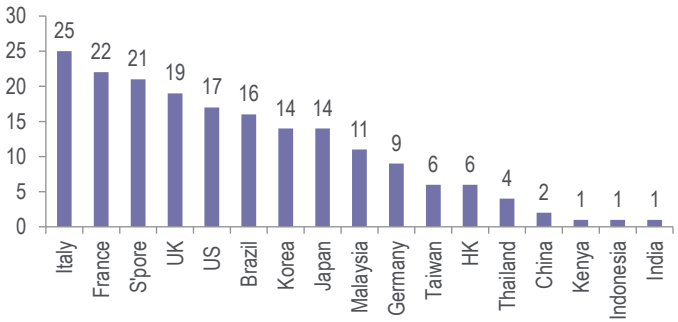
Source: Citi Mobile Analytics Team

Figure 14. Handset Replacement (in months)



Source: Citi Mobile Analytics Team

Figure 15. Point of Sale per Capita (# per billion)



Source: Citi Mobile Analytics Team

Digital Currency

Steven Englander
Head of G10 FX Strategy

Imagine a currency that isn't subject to the whims of central bank money printing, could be used for transactions seamlessly and almost without cost across the world, is more secure than any money transfer system, can be extended to non-monetary transactions and will make you rich. Who could conceivably argue against it? This is the sizzle attached to digital currencies.

What are Digital Currencies?

Digital currency is a medium of exchange that is electronically created and stored…

Wikipedia defines a digital currency as a form of virtual currency or medium of exchange that is electronically created and stored. Bitcoin, the most prominent digital currency, has additional attributes: 1) advanced cryptographic methods to secure transactions and ownership; 2) pseudonymous transactions; 3) payments that are verified and recorded in a decentralized ledger (blockchain); and 4) is maintained by 'miners' who are allocated newly created Bitcoins as incentive.

At present, there are more than 200 digital currencies (30 with market capitalization above $1 million and 12 above $5 million) with more created each month. Digital currencies differ along multiple dimensions, although Bitcoin is often used as a template. They typically share the characteristic that the pace at which the currency is created is pre-determined, there is an algorithm that governs the creation and distribution of the currencies and there is a market to determine the value of the currency. In order to encourage acceptance, most digital currencies are cheap to acquire initially and hold the prospects of substantial capital gains for those who buy early, provided that the currency gains broad acceptance and increases in value.

Figure 16. Market Capitalization in US$ bn (LHS), Total Bitcoins in Circulation mil (RHS Dark Blue)

Source: CitiFX, Blockchain.com

Figure 17. Bitcoin Market Price in US$ (LHS), Transactions per day – 7 Day Average(RHS)

Source: CitiFX, Blockchain.com

Price is determined by supply and demand in the market. The supply of most, but not all, digital currencies is pre-determined. Demand is determined by a combination of expected capital gains and the value in facilitating payments and potentially other financial transactions. Although any individual digital currency can have a fixed supply, the replicability of the Bitcoin and related protocols means that aggregate supply is far more elastic than that of any individual digital currency.

…and they are looked at as both assets and as a medium to facilitate transactions

Most digital currencies, Bitcoin included, are looked upon both as assets and as a medium to facilitate transactions. There is an intense debate as to which feature is the most important, Bitcoin was first introduced in 2009 in the midst of the global financial crisis and was designed as a non-inflationary alternative to fiat currencies. When the price of Bitcoin is rising this price appreciation is the main focus of

investors, but in periods such as Q1 2014, when prices were falling, more focus is on its ability to facilitate payments at a lower cost than conventional providers of such services.

For convenience we will discuss Bitcoin, recognizing that there is a branded Bitcoin digital currency, a freely available generic Bitcoin technology, and the potential that a non-Bitcoin alternative digital currency will one day supplant Bitcoin.

How Close is it to Becoming Reality?

After 5 years, there is a market for Bitcoin but with small volumes

Bitcoin has been in operation for five years despite earlier precursors that had failed. Today there are markets for buying and selling Bitcoin, businesses that accept Bitcoin and providers of Bitcoin related services, although volumes are relatively small. Two online marketers reported sales of $1 million in three months or less after accepting Bitcoin and a number of journalists have tried using Bitcoin as their sole means of transaction for brief periods, often highlighting the limited acceptance so far.

At current prices (about $500 per Bitcoin on April 19), the market cap for Bitcoin is about $6.2 billion and recent transaction volume is about 60,000 Bitcoin per day (Figures 16, 17, 18) although there are some questions about transactions at Chinese exchanges with zero transactions costs. Bitcoin is far ahead of other digital currencies in market capitalization but transactions in Litecoin, Dogecoin, and Blackcoin are significant as well.

Merchant uptake has been slow as transactions are slower than cash or credit/ debit purchases

As of April 2014, Bitcoinpulse counted 29,000 merchants accepting Bitcoin. Retail volumes are relatively low because dealing in Bitcoin remains more complicated than dealing in cash or conventional credit/debit cards. It appears that most merchants who accept Bitcoin convert the Bitcoin back into US dollars very quickly. The need for Bitcoin ledgers to confirm the transaction inherently slows transaction speed, although Bitcoin applications are being developed to get around this limitation.

Our assessment is that Bitcoin (and digital currencies) are still “wannabe assets” and “wannabe means of transactions”. Bitcoin holders, even if they are very wealthy on paper, have a hard time at present converting Bitcoin wealth into conventional goods and assets. You can have a lot of Bitcoin but there’s not much to do with it.

How Well Known is this to the Market?

Younger investors more likely to own Bitcoin vs. older or institutional investors

Bitcoin is familiar and welcome to younger investors. Older investors may have heard the word but generally are less familiar and more skeptical. There is very little Bitcoin activity among institutional investors in organized financial markets as it is considered far too risky and volatile. Bitcoin investment vehicles have emerged but these are modest in size and aimed primarily at retail investors. Venture capital and private equity investors are increasingly involved in designing applications to utilize Bitcoin and other digital currencies, but it is less clear that these investors are taking big speculative positions on Bitcoin appreciation.

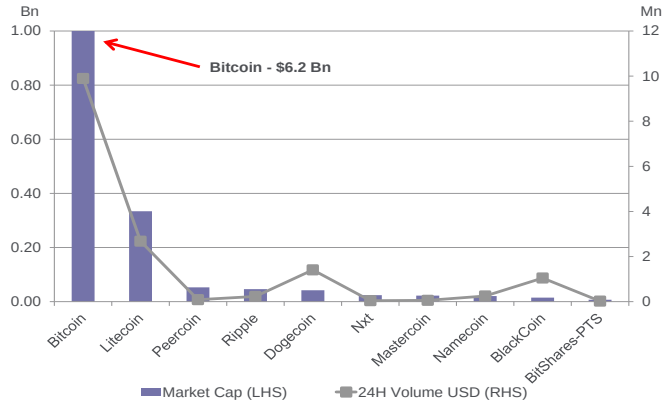
How Big Could the Opportunity Be?

Opportunity to fill gap in transactions where a “trusted intermediary” is needed

Bitcoin advocates see a huge potential market, either because of Bitcoin’s role as an alternative asset or its disruptive role in the payments system. The opportunities are different and generate very different paths for Bitcoin. The essential innovation in Bitcoin is that it can eliminate the need for a ‘trusted intermediary’ when the principals in a transaction do not trust each other. There are many such transactions but money transfer/ credit/ debit card transactions stand out.

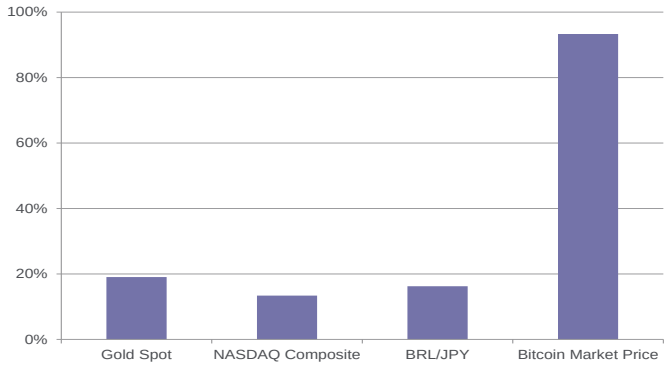
Conventional credit/ debit card payers transacted about $15.5 trillion in 2013, and the major credit/debit/payments firms have a market cap of more than $300 billion. Bitcoin transactions have potential cost advantages over conventional payments and reduce the need for intermediation. The gap between conventional transactions cost and any Bitcoin fees for convenience and increased security will allow Bitcoin to make incursions into this market. For investors, the question is how much of this gap will be eroded by competition, with the majority benefit going to consumers.

Figure 18. Market Capitalization of Crypto Currencies, bil (LHS), 24-hour volume US$ (RHS)



Source: CitiFX, Coinmarketcap.com, 24hr volume 4/23/14 10:30AM

Figure 19. Realized Volatility on Gold, NASDAQ, BRL/JPY, Bitcoin Price over Last 250 Days



Source: CitiFX, Blockchain.com, Bloomberg

Paradoxically, if Bitcoin takes off primarily as an alternative asset, the opportunities for investors may be more modest. Bitcoin would potentially have the characteristics of a high volatility, low liquidity commodity, and probably emerge as a fringe asset.

Bitcoin could become a fringe asset or as a way of transferring or registering an asset…

A third set of applications use Bitcoin logic, encryption and sometimes the actual Bitcoin blockchain as an almost infinitely flexible system for transferring property rights. The goal is to use Bitcoin technology as a way of irrevocably transferring and registering any asset, or engaging in any contractual transaction, including non-monetary transactions, that has to be verified but where parties do not want to 'trust' each other. Some of these approaches use the Bitcoin blockchain, other do not; some have a decentralized, independent blockchain, others rely on a trusted third party to verify transactions or satisfy that contractual conditions have been met.

…with proposed applications in betting, real estate contracts, land registration and financial contracts

Voting, betting, real estate contracts, land registration, secure naming of domains and financial contracts are a few of the proposed applications. Some propose that real estate transactions be attached to the blockchain, so there is a secure, definitively time-stamped record of ownership, avoiding costly title searches and others fees. Others argue that flexible contingent contracts are feasible and can be built into the blockchain at very low cost – Mr X pays Mr Y C$10 if the NY Rangers win the Stanley Cup and the gold price is above $2,000/oz. However, there has to be a mechanism to confirm the Rangers success and the price of gold.

Using Bitcoin as a secure means of exchanging and recording assets and other transactions is attractive

Combining Bitcoin-based cryptography with a blockchain ledger to have a secure means of exchanging and recording assets and other transactions is very attractive, even if there are conceptual issues to be solved before these applications become practical. The potential market extends far beyond the Bitcoin as currency idea.

What are the Barriers to Adoption?

Security, volatility, regulation and crime are widely acknowledged issues. Advocates see imminent solutions while naysayers see a mix of 'pump and dump' and 'crash and burn'. The part of Bitcoin that encrypts transactions and prevents double-spending of the same Bitcoin is very secure. Outside of this core, it has been very difficult to make Bitcoin secure. A Bitcoin is a private cryptographic key. If that key is misplaced, lost stolen, forgotten or destroyed there is no recovery – like cash in a mattress. Bitcoins have been stolen from hacked exchanges with insiders often under suspicion. Malware that steals Bitcoin out of 'wallets' has increased sharply, limiting the ability to use Bitcoin easily by forcing offline 'cold storage' of Bitcoin to prevent theft. Some see the security issues as teething pains, but it is possible that the security of the core transactions technology will be outweighed by the insecurity around that core.

Over 10% of all Bitcoins have been stolen or seized

Between the Mt. Gox bankruptcy and Silk Road/Sheep Marketplace criminal seizures, almost 10% of all Bitcoins have been stolen or seized as part of a criminal venture in the last year. With 'petty' thefts reported every week, the number is well over 10%. There is an internal Bitcoin community battle between those who want to fully legitimize it, implement anti-money laundering and know-your-client rules, and those who want Bitcoin to remain an unregulated, anti-fiat, outside currency.

So far most regulators have tolerated Bitcoin

Regulation will either bring Bitcoin into the tent with the conventional financial system or permanently marginalize it. So far most regulators have tolerated Bitcoin, warning consumers of the volatility and safety risks, and ensuring that financial institutions do not have exposure to Bitcoin fluctuations. Countries with capital controls or high inflation are more wary of Bitcoin as a means of evading the consequence of capital control or domestic macro policy.

The IRS announced that it will treat Bitcoin as a commodity and tax capital gains. Serious record keeping is involved if you are paying for today's $50 lunch with 1/10th of a $500 Bitcoin that you acquired a year ago for $125. Even if the IRS decided to treat Bitcoin as a currency, gains and losses would be taxed beyond some 'de minimis' level. Given Bitcoin volatility, swings in capital gains are likely to be large.

Capital gains earned by Bitcoin holders is seignorage removed from the hands of the government. Were digital currencies to become more material in the payments system, policymakers would come to view the loss of seignorage as an issue.

Many issues would be resolved if payments & value storage functions were separated

Many of these issues would be resolved if the payments function were separated from the store of value function, for example if the same cryptographic methods and ledger were used to secure USD or EUR transactions – accounting would match exactly what is in place today. Bitcoin advocates who benefit from Bitcoin appreciation argue strongly for its role as an asset, but the transactions technology is generic and efficient and less complicated than introducing an intermediate currency (Bitcoin) to facilitate USD to USD or USD to EUR transactions.

Winners and Losers? Who Gets Displaced?

In the near term the sectors most at risk are credit/ debit card and payments services. If fraud/charge backs can be reduced or eliminated by digital currencies there is plenty of room for margins to be eroded. Retail transactions across borders could also become very inexpensive, if the charges involved in going from one currency to another were substantively reduced. Wholesale FX transactions are already very low margin, so the room for margin erosion appears much more limited. Most broadly, intermediaries who charge high margins to stand between two transactors who do not 'trust' each other may find their franchise eroded if generic Bitcoin technology lowers the cost if these transactions.

Digital Marketing

Walter H Pritchard, CFA
US Software Analyst

Mark May
US Internet Analyst

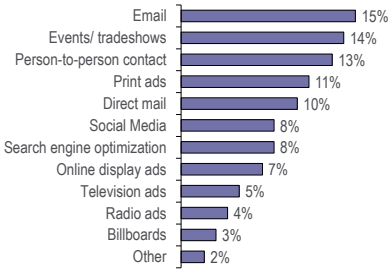
Thomas A Singlehurst, CFA
Head of European Media Research

As the Internet goes mainstream and customers spend more and more time online, marketing dollars continue to migrate to digital channels. This trend is not new and from the earliest days of the commercial Internet, unsophisticated banner ads and then search advertising gained traction and turned into large markets. Over time, this began to cannibalize offline marketing spend in areas such as print, radio, TV and other mediums, although offline marketing continues to dominate the marketing budget and digital channels make up well less than 50% of marketing and advertising spend.

We believe digital marketing will be the primary channel vs. offline advertising — i.e., "digital first"

As we look forward, we see a landscape that will ultimately drive digital marketing to be the primary channel, indeed in some countries in Europe and Asia, this is already the case where various programs within marketing (branding, product launches, promotions) are "offline first", with digital as an after-thought. This will not only flip spending trends, fueling further growth in digital channels, but also cause a ripple across related areas, including software, media and staffing / external services.

Figure 20. Marketing Budgets Can Vary by Customer Type (SMB example)



Source: Dazeinfo.com survey

This re-orientation to "digital first" brings forth a number of benefits that didn't exist in the offline world and exploiting these benefits is key to driving value in digital marketing. Many of these benefits come from the fact that the digital market uses and generates massive amounts of data and it is this data that differentiates digital marketing from traditional offline marketing. The result is a highly personalized experience for a consumer across all channels in an experience that the prospective or current customer appreciates and they in turn encourage through greater access to their personal data.

Consider a modern digital marketing campaign that begins with "anonymous" prospects coming to a website through search. If they can be uniquely identified by an affiliated network (through a cookie or other means), they can be narrowed down in demographics to no longer be anonymous. From there, if they reveal more information about themselves (signing up for an email or "following" the brand on Twitter or "liking" the brand on Facebook), their identity and more importantly key marketing attributes can be gleaned. If they search to make a purchase, but then don't complete the purchase, the brand can better understand price sensitivity and the specific attributes of the attempted purchase (for example a certain style of clothing) can be used to target the prospect later with promotional or other follow-up communications.

There are three primary constituents that are impacted as we transition to "digital first" in marketing: 1) the media owners; 2) agencies and ad tech; and 3) software.

Assessing the Impact on Media Owners

It's not just a switch to "digital-first" it's also a shift in monetization profile, cost base and a new competitor set

The challenge for traditional media owners in this transition is in managing three transitions simultaneously.

1. **Re-creating the monetization profile in an online world.** This is not a challenge for 100% ad funded media companies, but it is for those media companies that enjoy a dual stream of monetization in an analogue world, (e.g. print newspapers/magazines). For example, a regional newspaper may be able to defend a regional classified model online – this has been done successfully in Europe – but may struggle to fully replicate the cover price-related revenues that also accompanied straight advertising sales.

2. **Managing the cost base through transition.** Traditional media companies tend to have a significant fixed cost base associated with transmission/ distribution and 'variablising' this is a key challenge.

3. **Transitioning to a completely new competitor set.** The move to online significantly lowers the barriers of entry for new potential competitors. Clearly, the most famous examples involve exciting tech-based start-ups — the Google's, Facebook's, Netflix's of this world. We would also argue that the move by selected larger media conglomerates to own media channels in international markets (e.g. Discovery with Eurosport/SBS) is also perhaps a symptom of the same trend.

This has some over-arching impacts on media owners:

- **Free-to-air models are easier to transition to a digital world** than those with a pay-based revenue stream (either transactional or subscription). In blunt terms, offline or online, *free* is still a pretty compelling price point.
- **Content ownership/ control is an enduring barrier to disintermediation.** Great technology is a powerful enabler, but even the best technology is next to useless without a compelling content proposition with which to drive penetration.

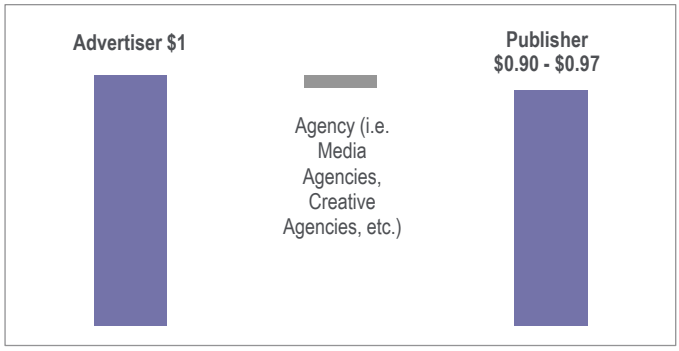
Assessing the Impact on Agencies & Ad Tech

Short-term, digital could generate better growth and returns…but could also change the risk profile in the long-term

For agencies, the emergence of digital actually breathes new life into what was becoming a commoditized, lower growth, lower return business. The short-term impact, therefore, will be better growth and better returns. The longer-term risk, however, is that it alters the risk profile of the agency model. Not only does it introduce trading risk as the companies move from pure agency- to a principal-based model, but it also (re-)introduces conflicts of interest, all of which could be a concern over time. There is also a drag in the short-term because aggressive take-up of digital services could cannibalize the core service offering.

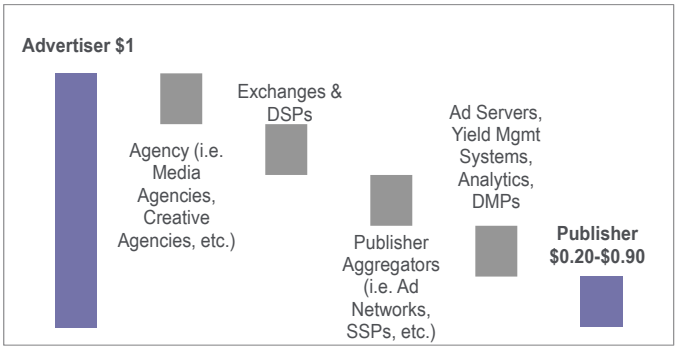
Ad tech feels like a very modern phenomenon, but the role it serves is obviously well established. Until the early 2000s, buying and selling advertising was a relationship-driven and highly manual process, requiring the manual management of nearly every phase of the transaction, from requests for proposals (RFPs) and negotiations to vendor selection and insertions orders to billing and reporting, etc.

Figure 21. The Cost of Buying Traditional Advertising



Source: Citi Research

Figure 22. The Diminishing Value of a Digital Ad Dollar

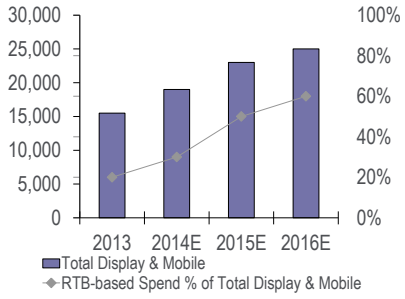


Source: Citi Research

While clunky, the 'legacy' media buying process had key benefits – transparency, direct payment and aligned incentives

It is important to note, though, that while relatively clunky, the "legacy" media buying process was not necessarily wholly without merit. Indeed, we think there were at least three key benefits of the old, analogue media buying setup. First, it is transparent, in that the role fulfilled, as well as the costs associated with the process, is clear to see and well understood. Second, a high proportion of the resultant ad spend goes directly to media owner (see Figure 21 and Figure 22 above) – advertisers often reference this when they draw a distinction between 'working' and 'non-working' dollars. Third, incentives are aligned between advertisers and agencies (fee-based models prevail), which means advertisers can not only trust they are getting the right advice as to whether or not they should spend, but also on which channel/platform spend should be targeted.

Figure 23. RTB-Based Spend Will Account for Nearly 60% of Total Display & Mobile Spend by 2016, up from 20% in 2013



Source: Citi Research

The move to online digital ad buying has significantly disrupted the original ad buying model, pushing apart what used to be quite a close-knit triumvirate: advertisers, agencies and media owners. This started with search, which introduced significant automation into the process and brought superior value vs. display advertising. This automation later came to display, helping to improve relevance/ targeting. Current programmatic tools and specifically real-time-bidding ("RTB") solutions have enabled advertisers to automate the ad buying and placement process in real-time and have benefitted media owners by broadening demand and realizing operational efficiencies.

We believe that deep programmatic/ RTB capabilities are now a prerequisite and this is likely to lead to significant growth (66% CAGR in RTB-based digital ad spend from 13-16E) and by 2016, RTB-based spend will reach nearly 60% of total display and mobile spend (vs. ~20% in CY13). At the same time, we shouldn't pretend that this won't come without challenges/ risks in the same areas we highlighted above with the traditional media buying process. RTB and automated media buying makes the system less transparent. From a cost perspective, more of the spend is captured by intermediaries, which is 10-90% of spend, vs. 3-10% in traditional media. Lastly, there is material risk of a distortion of incentives as media owners are given incentives to produce more inventory (at risk of quality), vertically integrated players (even agencies) prioritize their own inventory as the agent / principal issue resurfaces.

We expect above-average growth in RTB and for it to make up 60% of total display and mobile spend by 2016

We expect through 2016 there will be significant above-average growth for companies involved in RTB, although as the market matures, we expect greater price transparency and ultimately consolidation. Over the long-term, companies in RTB that leverage multichannel capabilities and/or have dual-service delivery models are best positioned.

Assessing the Impact on Software Companies

Digital marketing is becoming more of a science vs. art and requires innovative tools

On the software side, marketers are demanding a set of tools to help build and manage advertising campaigns, optimize their spending and have a view into prospective or current customer behavior in order to optimize their digital marketing experience. With a data-orientation to digital marketing, there is a move happening where marketing is becoming more of a science (although there will always be an "art" element to it). Technology tools fall into various categories such as lead management, multi-channel campaign management, community/ social engagement, analytic tools and even reach into areas such as content management and e-commerce. This software market has been fragmented, partially because technology is moving quickly and buyers place a premium on innovation. Over time, the "marketing suite" is likely to coalesce around a handful of players that have aggressively consolidated an integrated toolset over the last several years. In our view, the viable players focused on this opportunity include Adobe, IBM, Oracle, and salesforce.com.

More decision making on IT is sitting with the business leading IT vendors to change their selling relationships from the IT department to the line of business itself

The move to digital marketing as a primary marketing strategy has implications on the broader IT spending landscape as well. IT vendors have typically sold into the IT department, although increasingly, with lines of business having greater control over funding of IT initiatives, more of the decision making is happening outside the IT department. This put the onus on IT vendors to build relationships with a different buyer and have a vertical market expertise that these lines of business value more highly. With marketing becoming more dependent on technology, there is an opportunity for IT vendors to sell into this "line of business". This will require the building of solutions for marketing and wrapping these with services and line of business expertise in marketing. As a result, we expect the benefit to IT spend will be disproportionate toward the select few vendors that are able to orient their solutions towards the marketing buyer.

Risk #1: Privacy Concerns Could Slow All This Down

Regulation on privacy is important, but different regions have different approaches

As we discuss above, the opportunities from integrating data into the digital marketing process are vast. However, this data comes from individuals and in the wrong hands could be used for nefarious purposes, something that has been recognized by consumers and regulators alike. On the regulatory aspect, approaches vary significantly across regions, with the US more laissez-faire (although not disengaged) while the Europe is stricter with more active efforts underway to implement more aggressive privacy protections. We assume the industry is able to navigate the concerns about privacy. That all said, we do think there could be pitfalls along the way and we argue that the longer-term winners will have to take into account the shifting privacy and data protection landscape.

Risk #2: Conflicts of Interest

It's not just the move to "digital first"…there are other risks to traditional players

As the entire marketing landscape is impacted by the move to "digital first", much of it is driven by different players trying to disintermediate incumbents. This works on a number of levels:

- **Within the media landscape, new media companies are trying to disintermediate old established brands** as way of reaching consumers. From a technology perspective this point also holds: Over the top (OTT) platforms like Netflix, Pandora or Spotify, are trying to disintermediate established platforms.
- **On the ad tech side, new ad tech companies are trying to disintermediate the old ad tech companies, i.e. the agency groups**. Whether this is from the point of view of a vertically integrated technology/ media model (like the one offered by Google) or from the perspective of a new start-up/ established tech player, the message is the same: we have a more efficient way of buying media than the old model.
- **Selected agency groups themselves are also trying to disintermediate the ad tech startups** with their own trading desks and technology infrastructure. In time, if the ecosystem broadens sufficiently, this may even be a way of disintermediating the larger online publishers/ social networks.

The point with all of this is that the new landscape is not necessarily free from distortions that characterized the past; rather there are just new distortions to take account of. This risks dampening advertiser spending as they grapple with inefficiencies in the system.

Electric Vehicles

Itay Michaeli
US Autos and Auto Parts Analyst

After plenty of false starts, the electric vehicle's path to eventual disruption may be upon us. The appeal of Electric Vehicles (EVs) lies both in their long-term cost proposition and unique benefits. But before proceeding any further, it's worth injecting a dose of reality when discussing the automotive industry. Disruptive change, even that which is compelling, cannot occur overnight in an industry characterized by long product cycles, capacity requirements and high costs. There are also other compelling stories in traditional gasoline/diesel technologies, natural gas vehicles (NGVs) and hybrids. That all said, the race for the early mover EV crown may be decided in the next 4-6 years thanks to the success and future product plans of Tesla Motors.

Why Now? Tesla's Significant to the Industry

Although still a low-volume luxury carmaker, we view Tesla's early success with the Model S as having confirmed the following about electric vehicles:

1. It's possible to combine all the unique benefits of EVs (superior performance, sufficient range, greater usable trunk capacity, lower maintenance costs, green) with an attractive design and appealing marketing message. We don't believe any other EV in the market has yet to deliver all of these factors in a single car.
2. They can generate substantial consumer/media interest particularly when, in our view, they're sold at outlets that don't face a possible conflict of interest tied to selling both gasoline and EV vehicles.

A more affordable $35k car will likely give Tesla first mover advantage which could be strategically critical

Although the Model S in itself is unlikely to pose a disruptive threat to global automakers, Tesla does plan to deliver a more affordable $30-$35k "Gen-3" vehicle available roughly in the 2017 time frame. This vehicle too may not necessarily prove disruptive, but it may be significant in two ways: 1) A $35k price point is historically what's required to begin the path towards achieving sizeable volume of over 100k units (typically 2-3 years after launch), in theory enough to crown Tesla as the 1st mover in the affordable pure EV market. One doesn't need to look far to appreciate the value of this crown—just look at Toyota's remarkable hybrid leadership with the Prius vs. today's strong but late hybrid competition; 2) For any automaker, achieving an early mover advantage could be strategically critical ahead of the potential for more mass EV adoption early/mid next decade—once battery costs come down further and capacity is added.

Dealer conflict may be one reason why EV sales from traditional automakers have underwhelmed

Let's face it. Despite launching a number of innovative electric vehicles in recent years, the traditional OEM-dealer business model works best if EV penetration rises slowly over time. A substantial industry investment in gasoline/ diesel powertrain capacity/ IP is one reason for this, but another comes from some possible resistance from concerned auto dealers facing prospects of lower service levels on EVs (no oil changes, filters, etc.). This potential dealer conflict might partially explain why traditional automakers' EV sales have underwhelmed (Chevy Volt, Nissan Leaf). It's not that traditional automakers aren't recognizing the EV trend or innovating within it (Volt is a great example of impressive innovation), it's just that the industry's interests are better aligned to a gradual ramp vs. anything remotely disruptive.

Slow uptake for EV's might be the preferred pace in the auto industry

And for the past few years, the industry has been right. Fuel economy regulations (particularly here in the U.S.) haven't forced an excessive amount of EVs onto the market, consumer/ media interest has been limited, if not outright skeptical (remember the media reaction to the minor Chevy Volt fire incident?), and a handful of EV-related companies failed to deliver on promises and were ultimately forced to restructure/ liquidate. There are plenty of examples of why slow is the truly preferred pace in the auto industry.

Aren't' EVs Expensive? How the Battery Operator Model Could Unlock the Disruptive Catalyst

One way to reduce costs may be to separate the batter from the EV — creating a battery operator company as a servicer between the OEM and consumer

Despite all their benefits and appeal, EVs today are still expensive. Even the Tesla Gen-3 projected price point of $~35k would still run about $8k higher than the average U.S. retailed vehicle. So are we writing this section many years too early? Perhaps not. One way to potentially get around high battery costs (at least through the 1st & 2nd product cycles) might be to revisit the battery operator model. The concept behind this involves creating a battery operator company as a servicer between the OEM and consumer (this could be anyone, including an auto finance company). The technical idea is to separate the battery from the car at time of sale, and then charge a consumer a flat monthly fee to pay for operating costs and usage of a network. By separating the battery from the car, the consumer purchases a new EV at a much lower price ($11-13k depending on size/ cost) and does so worry free of any residual value risk tied to future battery technology advancements. The operator would own the batteries, bill customers and operate battery switching stations that allow consumers to quickly (and robotically) switch batteries when desired or when taking very long drives.

A battery operator model could benefit both the OEM and the consumer

The thinking goes that a battery operator can squeeze far more value out of the life of the battery vs. a battery bolted-on through the life of the car. The consumer then pays a fixed monthly fee for unlimited miles and access to switch stations. The monthly fee would approximate costs the consumer would have already incurred with a gasoline vehicle, without the volatility that's tied to gas prices. OEMs can still earn a respectable variable margin while avoiding carrying battery risk on their books. Note that Tesla has introduced a battery swap concept but not one where the consumer no longer owns the battery. Rather, Tesla has announced plans to expand its Supercharger stations that allow a 200-mile charge in ~30 minutes, with expected improvements in charge length over time.

Haven't we seen this model before?

Operational mistakes, not conceptual ones, led to failure of the battery operator model in the past

The battery operator model was originally championed by Better Place, a company that operates switch stations and charge spots in Denmark and Israel. Founded by entrepreneur and former technology executive Shai Agassi, Better Place saw some initial success but ultimately filed bankruptcy. In our view, the apparent failure of Better Place had more to do with operational mistakes than a visionary flaw, plus a car that was one generation too early. Importantly, consumer satisfaction was apparently high and the vehicle/switch stations performed well by all accounts.

Creating a $10,000 EV?

Building a simulated 2017 Ford Focus EV

In an illustrative example, we walk towards a hypothetical 200-mile Ford/Lincoln C-segment car/crossover in the 2017-18 time period. We start by comparing today's Ford Focus (gasoline) to the Ford Focus EV to capture the underlying economics, and then walk to a future EV:

1. We estimate the Ford Focus gasoline sedan currently transacts around $18k. Assuming a $5k variable margin, this implies $13k of variable costs.

2. We estimate the Ford Focus EV transacts around $37k but does come with added non-EV content (infotainment, rear camera, audio). We estimate the variable margin at $6.4k, implying variable costs of $30.6k—or $17.5k higher than the gasoline version. Assuming a $650/kWh cost on the 23kWh battery, the implied battery cost = $15k. The remaining $2.5k cost gap comes from the added content vs. the baseline gasoline Focus.

3. For the simulated 2017 EV, we make two battery assumptions: 1) A 10% improvement in range/kWh and 2) A $385/kWh battery cost, which matches Citi analysts' lithium-ion cost estimates (Lithium-ion batteries redux - Market sparking back to life?). To attain a 200-mile range (vs. 76 in a current Focus EV), the battery must be sized to 55kWh (from 23kWh) to yield a cost of $21k—or $6k above the cost of the current Focus EV battery, all else equal. Our battery assumptions are admittedly simplistic as realistically there would be other considerations (size of pack, performance, etc.), but it serves to illustrate the example.

4. With an added $6k of battery costs, the 2017 Lincoln/Ford EV vehicle would need to price at $43k to achieve the same variable profit as the current Focus EV. Note that this price would be $7k above Tesla's target of $35k on the Gen-3 vehicle. At this stage of the exercise, our 2017 EV vehicle appears uncompetitive.

5. However, removing the $21k battery cost brings the price down to $22k.

6. And remember, we're using the current Focus EV as the baseline vehicle, which comes pretty well-equipped. We estimate the value of the extra content at $4-$5k. So if the 2017 EV vehicle was offered at a lesser-contented base model, the price in our example drops further to $17k from $22k (ex. battery).

7. Finally, applying a $7,500 Federal tax credit would bring the price down to about $10k — enough to compete for demand even amongst used vehicle buyers (a much larger market) and utilize a presumably mostly unused tax credit allocation (in Ford's case this could be ~150k units). The lower price point, while perhaps temporary (1-2 years) pending exhaustion of Federal credits, would nonetheless be critical in order to establish a long-term early mover EV advantage, support the battery operator and achieve even greater cost scale (to narrow remaining per kWh disadvantage). Notably, this would leave the automaker with the same variable profit margin as today — and arguably more if we consider the corporate average fuel economy (CAFÉ) costs necessary to improve internal combustion engines to meet 2017+ standards. In fact, one could argue that at a $10k net price point, consumers might add more than $4-5k of content to enhance the vehicle, adding variable profit to the OEM.

The consumer gets the cost benefit

What Does the Consumer Get? The consumer gets to enjoy all that EVs have to offer at a cheaper price to gasoline cars, attain access to a network designed to eliminate long-range anxiety, avoid residual value concerns from future battery advancements and attain certainty for monthly budgeting with unlimited miles. Notably, consumers preferring to feel like they "own" their batteries could simply opt to never use switch stations.

Battery operators would charge a monthly fee, similar to what consumers are currently paying to operate gasoline vehicles

How Might It Work for the Battery Operator? The battery operator would charge the consumer a monthly fee for unlimited use of the battery, plus access to a network of swap stations. That monthly fee would likely correspond to what consumers were already paying to operate gasoline vehicles—say $250. But since the EV would also come with less maintenance and lower residual value risk, the monthly fee could be justified even higher, say $275-325. With Federal tax credits considered, the consumer would receive a new EV at a far lower monthly cost than a gasoline vehicle. Without tax credits, the consumer still pays a similar amount to enjoy some of the same EV benefits that have contributed to the popularity of the Model S. Either way, it becomes a far more attractive proposition. At $300/month, the consumer is effectively paying $0.24 per mile to operate the vehicle. The cost of

providing electricity to the consumer would only amount to about $0.03 per mile and battery depreciation at about $0.09 per mile. The gross margins are therefore inherently high while operating costs would presumably be low due to switch station automation — allowing for the cash flow ramp necessary to pay for the infrastructure and battery investments. Although the return dynamics wouldn't necessarily look compelling in the first few years, the operator's profitability would improve so long as battery costs decline, EV sales scale up and gasoline prices/ taxes rise over time. That is the effective goal of the business model.

OEMs benefit from the faster EV ramp expected by separating the battery from the car

What Does the OEM Get? OEMs are able to leverage their inherent advantage in manufacturing and distribution to allow for a faster EV ramp by separating the battery from the car. The capital investment that's likely required to build switch stations doesn't seem demanding — at an estimated $500k per unit, initially installing 1,000 strategic switch stations across the U.S. would only cost $500 million — not much compared to Ford's and GM's respective annual capital expenditure budgets of $7-$8 billion. Note that Tesla's supercharger network is expected to cover 98% of the U.S. population by 2015 with only a few hundred strategically located stations. Switch stations could also be placed at or near dealer locations to align customer service needs (tire rotations, etc.) and maintain a connection to the dealer, which may improve long-term loyalty.

Figure 24. Hypothetical Battery Operator Model

(1) What the Consumer Saves (EV vs. Gas)?

GAS:		EV:		Monthly Gap (EV-Gas)	
Miles Driven	15,000	Range	200		
MPG	23	Charges	75	Gas	$180
Gas Price	$4.00	Electricty (kWh)	$0.11	Maintain (50%)	$33
Gas Cost	**$2,609**	EV Cost	**$454**	**Total:**	**$213**
per Mile	**$0.17**	**per Mile**	**$0.03**	5-yr D&A	$67
Per Month	$217	Per Month	$38	**Grand Total:**	**$280**

(2) Battery Operator Simulated P&L

	Dollar Revenue	*Per Mile*
Per Month	$300	
Revenue *($mlns)*	**$1,080**	
Electricity	($136)	
Battery D&A	($432)	
Gross Profit	**$512**	
Margin	47%	
- Labor	($70)	
- Operating	($30)	
Pre-Tax Cash	**$412**	
- Tax (20%)	($82)	
Net Cash	**$329**	
EBITDA	**$761**	
	7.5	

Key P&L Assumptions	
Battery Cost (avg 2017E-2019E)	$19,360
- End of Useful Value (15%)	$2,904
Useful Life (Years)	12
Annual Depreciation	$1,371
Per Mile	$0.09
# of Subscribers	300,000
Batteries on Hand per Sub	1.05
Batteries Purchased	**315,000**
Extra Batteries / Swap Station	15
Capital Outlays	
Batteries (in millions)	$6,098
Swap Stations (1,000 nationally @ $500k)	$500
Gross Outlay:	**$6,599**
Year-12 Residual Battery Payback	($915)
Net Outlay:	**$5,684**

Source: Citi Research

Energy Storage

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Tsubasa Sasaki
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We are all familiar with the basic concept of electricity storage — from the batteries that power our mobile phones, the TV remote control, or those that start our cars. However, energy storage has the potential to be a far bigger industry in the future as it moves from smaller scale, application specific storage as above, to residential-level, commercial, or even grid-level scale, and it has the potential to change the way we use and think about energy, itself one of the building blocks of modern life in the developed and developing world.

Energy storage has the potential to become a much larger part of our lives, being disruptive to both power and transportation markets

The debate on energy storage used to focus on its ability to make renewable energy more cost competitive by eliminating its intermittency. However, as the cost of solar and wind has dropped at a staggeringly fast rate in recent years, the economic disparity will be all but eliminated this decade (and in many examples already has been – see our recent report Energy Darwinism). What had perhaps not been fully anticipated was the extent to which this alarmingly fast roll-out of renewables (which the cost reductions only exacerbate) would disrupt electricity systems. We now find ourselves in a situation where storage is being seen by many as necessary to balance supply and demand on the grid, as well as potentially protecting the economics of conventional power generation by allowing power generators to run at optimal levels (an ironic about-face in terms of what type of generation storage has the potential to make economic sense). But the impact of storage is not limited to the utility world; while power generation accounts for 42% of global primary energy demand, transportation accounts for 18%, taking the combined total to 60%, and the potential impact of EV's on the world of transport is significant.

The Utility Opportunity

Utilisation rates on conventional plant have fallen significantly due to increased renewable penetration…

The poster child for the disruption caused by renewable electricity is undoubtedly Germany which has some of the highest levels of solar and wind installed capacity in the world. Indeed, German power consumption has only grown by 3.5% from 2000-2014, while generating capacity has increased by 44.7%, most of that being new renewables capacity. In the first quarter of 2014, solar and wind combined generated 28% of German electricity.

…and they have 'lost' the most valuable peak units to solar, leading to utility profit warnings

Across Europe as a whole, load factors on conventional plants have fallen from 51% in 2006 to around 44% by 2012. For gas, the reduction has been far more marked, falling from 65% in 2006 to an estimated 25% in 2013, and we expect it may fall further to 15-20% in 2014. While much of this effect is due to a reduction in coal price as coal is displaced from the US following the shale gas revolution, the situation has undoubtedly been exacerbated by renewables. However, the impact has been most greatly felt in terms of 'which units' solar has stolen – by stealing peak demand from gas, solar has taken the most valuable (highest priced) units away from utilities, causing many of them to issue profit warnings.

This has made many conventional plants uneconomic, but they must be kept open for the winter via capacity payments

The greatest issue for utilities is that much of the power generated from the displaced conventional plants is at risk of being rendered uneconomic because of these lower load factors (the amount of time a plant runs, and which units it generates), but given that these plants are still needed for higher winter peak demand, they must be compensated via capacity payments.

The other impact of these power generation mix changes is the emergence of negative electricity prices at times, whereby utilities/grids have effectively had to pay customers to take (free) electricity simply to balance supply and demand. If that excess electricity could be stored not only would it not be wasted, but we could also protect the load factor and hence the economics of conventional plants.

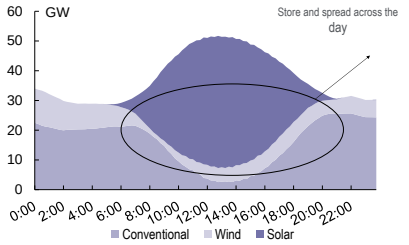
Storage – The Potential Solution

Distributed generation and storage have the potential to revolutionize power markets

The key benefit of storage as well as not 'wasting' electricity is that by storing excess power generation, we could allow a conventional plant to run at its most efficient load factor, thereby making it economically viable and theoretically negating the need for capacity payments (though the more renewables one puts on a grid, the harder to do this becomes).

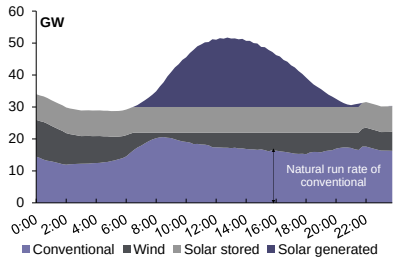
This effect on a synthesized daily load curve (with 50GW of solar capacity, the level at which Germany has said it will cease feed-in tariffs) is demonstrated in Figure 25 and Figure 26 where we can see the 'excess' solar generation being put into storage thereby protecting at least part of baseload and allowing it to run more economically.

Figure 25. German Electricity Load Curve with Double Current Solar and Wind Penetration



Source: Citi Research

Figure 26. The Same Load Curve, Using Storage to Spread 'Excess' Solar Generation Across the Day



Source: Citi Research

Although this effect on a synthesized daily load curve (with 50GW of solar capacity, the level at which Germany has said it will cease feed-in tariffs) is demonstrated in Figure 25 and Figure 26 where we can see the 'excess' solar generation being put into storage thereby protecting at least part of baseload and allowing it to run more economically.

So the value of storage is many-fold. The most obvious value is simply to take advantage of price differentials; for example German residential electricity prices are currently around €28c/kWh, while the feed-in tariff that a household receives for electricity it sells back to the grid is only around €16c/kWh. The problem is that solar generates its electricity when most households are empty, or have limited demand. Clearly if that electricity could be stored and then used (rather than exported at a lower price), it would offset the purchase of electricity at €28c, thereby providing an incremental value per unit of electricity of €12c/kWh (€28c-€16c).

However, the potentially greater value is in terms of avoided capacity payments, and the grid stability which storage could provide. If storage could be combined with smart metering and demand response, we could conceivably move to a situation where load is managed (i.e., by dishwashers etc. being turned on automatically when demand was lowest and vice versa) and supply is being managed by storage. This could significantly reduce the amount of stranded capacity and hence wasted cost on an electricity system, as well as improve its reliability.

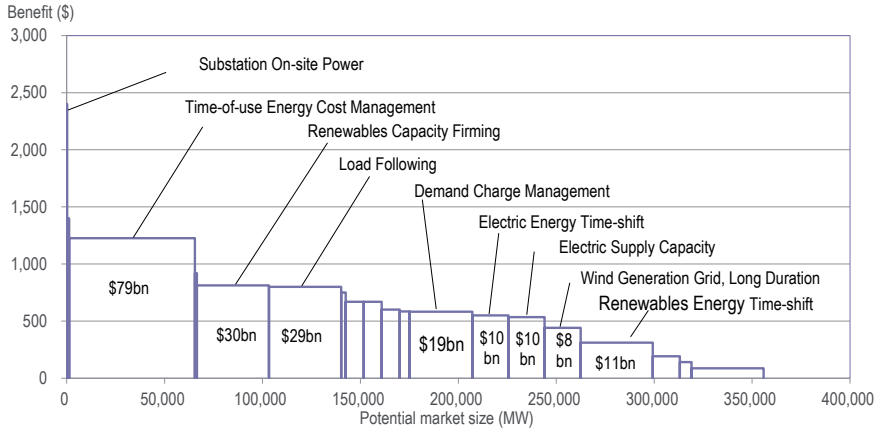
For some real long-term crystal-ball gazing, what is perhaps most exciting is that storage has the potential to be 'distributed', i.e. at the domestic level. Imagine a situation where homes have solar panels, and an electric vehicle in the driveway (and thereby a large-capacity battery), with a smart meter and energy management system. Utilities could theoretically become much more localized, conceivably even on a multi street basis, with each household becoming its own energy trader by setting rules to purchase centralized power generation when prices were low, to discharge back to the grid when prices were high (potentially within customer-set price parameters) with appliances running on the same 'rules' basis (i.e., a limit on an EV battery where the charge should not be allowed to fall below 80%.)

So How Big Could it Be?

10-year economic benefit of storage to the US alone could be $228bn

The problem with industries in their infancy is that it is phenomenally difficult to predict their potential size. However, as a guide, a recent study for the US Department of Energy estimates that the economic value of storage over a 10-year period in the US alone could be $228 billion (Figure 27). Clearly there is a cost to building storage which is currently a major stumbling block, but the value potential is clearly significant when applied to the whole world. In terms of primary energy inputs to power generation, the US uses 21% of the global total, so simplistically the 10-year economic benefit to the world could be well in excess of $1 trillion. Clearly the benefits would be larger in some countries and less in others, but the potential scale of the utility storage industry alone starts to become apparent.

Figure 27. Potential Market Size of Storage Battery by Applications in US.

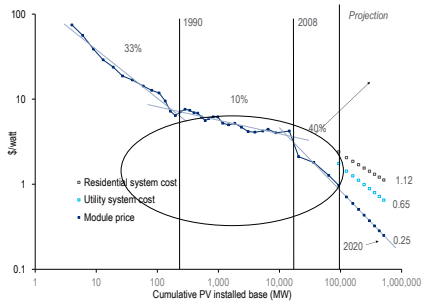


Source: Sandia National Laboratories, Citi Research

Cost

While the 'value' of storage is becoming increasingly evident, the cost of storage remains the prohibitive barrier to entry, being cited by many commentators as the reason why 'it will never happen'. However, to us this is reminiscent of the dismissive attitude to solar seen as recently as 5 years ago (including by some utilities) that the cost would never come down enough to make it competitive. As shown in Figure 28, solar has exhibited extraordinary learning rates of 22% (i.e. for every doubling of installed capacity the price of a panel has fallen by 22%), meaning in reality that the price of a panel has fallen by >80% in the last 5 years. Similar data for these learning rates is becoming available in the world of lithium ion batteries (LIB), where prices have fallen from ¥320/kWh in 1995 to around ¥33/kWh in 2013, a reduction of 90% in less than 20 years. Similarly, prices of automotive lithium ion batteries have declined from $1,500/kWh in 2009 to around $500-600/kWh in 2013, and we expect them to decline to $300/kWh in 2020 (Figure 29). Solar provides the template that when capital is deployed (and helped by subsidies), the cost of a technology can reduce dramatically, and it is noteworthy that both Germany and Japan have introduced (admittedly small so far) subsidy schemes for storage.

Figure 28. Solar Learning Rates Since 1972



Source: Citi Research, BNEF

Figure 29. Historical Price Decline in Consume LIB in METI Statistics and Auto Lib.

Note: We assume JPY100/$ for consumer LiB prices. Auto LiB price is estimated by Citi.

Source: Company data, Wards, Anfavea, AEB, JAMA, JAPA, CAAM, SIAM, GAIKINDO, TMT, TSR, Markline, METI, Citi Research

Which Sectors/ Subsectors are the Winners?

Many competing technologies

Several types of batteries are used in storage applications, including lithium-ion batteries, lead-acid batteries, redox flow batteries, and sodium sulfur (NaS) batteries (Figure 30). Currently storage systems (like uninterruptable power supply) use lead-acid batteries, but this is a mature technology that uses the toxic substance lead, and we believe the market will expand driven by lead-acid replacements like lithium-ion and redox flow batteries. It is simple to make redox flow batteries larger and they have long cycle lives, so they are suitable for key infrastructure applications like grid storage. In our view, lithium-ion batteries can be used not only in infrastructure storage applications, but also in office/residential applications due to the ease with which they can be made smaller.

Battery manufacturers are the obvious beneficiaries

Key players in the storage battery market include Panasonic, NEC, Sony, Toshiba, Sumitomo Electric, and GS Yuasa. Recent M&A and joint venture activity shows how many large companies are moving into the storage market, including NEC's acquisition of the storage battery business of A123, part of China's Wanxiang Group, for $100 million (March 2014), and the announcement by Sony about a tie-up with Canada's Hydro Quebec in storage batteries (April 2014). In addition, many companies are working to expand the overall storage battery market, i.e., Panasonic marketing residential storage batteries and GS Yuasa involved in verification testing of industrial lithium-ion batteries to be used by Kyushu Electric Power.

Automotive industry a potential beneficiary, power generation markets depending on fuel choice

Automotive companies have something of a choice of whether to be a beneficiary or a loser in the longer term, depending on their route of development, and to what extent electric vehicles gain penetration. Renewables manufacturers and developers are clear potential beneficiaries of storage as it makes their plant more economic and allows greater penetration. Baseload technologies such as nuclear (perhaps less so coal given emissions) are potential beneficiaries as they can be protected by storage, but the potential loser in generation in the much longer-term could be gas, given storage could ultimately provide the flexibility which is one of gas' key advantages.

Figure 30. Comparison of Major Storage Device Technologies: Lithium-ion Batteries Offer High Voltages and Storage Densities

Battery type	Lithium ion	Nickel Hydrogen	Nickel Cadmium	Acid Lead	NAS	Redox Flow	EDLC	Lithium ion Capacitor
Discharge Potential (V)	2.4-3.8	1.2	1.2V	2.1	2.08	1.4	0-3	2.2-3.8
Power Density (W/kg)	400-4,000	150-2,000	100-200	100-200	-	-	1,000-5,000	1,000-5,000
Energy Density (Wh/kg)	120-200	70	50	35	100	30	2-20	10-40
Cycle Life (times)	500-6,000	500-1,000	500-1,000	500-1,000	4,500	10,000>	50,000>	50,000>
Charging Efficiency	95%	85%	85%	80%	75-85%	80%	95%	95%
Cost	Poor	Good	Good	Excellent	Poor	Poor	Very poor	Very poor
Safety	Poor	Excellent	Good	Good	Very poor	Excellent	Excellent	Excellent
Cathode Material	Lithium Compounds	Nickel Hydroxide	Nickel Hydroxide	Lead Oxide	Sulfur	Carbon	NA	NA
Anode Material	Graphite	Hydrogen Storing Alloy	Cadmium Hydroxide	Lead	Sodium	Carbon	NA	NA
Electrolyte	Organic Solvent Lithium Salt	Potassium Hydroxide Solution	Potassium Hydroxide Solution	Dilute sulfuric acid	β-Alumina	vanadium sulfate Solution	NA	NA
Characters	Risk of combustion	Self-Discharge Memory effect	Memory effect Cadmium is toxic	Easily deteriorated Lead is toxic	Operation at 300°C Risk of combustion	Pump Circulation Vanadium is toxic	Good power density Self-Discharge	Good power density Self-Discharge

Source: Company data, compiled by Citi Research based on various data

Immunotherapy

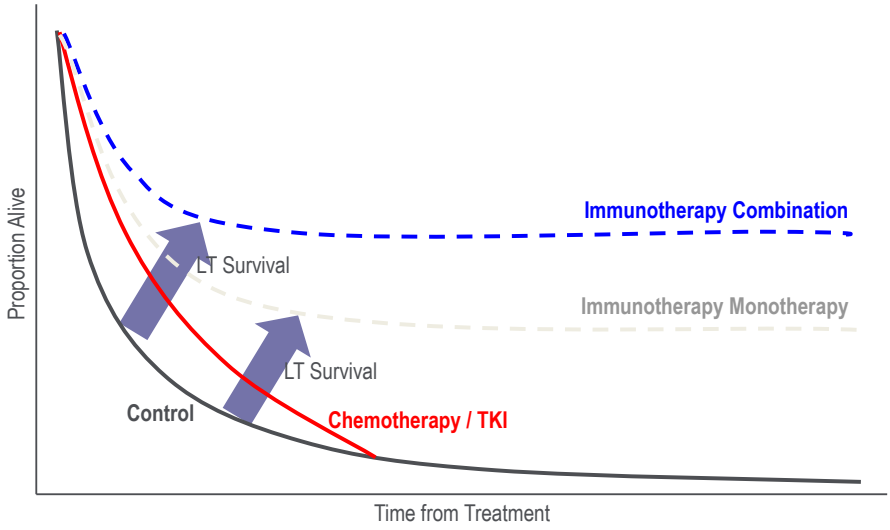
Andrew S Baum
Global Head of Healthcare Research

Cancer is the developed world's second most common cause of death, accounting for a quarter of all deaths and with an economic cost in 2008 estimated at $200 billion per year. Immunotherapeutic approaches leverage the patient's immune system to eliminate or slow the growth and spread of cancerous cells with the potential to dramatically improve the economic and medical outlook for cancer patients. New advances in tumor biology are enabling the development of newer potent T-cell mediated therapies that prevent the tumor from evading immune detection while offering the patient a manageable safety profile. Experimental T-cell immunotherapy comprises multiple modalities including checkpoint inhibitors, which work to defeat a cancer resistance mechanism that causes immune cells to see a tumor as 'self' which enables the immune response to defeat the cancer cells on its own, as well as therapeutic vaccines.

Durability of existing chemotherapy is very short. In contrast, immunotherapy can lead to very durable responses

While existing chemotherapy or even newer oral drugs have a powerful initial effect on tumor shrinkage (the so called "response rate"), the durability of these responses are typically very short, after which the tumor begins to grow again and starts to spread (metastasize). In contrast, the durability of responses with immunotherapy can last a decade or longer, due to the induction of an ongoing immunological memory, targeting cancer cells for an indeterminate length of time and making it a potential tool to transform a significant percentage of cancers into something akin to a chronic disease. We draw parallels with the much smaller HIV population where HIV therapies have transformed life expectancies, with significant medical and economic implications.

Figure 31. Immunotherapy Responders can Experience a Dramatic Impact on Survival Compared with Conventional Chemotherapy Due to Durability of Response



Source: Citi Research

Immunotherapy For (Almost) All

Immunotherapy is set to become the treatment goal for almost all advanced cancers

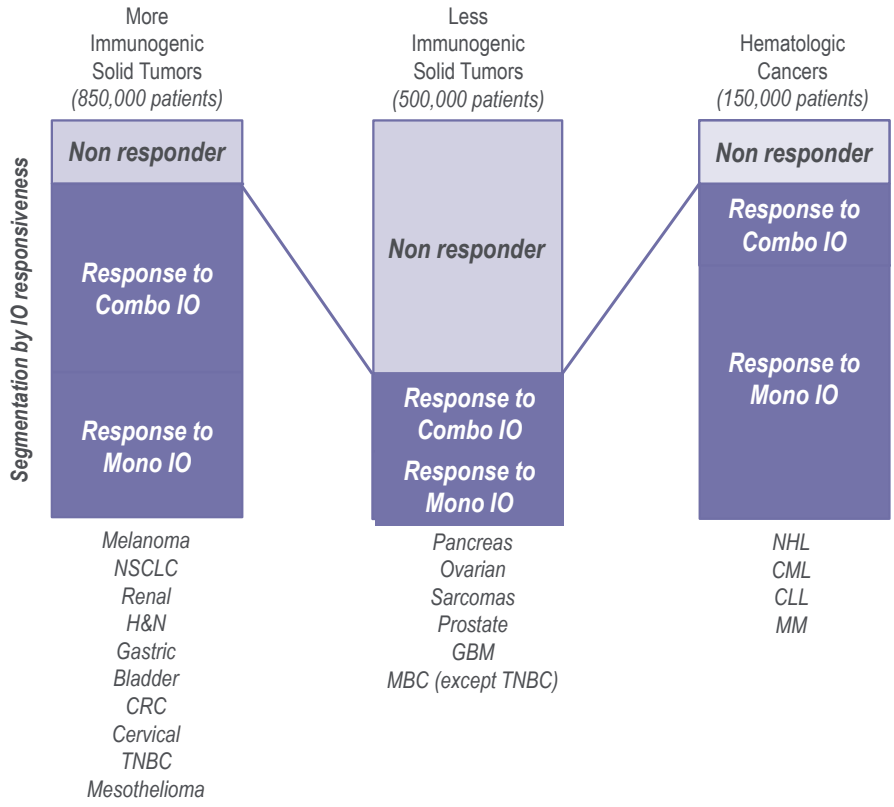
Making a cancer immune-responsive is set to become the over-riding treatment goal for oncologists across almost all indications. Immunotherapy is the only treatment through which advanced cancer can potentially be transformed without the need for chronic administration of agents and their associated toxicities. The use of precision medicine (using personalized therapeutics) will shift from the current dominant role of chronic targeted therapies, to a more subsidiary role in

enhancing the activity of immunotherapeutic agents. The evolution of tissue and blood immunodiagnostics will also open up a new paradigm of pharmacologic cancer care for solid and hematologic tumors.

Immunodiagnostics will transform development and treatment strategies in oncology and dramatically transform outcomes for the many, rather than the few

Immunotherapy will evolve into the dominant treatment modality for almost all advanced cancers by 2025. The primary treatment goal for almost all advanced cancers will be to maximize the responsiveness of a given patient's cancer to immunotherapy. Molecular diagnostics can already identify which patients are likely responsive at baseline to immunotherapies, a measure that can then be monitored and treatment modified as the disease progresses. Patients without an immuno-responsive tumor micro-environment will be addressed through a wide array of approaches designed to elicit and maximize immuno-responsiveness (i.e., cancer vaccines). The percentages of patients more, or less, likely to respond to immunotherapy at baseline will differ across indications and are outlined below.

Figure 32. Cancers Can be Segregated by their Likely Responsiveness to Immunotherapy



Source: Citi Research, American Cancer Society

Immuno-responsiveness is determined by the interaction of a patient's immune system with the tumor

Potentially "immuno-responsive" cancers account for two-thirds of the total Western cancer incidence. We anticipate 20-40% responsiveness in this patient cohort with baseline PD1 mediated baseline monotherapy.

1. Cancers that are induced through exposure to a known mutagen appear to be among the most responsive to immunotherapeutic approaches. Confirmed examples to date include non-small cell lung cancer (NSCLC) (smoking induced), malignant melanoma (UV light induced) and mesothelioma (asbestos induced). In a similar manner, we anticipate bladder cancer to be highly

immune-responsive given the strong correlation between incidence and smoking or industrial chemicals exposure.

2. Virally mediated cancers are likely to generate strong responses to immunotherapy given the detection of non-host protein by T-cell receptors (TCRs). Likely responsive virally induced cancers include head and neck (HPV), cervical (HPV), and hepatocellular carcinoma (HCV) among others.

3. We anticipate strong responsiveness to mono or combination immunotherapy in hematologic cancers (blood cancer) given the high incidence of frequent somatic mutations and the likely minimal inhibitory impact of regulatory T-cells (T-regs). Potential disease targets include multiple myeloma, chronic myelogenous leukemia (CML), diffuse large B-cell lymphoma (DLBCL) and chronic lymphocytic leukemia (CLL)

$35 Billion Peak Market Potential

We think the market is dramatically underestimating the potential for checkpoint agents

We believe that in 10 years, immunotherapy will likely form the backbone of 60% of all cancer management regimes in the developed world given the likely paradigm shift in overall survival benefit improvements in responsive patients. Current published estimates for the size of the immunotherapy market at about $7 billion include only sales in metastatic melanoma, NSCLC and renal cell carcinoma, which represent less than a quarter of all the cancers in the developed world. We forecast around $10 billion in peak market potential for vaccines and adoptive T-cell technologies and believe the potential size of the immunotherapy opportunity for checkpoint agents alone across multiple tumor types and chronic viral infections is $24 billion — nearly 3x published estimates — driven by:

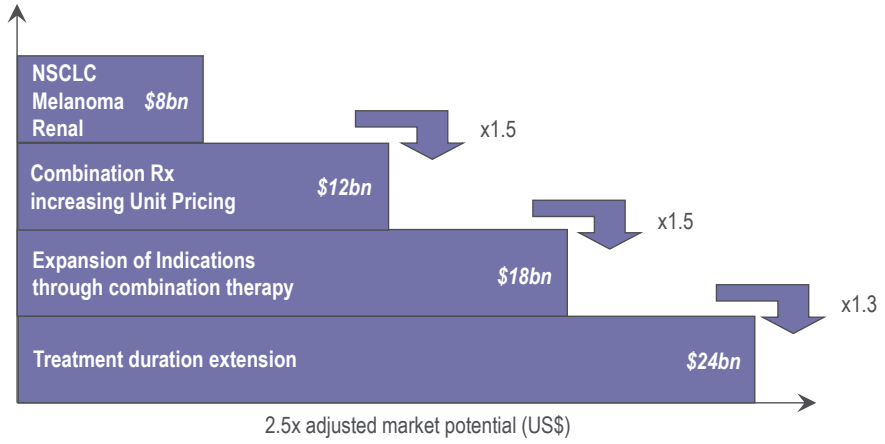
1. **Indication expansion:** Combination strategies of checkpoint agents with chemotherapy/ radiotherapy / monoclonal antibodies/ vaccines/ cryotherapy or other checkpoint inhibitors will likely expand the potential indications for checkpoint agents well beyond NSCLC, melanoma and renal cancer.

2. **Market penetration:** Unlike first generation immunotherapies, we anticipate high adoption rates in Western countries given a largely well-tolerated adverse event profile compared with conventional chemotherapies.

3. **Duration:** The months per patient (duration) of immunotherapy will likely materially expand given the anticipated improvements in progression-free survival time when immunotherapy is used as part of a combination regime. Maintenance and adjuvant therapy are two addition drivers of increased treatment duration.

4. **Unit price:** The unite price of therapy is set to increased associated with migration to checkpoint combination therapy. We have assumed a price per month of $110,000 in the US and $80,000 outside the US for checkpoint agent therapy and anticipate the US will allow additional sales of $6-$8 billion for a second immuno-modulator to be used in combination with the checkpoint agent. This translates into a maximal unit price of $15-$20,000 per month for combination therapy.

Figure 33. Checkpoint Agents have Market Potential in Excess of $20 Billion by 2021



Source: Citi Research

Cancers not normally immunotherapy-sensitive can be induced to become highly sensitive to immunotherapies, rapidly expanding the addressable market

The market is not reflecting the likely breadth of oncology indications addressable with immunotherapeutic approaches. Investor awareness of immunotherapy is largely limited to melanoma and renal cancer, and more recently with NSCLC. We believe that, ultimately, immunotherapy will form the backbone of treatment for up to 60% of metastatic disease and perhaps 30% of adjuvant therapy. Tumors traditionally thought of as non-immunogenic can likely become immunogenic and respond to immunotherapy through co-administration of pro-immunogenic therapies designed to increase antigen release from the cancer cell, effectively mimicking the actions of a vaccine. Potential priming agents for immunotherapy include chemotherapy, monoclonal antibodies such as Erbitux, Herceptin and Rituxan, radiotherapy and even cryotherapy.

Immunotherapy applications can also be extended to viral infections and autoimmune disease

The potential to selectively influence the T-cell mediated immune system may have important applications in anti-viral therapy, in particular for HPV and Herpes Simplex. In combination with current inhibitors, checkpoint agents offer the potential to attain functional cure through eradication of viral load. In addition, immunotherapies have the potential for treatment of autoimmune diseases by inducing self-tolerance through down regulating the innate immune system. Potential indications include lupus, rheumatoid arthritis and psoriasis.

Insurance Securitization

Todd Bault
Head of US P&C Insurance Research

Erik J Bass, CFA
US Life Insurance Analyst

If you don't follow (re)insurance closely, you may have never heard of *insurance securitization*. And if you do know about it, you know that it's not new, with the first securitized transactions dating back to 1996. So how is it that a 17-year old technology can only now be called disruptive? Because securitization is indeed the most disruptive long-term force we see at present: it is already cutting prices, changing market shares, birthing new players, and forcing old ones to consider potentially radial changes to their existing strategies.

A sleepy industry wakes up to disruption

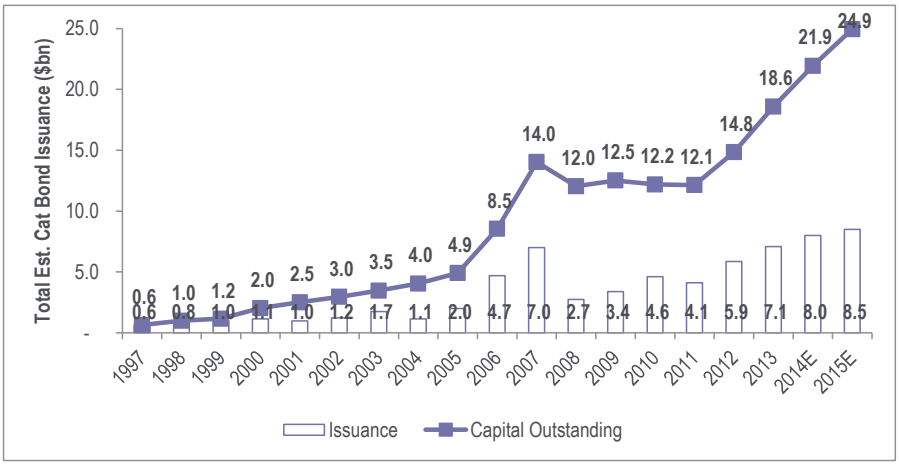
So what *is* insurance securitization? At its simplest, it is a change in the capital structure of (re)insurance. (Re)insurance naturally employs *leverage*: (re)insurers are allowed to write policies whose losses could be multiples of the capital they carry on their balance sheets. Through diversification, risk management, and credit ratings, this leverage is an accepted part of (re)insurance, but it does mean that a company's capital must be available to cover each and every risk.

Throughout this report, we use the shorthand *(re)insurance* to refer to "insurance and reinsurance", as securitization applies to both. As a reminder, *reinsurance* is the mechanism by which insurers spread their risk globally to manage concentrated exposures.

Securitization eliminates leverage with a blunt instrument: *full collateralization*. A securitized risk (which we shall refer to generically as an *insurance-linked security* or ILS for short) must hold cash & liquid securities equal to the full possible limit of payout. This eliminates credit and payment risk (in theory), and makes liquid trading a possibility (which is still very thin). There are many details surrounding ILS structures, and there are many variations in the market, but the notion of full collateralization is key to most of them. As a result, ILS is mostly viewed as a substitute for, and competitor to, reinsurance.

Investor Interest in ILS Has Boomed of Late…

Figure 34. Estimated Cat Bond Issuance, 1997-2015E (Total 2013 ILS Issuance ~$45bn)



Source: Guy Carpenter, Citi Research

Cat bond issuance began to reaccelerate in 2012

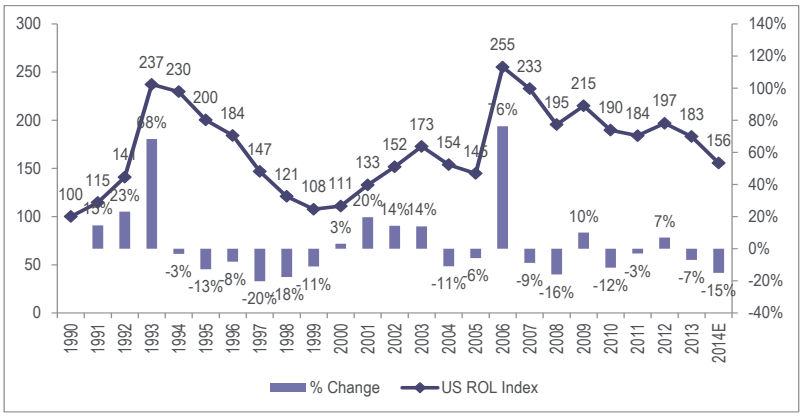
Tracking ILS issuance remains complicated, but many organizations do a credible job. Easiest to track are *catastrophe bonds (cat bonds)* — fixed income securities designed to pay out in the event of specified catastrophic risks. Per Guy Carpenter, a global (re)insurance broker, cat bond issuance began to reaccelerate in 2012, with the new issue market growing 30% per year and capital outstanding growing 23%.

Total issuance of ILS issuance is estimated at $45 billion, and could move to $60 billion by 2015

This understates total issuance, which includes more generalized pools of collateralized reinsurance funded by investors and managed by reinsurers or other specialists (known as *sidecars*). In 2013, Guy Carpenter estimates total issuance to be closer to $45 billion, and this could understate things. $45 billion is estimated to be about 15% of the global property catastrophe market as measured by limit, and we should point out that nearly all issued ILS has been focused on property, though there are early hopes that this will start changing in 2014. We increased our own estimate of cat bond issuance in 2014-15 owing to initial reports of strong Q1 issuance (per Artemis for cat bonds and Lane Financial LLC for sidecars), and it no longer seems out of the question that total ILS issuance could be $60 billion by 2015, around 20% of current limits.

…And Traditional Reinsurers Have Been Forced to React

Figure 35. US Catastrophe Pricing Impacted by 2012-13 ILS: 25-40% ILS Cuts in 2013 Resulted in 15% Price Cut Response by Traditional Reinsurers



Source: Guy Carpenter, Citi Research

Demand for ILS drove prices down which drove further issuance as pricing for ILS become close to pricing for traditional reinsurance

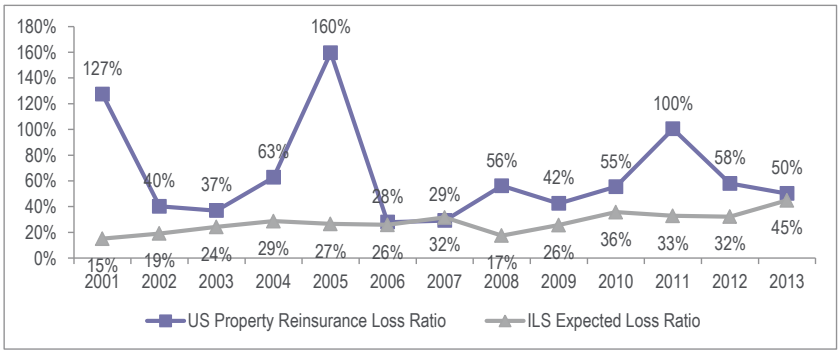
You know disruption is real when the incumbents react, and this was the headline event of 2013. As more and more institutional investors became comfortable with the structure of ILS, they began to focus on the potential yield pickup versus other fixed income asset classes. This drove increased demand for cat bonds, which helped ILS pricing to decline by an estimated 25-40% in 2013. This, in turn, drove further issuance as pricing for ILS was now closer to pricing for traditional reinsurance. In response, comparable US catastrophe reinsurance pricing saw an estimated decline of 15% at the start of 2014 (and reinsurance pricing generally fell 5-25% per Guy Carpenter). This pricing pressure has continued year to date as cat bonds have continued to gain share. Without context, this might sound like irrational behavior by new entrants, but as we shall show, most ILS pricing has been *higher* than comparable reinsurance.

Is the ILS Model Simply a Better One? Lower Potential Losses…

ILS now has a track record and we believe recent momentum is sustainable

It has taken longer for the ILS market to develop than initially projected, but we believe recent momentum is sustainable. Many claims had been made at the market's inception: it would have lower transaction costs; it was the only way to manage ever-growing global catastrophe risk; it was uncorrelated to the market. But given its complexity and lack of a track record, uptake was slower than expected, and the financial crisis derailed growth after the 2004-05 hurricane seasons. But perhaps now we have the most powerful growth incentive of all: ILS has a track record, and it might just be a better one than traditional reinsurance.

Figure 36. ILS Profitability Looks Better Than Reinsurance At First Glance…



Source: SNL Financial, Lane Financial LLC, Citi Research

The *loss ratio* is the ratio of incurred (re)insurance losses to earned premiums, and is a key component of overall (re)insurance profitability. A *lower* loss ratio is better.

Lane Financial LLC has been examining the ILS industry since its inception and have developed strong quantitative techniques for analyzing ILS. Using their data, we can make some comparisons to the traditional reinsurance industry. For example, Lane has estimated expected loss ratios back to 2001, which we can compare to excess property reinsurance in the US. The loss ratio for reinsurance is both higher and considerably more volatile than for ILS. Now this may not be fully comparable: Lane estimates expected losses, not actual losses, and traditional reinsurance reinsures a broader range of property coverages than ILS. Still, this at least suggests that ILS is producing better risk-adjusted returns.

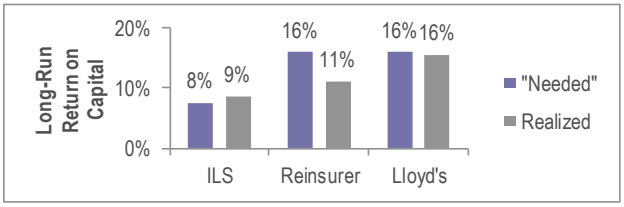
Figure 37. …And Digging In Further, ILS Track Record is Better Than Traditional Reinsurance with Lower Volatility

Theoretical Returns, Reinsurer (Levered) vs. ILS (Collateralized)

1)	Limit ($m) (assumed)	100
2)	Rate on Line (ROL) (assumed)	10%
3)	Premium ($m) (1)x(2)	10
4)	Premium/Equity (assumed)	0.25
5)	Limit/Equity (4)/(2)	2.50
6)	Equity ($m) (3)/(4)	40
7)	**Reinsurer Return % (assumed)**	**16%**
8)	Risk-Free Rate (assumed)	2%
9)	Risk Premium ($m) [(7)-(8)]x(6)	5.6
10)	Collateral ($m) (1)-(6)	60
11)	Collateralize Return ($m) (9)+(8)x(1)	7.6
12)	**Collateralize Return % (11)/(1)**	**7.6%**

2002-13 Actual Returns (Lane Financial, LLC)

	ILS	Reinsurer	Lloyd's
Annual Return	8.6%	***11.1%***	15.6%
Std. Dev.	4.3%	9.1%	10.3%
Sharpe	2.0	1.2	1.5



Source: Lane Financial LLC, Citi Research

…With Potentially Higher Returns and Lower Volatility

Lane Financial LLC seems to agree based on computed total returns over 2002-13 for ILS, reinsurers, and the Lloyd's market, an important global reinsurance market. Traditional reinsurance has a lower Sharpe ratio (1.2) compared to ILS (2.0). We constructed a benchmark to put levered (re)insurance on the same basis as unlevered ILS to allow comparisons of returns. Assuming a needed 16% ROE for traditional reinsurance, this equates to around a 7-8% needed return for ILS. Our assumptions are judgmental based upon our knowledge of reinsurance, but it is interesting that they seem to correspond rather closely to what ILS and Lloyd's actually produced, with ILS a bit better than needed and Lloyd's a bit worse. But reinsurance was *much* worse, consistent with the higher loss ratio data.

ILS has a '"lower cost of capital" than reinsurance but the apparent cost difference is actually a different capital structure, unlevered vs. levered

This analysis helps to clarify a common misperception we hear in discussions about ILS, namely that it has a "lower cost of capital" than reinsurance. This is heavily overstated, in our view, in that much of the apparent cost is actually a *different* capital structure, unlevered vs. levered. As such, unlevered *should* have a lower cost of capital than levered. But what's important is that ILS appears to have done a better job of achieving and exceeding its cost of capital, whereas reinsurers have missed badly.

Having done a better job of achieving and exceeding its cost of capital vs. reinsurers and with a 10-year track record….

….we expect the market share of ILS to rise much faster than many expect

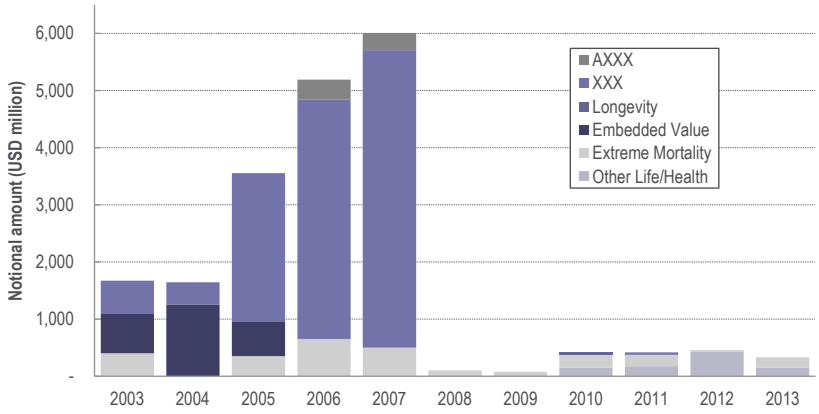
And this represents the real disruptive potential of ILS longer-term. At a recent industry conference, a leading reinsurer with strong ILS capabilities was asked what it would take for ILS' current 15% estimated market share of property cat to rise to 50%. They did not miss a beat with their answer: a 10-year track record. But, as our analysis shows, ILS has that already! So we would not be surprised if the market share of ILS rises much faster than many expect. Given a successful track record, ILS may be regarded as a vehicle for greater transparency, selectivity, and liquidity compared to reinsurance. This is nothing less than a new principal-agent fight, with investors (principals) possessing a new tool, ILS, to make more demands on agent (re)insurers as to how their capital is stewarded.

Life Insurance ILS Market Not Dead, but still in Hibernation

Life insurance securitization activity hasn't yet rebounded like the ILS market

While the ILS market for P&C risk has been booming in recent years, life insurance securitization activity has yet to rebound to pre-crisis levels. In 2013, only $330M of securities was issued, down from a peak of $6B in 2007. We attribute the decline to both lackluster demand from investors (due to poor performance of many life ILS deals during the crisis) and lower relative costs for other reserve financing options (namely captive reinsurance). That being said, life insurers still have considerable demand for solutions to manage reserve strain and exposure risks. In our view, life securitization could re-emerge as a viable, and attractive, means of risk and capital management for the industry over time. Much as we saw with P&C, the key is generating enough investor interest to make pricing competitive with reinsurance. If this occurs, it would be positive for primary insurers by reducing costs, but it would likely increase competition for life reinsurers.

Figure 38. Life Insurance ILS Volumes Have Yet to Recover Post Financial Crisis ($m)



Source: Swiss Re Capital Markets, Citi Research

Uncertain Outlook for Reserve Relief Transactions

Life insurance securitizations used mainly to reduce required reserves…

Historically, most life insurance securitizations were used to reduce required reserves rather than as a tool for managing risk. While structures differed significantly, the essential goal was to securitize a block of policy reserves to get them off the insurer's balance sheet. This was an especially popular way to reduce the strain from "excess" reserves required for term life (XXX reserves) and universal life (AXXX) policies. Securitizations provided a cheap means of reserve financing as companies could use a financial guarantor wrapper to get a AAA rating. However, the cost has gone up significantly post the financial crisis as cheap bond insurance has gone away. Currently, it is cheaper for most insurers to finance excess reserves through either letters of credit (LOCs) to captive reinsurers or third party reinsurers.

…and it's currently cheaper for insurance to finance excess reserves through letters of credit or third party reinsurers

In our view, whether or not the market for reserve financing securitizations recovers will be a function of both the cost and availability of alternative solutions. Currently, the National Association of Insurance Commissioners (NAIC) is reviewing the rules for captive reinsurance entities. While we do not anticipate significant changes, any measures to restrict usage could drive increased interest in capital markets solutions. On the other hand, the NAIC is also contemplating allowing expanded use of principles based reserving (PBR). This would likely result in lower required reserves for term and universal life (UL) policies, reducing the need for financing solutions.

Strong Potential Growth for Risk Mitigation Solutions

Risk management relating to extreme mortality, morbidity or longevity is similar to the P&C cat bond market

Post crisis, most life ILS transactions have been focused on risk management, with insurers looking to securitize the tail risk related to extreme mortality, morbidity, or longevity. This is similar to the P&C catastrophe bond market, and we believe investor interest could pick up as these products develop a more robust track record. If life ILS can deliver attractive returns to investors with uncorrelated risks, we see significant potential demand. This, in turn, would likely drive down costs and make the market more attractive to issuers. In our view, the other potential catalyst would be accelerating sales growth. Recent tepid sales of individual life, disability, and annuity policies have prompted insurers to retain most of the risk they underwrite. If volumes pick up, we anticipate demand for risk transfer to increase, with some of that being captured by ILS.

The Disruption: (Re)insurers Adopt Capital Markets Norms

The key question in terms of disruption is how much might behavior in the (re)insurance industry shift towards that of the capital markets?

There are many obvious near-term questions about insurance securitization. How much market share can they take (more than 15%)? How much more will it pressure property pricing (more to come per Guy Carpenter and other brokers)? Can it expand beyond property (we will likely see attempts at this)? Will the life ILS market take off similarly to the P&C market (unlikely near-term, but stay tuned)? But in the context of longer-term disruption, we believe the key question is: *how much might behavior in the (re)insurance industry shift towards that of the capital markets?* In many respects, (re)insurance companies are quite different from other financial firms. (Re)insurers sell highly customized products that are priced infrequently, must be held for relatively long periods of time, and have no real after-market liquidity. Securitization has the potential to nudge — or perhaps shove — (re)insurers more in the direction of their capital market counterparts.

As we discuss some future scenarios, keep in mind that we are not necessarily advocating for these developments, or forecasting that they are inevitable. There is quite a lot that could go wrong with securitization's next act. But what we do believe is that the securitization model (and other innovations like the hedge fund model) could be increasingly preferred by investors over providing capital to (re)insurers.

- **From insurance to hedging:** An insurer today that buys catastrophe reinsurance usually retains a good deal of the exposure and still has catastrophic losses from time to time in its results. These losses are unpredictable from quarter to quarter, but are usually quite manageable. But if cat bonds become available for a broader array of catastrophe losses, specifically for losses lower in limit (i.e. closer to the insurer's retained losses), the insurer's investors could begin to demand that the insurer use cat bonds to cover even more catastrophe losses. This would be a shift from managing retained catastrophe losses to *hedging them in the capital markets*. What would cause this shift? A belief that they "belong" in the capital markets, and not on insurers' balance sheets. The track record of cat bonds and other ILS is an important piece of evidence supporting this shift. Note that this argument was the original one at the birth of ILS, but for the wrong reason (it was thought there was insufficient reinsurance available to cover growing catastrophes). This shift in thinking would be comparable to banks being expected to hedge interest rate risk. This shift could also apply to greater use of securitization for risk mitigation in life insurance.

- **The hedge fund reinsurance model:** This is not strictly speaking securitization, but it is another development in changing the capital structure of (re)insurance. The idea is to pair a (re)insurance balance sheet with hedge fund asset management, and there are multiple companies pursuing this model with both P&C and life insurance. The current approaches assume that the company would take less (re)insurance risk and would attempt to generate alpha on the assets. Insurers taking more asset risk is not a new idea, but the track record is spotty, and such companies are still thought of as (re)insurers first. But the hedge fund model would shift the focus towards asset management, with the (re)insurance liabilities providing a source of funds (*float*) for alpha generation. There are *many* things that could go wrong with such a model, of course! The double leverage alone could destroy a company if bad things happen simultaneously to both sides of the balance sheet. But many smart industry insiders are making big bets on this model and are using it to push the boundaries of what can be written. One of the newer entrants, Watford Re, has specifically stated its goal of providing non-property reinsurance, which is a significant development. In addition to potentially providing more attractive risk-adjusted returns, the hedge fund model could allow investors greater selectivity in the kinds of risks they can back. For example, the fund could segregate its capital into pools dedicated to certain types of insurance, allowing investors to avoid some kinds of risk.

- **"Why are you writing that?":** An equity investor in a (re)insurer is following the business strategy of that company's management. The track record of reinsurance over the last decade has been mixed, to say the least, and one constant investor complaint has been reinsurers' long-term commitments to lines of business past the point of profitability. Reinsurers might point out, with justification, that many lines of reinsurance are inherently long-term in nature (i.e. their volatility can only be diversified over time). But as alternative capital models arise that allow for greater selectivity, and even nascent liquidity, investors gain a tool to push management towards their preferences. Already, reinsurers are being forced to consider providing more of their capital in discrete collateralized pools, and even to consider taking more risk in their investment portfolios. This could shift reinsurance itself from being a balance sheet play to an underwriting management play, with reinsurers generating more fees managing risk that is increasingly ceded to the capital markets directly. This could have mixed consequences — less of some kinds of insurance may be available if they are viewed as unsuitable for securitization — but this may be the way of things.

Precision Agriculture

PJ Juvekar
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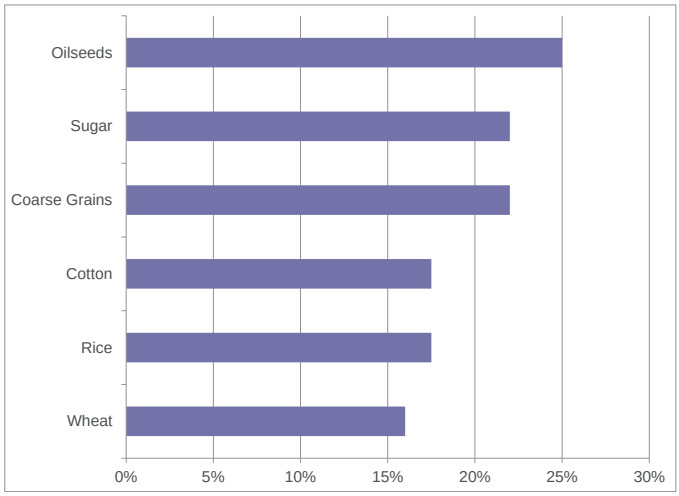
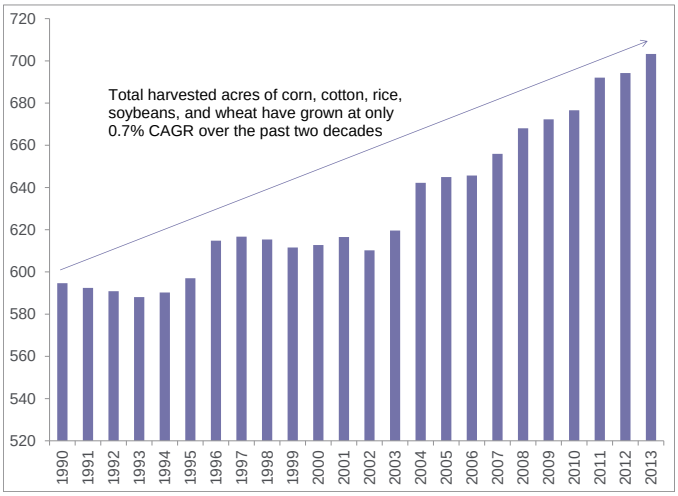
Agriculture is one of society's oldest professions and its history is peppered with a multitude of disruptive innovations. From field management (crop rotations; advancement of no-till farm practices) to the machinery a farmer uses (cotton gin; GPS controlled tractors) to even the type of seeds planted (the biotech revolution started in the '90s) innovators have focused on improving the productivity of land to help feed a growing population. With the emergence of the middle class in developing economies, and a global population which is rising by ~75mm people per year, agricultural producers will need to boost production by 20%, on average, for key crops over the next decade (Figure 39). Bringing new arable land into production can help, but as shown in Figure 40, unless there is a major divergence from historical trends, new land will not be nearly enough to meet the need alone. Farm productivity needs to take another step higher, and we think Precision Agriculture will be an important avenue to achieve these productivity gains.

Figure 39. Required Increase in Global Production by 2022



Source: OECD, FAO

Figure 40. Global Acreage of Key Crops (mil hectares)



Source: Citi Research, USDA

What is Precision Agriculture?

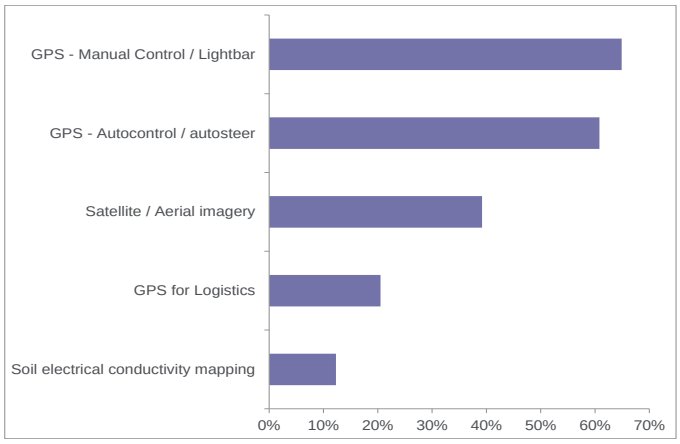
Precision Agriculture is about giving farmers the ability to maximize the capability of a given acre of land

Precision Agriculture is a generic term encompassing a variety of products and services. But at its essence, we see Precision Agriculture as: 1) A set of technology-based devices which enhances the ability of growers to manage their farms; and/or 2) Analytics and services which provide farmers insight or predictive tools to lift productivity and reduce production volatility. At its core, Precision Agriculture is about giving farmers the ability to maximize the capability of a given acre of land. Unlike some of the other disruptive innovations in this report, farmers in some of the most advanced agricultural regions like North America, Europe and Latin America have already adopted some the first generation of these products, such as:

- **GPS Utilizing Equipment** – Farm equipment like planters, tractors and harvesters with utilize GPS to steer, or is used in support of yield/soil monitoring. According to Purdue University, roughly 60% of US farmers utilize at least some equipment with this technology, up from 20% in 2006.
- **Yield Mapping** – Sensors which detect crop yield and quality characteristics while harvesting, allowing farmers to analyze data to determine high/low quality regions within a field to adjust future production optimization needs.

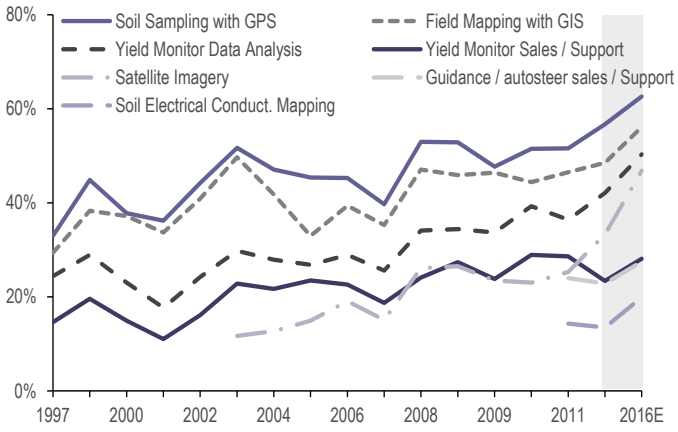
- **Soil Sampling and Mapping** – Tests soil for nutrient levels to determine fertility needs. Typically soil sampling is done at the beginning or end of the season. Next generation applications include real time analysis and mapping to develop variable rate fertilizer application algorithms.
- **Fleet Management** – Wirelessly tracks a range of machinery statistics including operating hours, engine load and usage rates. Management software allows farmers to remotely optimize equipment settings, improve fuel efficiency through logistics and identify potential maintenance issues.

Figure 41. Precision Ag Used by US Farmers



Source: Purdue University

Figure 42. Precision Ag Services Offered by US Farm Dealers

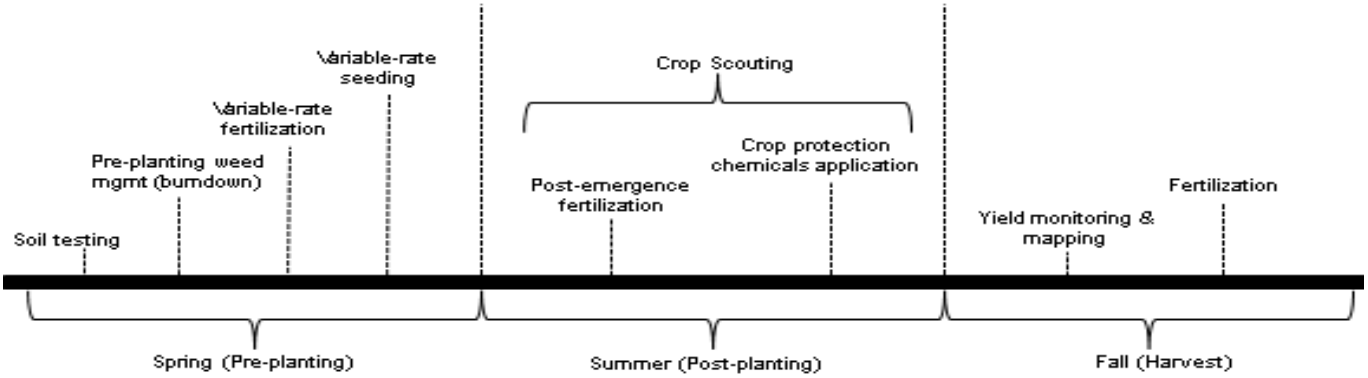


Source: Purdue University

First generation adoption of Precision Agriculture being helped by farmer profitability and tax incentives

Strong farmer profitability and favorable tax incentives for machinery purchases have supported the adoption of first-generation Precision Agriculture products. With farmer cash income reaching all-time highs in 2012 and Section 179 depreciation benefits providing a beneficial tax environment for farmers, new farm equipment sales have remained well above historic levels in recent years. Precision Agriculture adoption followed the influx of new equipment investment as farmers sought to modernize their fleets. Based on Citi's Spring 2014 Farmer Survey ~50% of farmers report using some sort of Precision Agriculture product today. The next driver for equipment with Precision Agriculture capability would be improved yields and higher profitability, in our opinion.

Figure 43. Generic US Farmer Seasonal Timeline (First Gen Precision Planting Adopter)



Source: Citi Research

Second generation Precision Agriculture includes things like hyper-localized weather, eco-system coordination and predictive analytics

In the past year, a variety of companies have accelerated development of what we would call second generation Precision Agriculture. Products which we include in this bucket include:

- **Hyper-localized Weather** – Weather is a critical component of farming. Not only does it affect the development of the crop, weather conditions determine what type of field work a farmer can do on a given day. While there are numerous weather services currently available for farmers, next-generation weather applications are being launched. Examples of this include Monsanto's Climate Corp Pro application for mobile devices will provide field-specific temperature and precipitation projections, while Pioneer has partnered with DTN to provide customers access to an exclusive network of weather stations, including those on growers' farms, for real-time local information as well as environmental conditions.

- **Eco-system Coordination** – The first generation of Precision Agriculture platforms were generally developed independent of other parts of the Agriculture value chain. We are now seeing more coordination across machinery, seed, fertilizer and crop protection chemical companies to provide "eco-system" solutions to provide incremental yield improvements above and beyond what each product/service has offered separately before. In our recent March Madness Agriculture conference call series, farmers expressed this as their main concern that they want equipment and applications to "talk to each other". As an example of this, Monsanto's IFS platform provides farmers with a digital roadmap to vary the number and spacing of seeds planted per acre, using Monsanto's proprietary algorithms (developed during its own field trials) to optimize seeding density based on the type of corn seed planted. Other companies have formed JVs or partnerships, including Deere which recently entered into non-exclusive partnerships including DuPont, Bayer, and Dow, allowing partners to access pertinent data collected by Deere machines in the field. AGCO and CNH have entered similar partnerships with TopCon and Trimble, respectively.

- **Predictive "Big Data" Analytics** – Farmers make at least 40 key decisions each season while growing their crops. In the view of many companies in the agriculture value chain, the decision making process for farmers could be improved through use of "big data" analytics, which will take real-time on-farm data for key variables and then devise prescriptive solutions for farmers. Climate Corp has developed a "predictive model" based on years of historical agronomic data by county that can help farmers make several on-field decisions to maximize yields. As an example, a service could monitor weather conditions and prescribe a crop protection solution for farmers to minimize the impact of insects. This is among the less developed product markets currently, but several companies anticipate rolling out more services within this segment over the next few years.

How is the Precision Agriculture Value Chain Evolving?

As alluded to above, Precision Agriculture is a competitive environment with barriers between different parts of the value chain evolving, and in some cases, falling completely. We think the recent ramp up of investment is this space is due to three factors:

- **First Mover Advantage** – The experience of Monsanto in biotech seeds offers a poignant example of the benefits of being first to market with a disruptive technology. The company launched its first biotech seed in 1996. To this day, the company is perceived by farmers as the technology leader which allows for a premium price point. We think companies are ramping up investment quickly to try to "lock in" growers into their Precision Agriculture platforms.
- **Looking for New Avenues for Growth…**– Several sectors of the agriculture value chain, like seeds and fertilizers, are relatively consolidated. Seed companies fight over a few points of market share as a vast majority of business is sticky. Precision Agriculture offers the potential for a new growth driver to sell more products and services to current customers, increasing the depth and breadth of the relationship.
- **…While Dampening Volatility** – Agriculture companies have benefited from high grain prices over the past few years, but ultimately agriculture is a cyclical business driven by supply and demand. Over the long-term, fundamentals over the business are strong driven by an emerging middle class in developing economies, but in the short-term lower grain prices are likely to pressure farmer income. For crop input and machinery providers, offering services could add a less cyclical component to a historically volatile earnings stream.

Outlook & Risks

Machinery companies in the lead with first-generation products

For first-generation type products, machinery companies clearly hold the lead. Our channel checks with farmers recently showed that ~60% of Precision Agriculture products and services are currently supplied by machinery companies. However, as newer products like hyper-localized weather and predictive analytics become more widely used, we see other companies like seed producers, dealers, cooperatives and fertilizer companies becoming a more important players in Precision Agriculture.

Consultants currently estimate that the Precision Agriculture market in the US is a $1.5-$2.0 billion industry which could double by 2018 as second generation products are commercialized. This seems like a reasonable estimate, in our view. For example, biotech seeds typically exceed 50% market penetration within 5-7 years of launch. Assuming a vast majority of new Precision Agriculture platforms are focused on US corn and soybeans, at 50% adoption these services would only need revenue of ~$11/acre to exceed $1 billion of revenue. Further, many of these products will be subscription based (instead of one-time purchases), offering companies a relatively steady stream of revenue as planted acreage in the US does not change much from year to year. We think second generation products and services will eventually be launched in regions like Latin America, although this may be a few years away.

Risks include an aging US farmer population, peak farmer profitability in 2013 and competition in the sector

We see three major risks for Precision Agriculture type services: 1) According to the US Census, the average age of a farmer in the US is 57 years old (~15 years old than the average worker in other industries), and may not be technologically sophisticated enough to add these tools to their toolkit; 2) US farmer profitability peaked during 2013, and with lower grain prices expected in 2014, farmers may tighten their belts and not spend on "supplemental services"; and 3) Competition within the Precision Agriculture sector is already heating up, with seed companies, Ag retailers, machinery, and fertilizer companies all investing in this market.

Robots

The trend may not be your friend

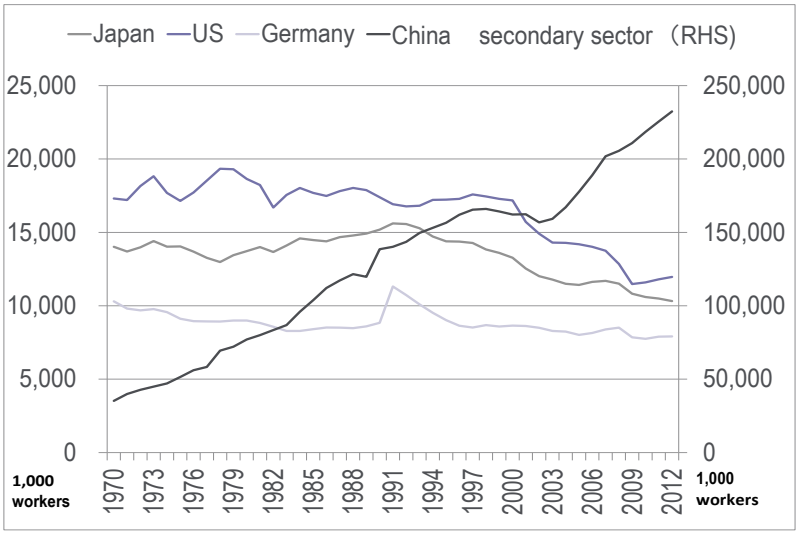
Graeme McDonald
Japanese Machinery & Shipbuilding Analyst

The publication of the book "The Second Machine Age" by MIT's Erik Brynjolfsson and Andrew McAfee has re-kindled interest in the disruptive impact of robots in particular and digital technologies in general . While the rising diffusion and broadening applications of industrial and service robots are not necessarily new trends, this book combined with other events in late 2013 including Google's decision to buy eight robotics companies, a Japanese robot called SCHAFT winning the DARPA Robot Challenge, a paper entitled "The Future of Employment" by Carl Frey and Michael Osborne of the University of Oxford and the launch of a robot ETF have ensured that robotics remain an important focus for global industrials

Rage against the machine….

As shown in Figure 44, manufacturing employment in the three largest developed economies has been on a forty year downward trend. In our view, robots in particular and the general trend of automation have only played a small part in this process. Other factors such as the growth of manufacturing in China and other low-cost countries have been more significant, especially over the past 10-20 years. From now, however, advances in artificial intelligence (AI), software and sensor technology coupled with lower computing costs and the growing influence of "Internet of Things" mean that the disruptive impact of robots will become increasingly apparent in economic data and our everyday lives

Figure 44. Long-term Down Trend of Manufacturing Employment in DM



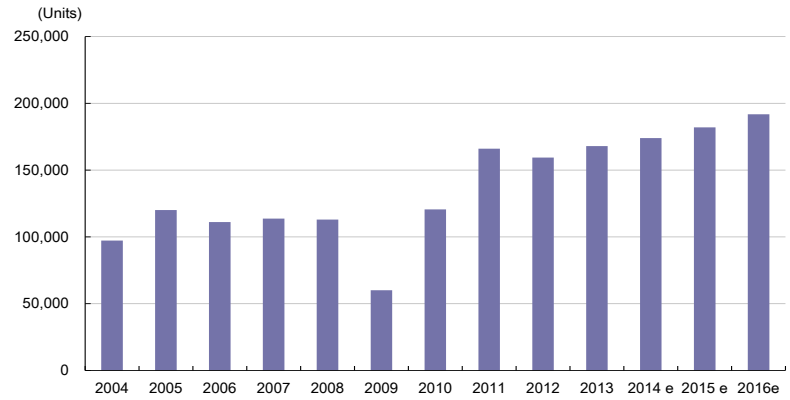
Source: Citi Research

Market Size

CAGR of 8.5% since 2008 with some makers saying that robots save factories

In 2013 the International Federation of Robotics (IFR) says that global demand for industrial robots reached 168,000 units (+5% YoY). Based on unit data since 2008, we estimate that the CAGR for global volumes is ~8.5%. The most recent forecast from the IFR for 2016 is for global demand to rise to close to 192,000 units, with China emerging as the largest end market. Few doubt the opportunities for robot makers to expand their top line but these companies are in a difficult position as there is an obvious risk for employees at their customers to see their jobs disappear. With that in mind, perhaps it is no surprise that Fanuc Robotics North America and Rethink Robots in Boston, maker of the $25,000 Baxter robot, both claim that their robots either "save factories" and "augment human labor" rather than simply substitute people.

Figure 45. Unit Growth in Industrial Robots



Source: Citi Research

How Big Could the Opportunity Be?

Industrial robots - maybe a $30bn market in 2016?

Estimates from the IFR suggest that the total value of the industrial robotics market in 2012 was around $25 billion including software, peripherals and system engineering. However, just taking the market for the physical robots, the market was worth $8.7 billion. From a base of 168,000 units in CY13, assuming volumes grow at an annual rate of 7%, and allowing for some down trend in average selling prices (ASPs), we think the overall market could easily exceed $30 billion by 2016

Service robots – focus on medical and defense (including drones)

The market for service robots is significantly smaller than the industrial segment in both in terms of value and volume. The IFR suggests that in 2012 the market was worth $3.4 billion (-1% YoY), with approximately 16,100 units sold (+2%). By value, the largest segment was the medical industry estimated to be worth about $1.5 billion. In unit terms, however, only 1,300 units were sold (+20%) though with an average selling price (ASP) of ~$1.2mn medical robots are the most valuable part of the service robot industry. In unit terms the largest segment is defense, with about 6,200 units accounting for approximately 40% of service robots sold for professional use. An estimated 5,450 of these units were un-manned aerial vehicles (or drones).

Data from Japan highlights potential for service robots

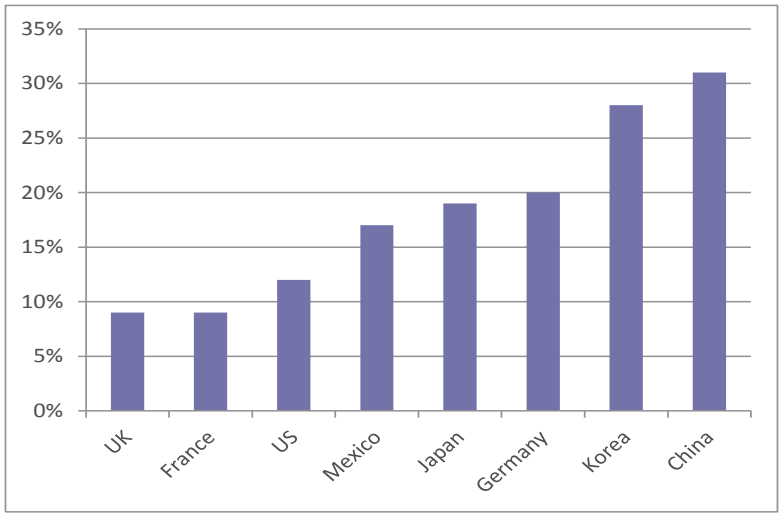
In Japan, estimates from NEDO (New Energy and Industrial Technology Development Technology) suggest the domestic robotics industry will increase to ¥2.9 trillion ($29bn) in 2020, up from ¥1.5 trillion ($15bn) in 2015. During this time frame the industrial robot segment will grow by 20% but the service robot segment will expand 2.6-fold to ¥1.6 trillion ($16bn)

Where is Next / What is Next?

China – the next big market?

Figure 46 shows that in 2012 manufacturing comprised just over 30% of China's GDP, compared to 19% in Japan, 12% in the US and only 9% in the UK. What is striking is that according to forecasts from the IFR, China is set to become the largest market for robots by 2016. Reasons for this include the up-trend of wages (albeit from relatively low levels), the peaking out of the working population, the high level of job-hopping and the general trend of Chinese workers not wanting low-paid manual assembly, picking, inspecting or packaging jobs in factories.

Figure 46. Manufacturing Value Added as a Percent of GDP (2012)



Source: United Nations, Citi Research

We have seen robots in use in China in our recent travels

In two recent visits to China we have seen robots at work and with a range of other processes having been automated. At Makita's power tool factory in Kunshan, the company highlighted the automated process of bearing assembly with signs saying how many workers had been reduced at each cell; at Omron's Industrial Automation Centre in Shanghai we saw how a wide range of assembly and inspection processes had been automated, again, with the specific goal of reducing headcount; and at Nabtesco's hydraulics plant near Shanghai, we heard how the company had invested in a state of the art assembly robot in order to show local workers how it could be incorporated into the manufacturing processes.

But white collar workers are increasingly under threat

These examples highlight the role of robots to replace blue collar factory workers in China. More worryingly for some, however, was the recent study by Oxford University academics entitled "The future of employment: how susceptible are jobs to computerization" which suggested that 47% of total US employment is under threat, perhaps over the next decade or two. The report notes that it is not just workers in production occupations but also transport & logistics, and the bulk of office and administrative support workers who are at risk.

Elementary, Watson

Even more worryingly for some white collar workers (especially in information intensive industries) is the progress made at IBM with Watson (it's artificially intelligent computer system) and its cognitive capabilities. Winning the TV quiz show Jeopardy brought to the world's attention the ability of computers not just to think but to process information faster than humans, via powerful algorithms. Watson has helped to open up a whole new range of opportunities for Machine Learning and humans' digital alternatives initially in the US healthcare industry and in US consumer banking, with lots more to come.

Medical apps

In the medical industry, Intuitive Surgical (US) is the top supplier of robotic-assisted surgery with its *da Vinci* systems. Current shipments are at relatively low levels (Q1 2014 guidance is for 87 systems versus 164 a year ago and 138 the previous quarter) but we believe there is significant upside for these kinds of systems to be used in minimally invasive general surgery. In 2013 there were 523,000 surgical procedures performed with *da Vinci* systems, up 16% YoY. Other applications for medical robots include sampling and testing in research labs and pharmacies. Able to work 24 hours a day, 365 days a year without getting tired or making a mistake we think these robots will threaten the jobs of some pharmacists and lab assistants

Automating the supply chain, entertainment and even the legal industry and defense

In March 2012 Amazon bought Kiva Systems, with the company saying the move was aimed a further improving productivity at its fulfillment centers. This news attracted a lot of attention but there were already many suppliers in the automated warehousing and logistics field such as Daifuku (Japan) who show-case their capabilities at its demo center near Kyoto, emphasizing their ability to substitute human labor in sorting, picking and stacking processes. As witnessed by all robot bands like Robocross or Compressor Head, advances in robotics mean that some ageing rock stars could be substituted by their digital alternatives, threatening employment in the entertainment industry. In the legal industry, progress in automating the scanning of legal documents using Symantec's Clearwell systems is said to threaten jobs for paralegals. In the defense industry, the growing applications of robots in situations such as bomb disposal, surveillance and reconnaissance suggests that head count in the armed forces could fall over time.

What jobs are safe? Special skills and the right education may not be the only answer

So, what jobs are safe and what jobs should we re-train for? We think careers like teaching are relatively immune from robotization; builders repairing aged infrastructure or erecting scaffolding seem to have some form of protection around their work place; similarly, craftsmen making fine lacquer-ware products or porcelain tea cups, or laying / repairing thatched roofs; or even controllers for unmanned drones, trains or trucks. Over the next 5-10 years, given current limitations on robots' speech perhaps there is still a role for salesmen and other client facing roles especially where it involves negotiating or persuasion. Finally, the growth of the Roomba cleaner made by iRobot is well known (~8mn have been sold globally) but if it still takes a robot 24 minutes to fold a towel, perhaps some jobs in the hotel industry remain safe.

Workers needed – in robotics!

We note data from Wanted Analytics which showed in 2013 there was a 13% YoY increase in jobs advertised online for robotics skilled professionals, with the medical industry accounting for more than a third. Perhaps some of us could re-train to work in the robotics industry or at least encourage some of our friends or family to!

What are the Barriers to Adoption?

Some things still can't be done by robots but humans and their digital alternatives will increasingly work together

In spite of the rapid progress made over the past few years there are still things that robots find hard to do: running up stairs, cutting someone's hair, or making a decision on whether someone accused of a crime is guilty or not. Developments in control technology, vision sensors and AI algorithms may well address these and other barriers. Regulation could cause progress to stall but we note the introduction of ISO 13482, in February 2014, which tries to address some of the concerns relating to errors or faults in service robots that could lead to accidents with humans. This is seen as a further step in the process to establish a framework which will allow robots and humans to work more closely together. This goal can be witnessed at some manufacturing plants but it was also a key part of ABB's booth at the Robot Show in Tokyo November 2013, show-casing the ability of humans and their digital alternatives to work together in a laboratory-like situation.

A recent Bloomberg report quoted Takahiro Fujimoto of Tokyo University's Manufacturing Management Research Center saying "fully automated machines don't evolve on their own". They are dependent on the knowledge basis of the humans working around them. At present the main disruptive innovation from the growth of robots is on blue-collar employment but going forward white-collar workers will need to be aware of the threat to their jobs Some kind of collaboration needs to be reached as humans and their digital alternatives will rely increasingly on each other.

Updates on the First Ten Disruptors

When we set about looking for ideas for this second Disruptive Innovations report, we were curious as to how our first ten disruptors had progressed one year later. Below we provide updates for each of the original disruptive innovations.

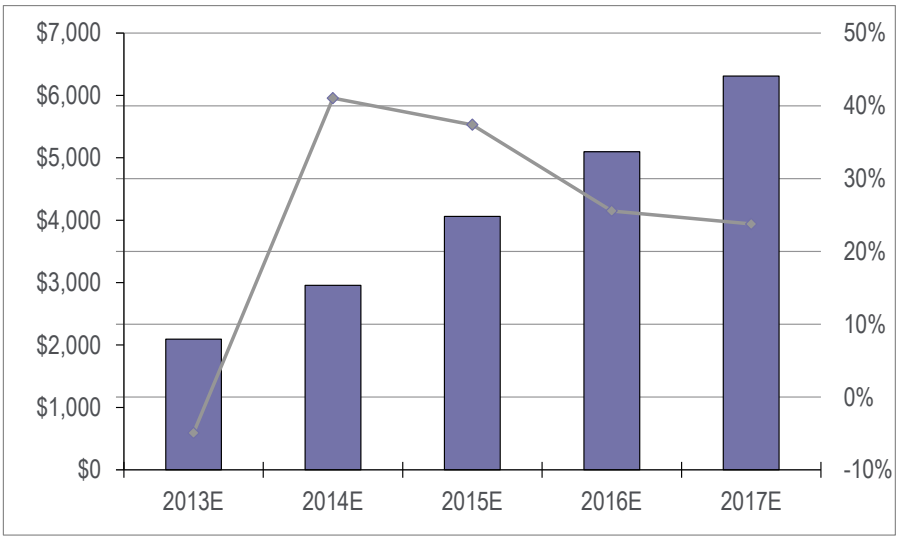
3D Printing

April 2013: We introduced 3D printing as having the potential to rewrite the rules of global manufacturing given its novel way of fabricating prototypes and on-demand parts.

Kenneth Wong, CFA
US Software & Printing Analyst

Update: We believe the ~$2B+ additive manufacturing market (3D printing) is beginning to attract customers beyond the traditional concept modeling and prototype engineer crowd. Larger manufacturing companies are looking to add elements of additive manufacturing into the production process and specialty end-markets such as medical, dental and jewelry are already printing end-use parts and goods for commercial use. General Electric is incorporating 3D printed components for its next generation LEAP engine due to the ability to create more complex and intricate geometries. Companies within the health vertical such as hearing aid maker Phonac and Invisalign braces manufacturer Align have already based their entire manufacturing process on the technology.

Figure 47. Market Still Increasing



Source: Citi Research, Wohlers Report 2012

Market opportunity expanding

While advance manufacturing applications currently account for 10-15% of total sales, over the long term we believe direct digital manufacturing (DDM) could represent the biggest share of the 3D printing market. Additionally, the recent "Maker" movement (putting power in the hands of the people to design, manufacture and market their own goods) has created a flood of consumer curiosity and interest which we believe will materialize into a significant new market segment. We see the addition of those two opportunities as more than tripling the addressable market. We believe as customer awareness of the technology's capabilities evolves, demand for print systems, materials and custom parts will accelerate.

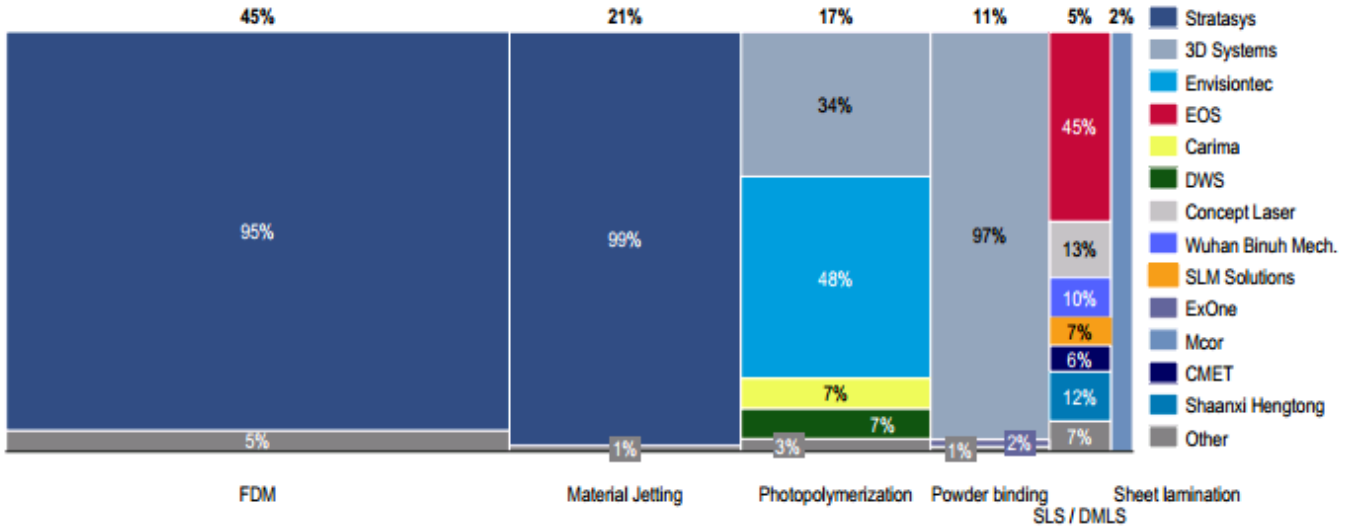
Margin expansion coming from improving revenue mix

We expect a growing print materials mix to drive sustainable long-term margin expansion. As is the case with the traditional 2D printer market, 3D printer manufacturers generate significantly higher gross margins (~70%) on the print materials than the actual systems (~40%). Materials, also known as consumables, currently account for <30% of total sales, much lower than the traditional print market (~80%) and we believe consumption will trend higher in the coming years. Additionally, adoption of higher-margin specialty materials which carry gross margins closer to 80% and a growing mix of software (~90%) will bolster the industry's current margin profile.

3D printing is still a green field

We see plenty of open field for market participants to roam, but the competitive environment is getting warmer. While 3D Systems and Stratasys are the clear leaders in the sector accounting for a disproportionate share of the current market (see figure below), the industry is still early enough such that it is not yet a zero sum game. At the present, each system manufacturer offers relatively unique print capabilities and materials. Our discussion with those in the industry suggest it is not unusual for customers to have machines from multiple vendors running side by side in order to address different needs and applications. M&A activity has been picking in the space creating overlap across technologies. Over time, we anticipate that as consolidation gets more pronounced the product overlap could eventually create a more intense competitive environment. For now, we believe a rising tide lifts all ships.

Figure 48. Unit Market Share by 3D Printing Process



Source: Citi Research, Wohlers Report 2012, Company reports

Roadblocks to broader consumer adoption slowly being removed

Pundits typically highlight the lack of a clear-cut use case when arguing against the growth of the 3D printing industry, but we believe that is a problem that should resolve itself over time as is typically the case with all new and revolutionary consumer products. It is only in hindsight that the applications for PCs, cell phones, microwaves and other novel consumer products become apparent. Considering the infinite number of applications that a 3D printer could be used for, we believe it would be unrealistic to pigeonhole the device to a singular "ideal" use case.

E-cigarettes

April 2013: E-cigarettes are battery-operated devices that are meant to mimic the experience of smoking a traditional tobacco cigarette. The industry has seen tremendous growth having reached estimated sales of over $1 billion globally in 2012.

Citi Global Tobacco Research

Update: We estimate that at the end of 2013, the e-cig category accounted for a little over 1% of U.S. cigarette industry volumes. However, we have seen e-cigarette volume growth decelerate notably as we believe the category is essentially at saturation with the early adopter.

To be clear, we fully recognize that there is real consumer interest in the category. Indeed, as of mid-2013, 20 million smokers had tried an e-cig. The issue as we see it is that only about a quarter of them stayed on the platform. And, while that drove e-cigarettes to gain industry share in 2013 (helped by significant distribution gains) that doesn't seem like a sustainable growth algorithm. Indeed, rolling 12-week year-over-year industry volume growth (as reported by Nielsen, in c-store and AOC channels) has decelerated from a peak of 114% in August 2013, to 55% as of January 2014. We believe this serves as evidence that the category has reached near saturation with the early adopter and needs a catalyst.

In a perfectly accommodative world, in terms of both the ease of innovation and the reasonableness of regulation / taxation, this category could have great potential. But the e-cigarette category (and tobacco more broadly) is unique, and we are mindful of exogenous headwinds that could prove to be disruptive.

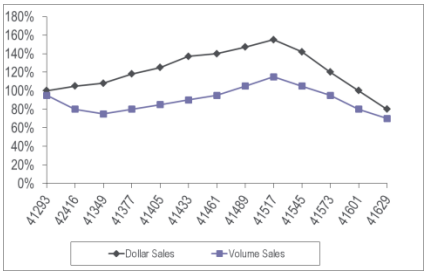
Why is the Category Slowing?

Category is slowing on negative mix shifts and softening volumes

Over the last six months, we have seen both dollar and volume sales growth decelerate in the e-cigarette category (Nielsen-tracked, brick and mortar). Indeed, the deceleration is coming from both negative mix shifts as well as softening volumes. The negative mix-shift seen for the category is inevitable as technology improves, formats change, competition intensifies, and prices come down.

However, we believe the decelerating volume growth that we are seeing reflects: 1) changing retailer brand preferences (e.g., brand destocking / replacements); as well as 2) consumer dissatisfaction with the product. Indeed, we suspect that the ~26% adoption rate for e-cigarettes, relative to a trial rate of 40%-50% (including non-purchase), probably falls well below that seen for many consumer electronics.

Figure 49. Sales and Volume Growth have Decelerated Sharply

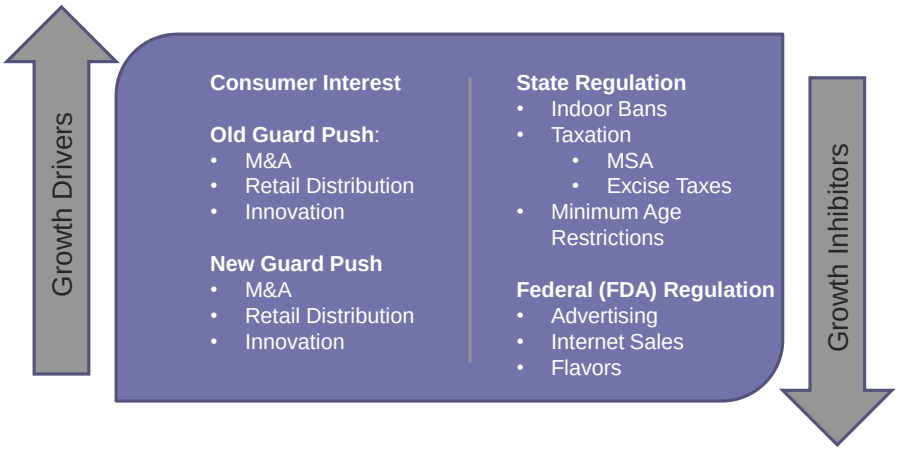


Source: The Nielsen Company, Citi Research

Where Do We Go From Here?

Given the underlying consumer interest that does exist, we think that it's quite reasonable that all the manufacturers are going to be stepping up their investment spending behind e-cigarettes (or keeping it at elevated levels). What is more, we think that pulling forward some of that spending will also prove helpful, given the incremental headwinds that continue to pop up. Indeed, we've recently seen action from both the old and new guard in the e-cigarette category, including: distribution gains, M&A and innovation (both current and forthcoming across the board).

Figure 50. Ample Headwinds and Tailwinds to Consider



Source: Citi Research

The Key Issue is Regulation and Taxation

Regulation of e-cigarettes is gaining momentum

State and local regulatory activity directed towards e-cigarettes seems to be accelerating as these entities are opting to move forward with local regulation rather than wait for national guidelines from the FDA. States are considering a range of options, from banning the use of e-cigarettes in enclosed public spaces and applying excise taxes to e-cigarette sales to minimum age restrictions. On the federal side, in April 2014, the FDA proposed rules that call for strict regulation of e-cigarettes including 1) age limits on purchases; 2) health warnings; 3) prohibition of sales through vending machines; 4) requiring manufacturers to provide scientific evidence before making any claims of direct or implied risk reduction associated with their product; 5) FDA review of marketing; and 6) elimination of free samples.

Genomics and Personalized Medicine

April 2013: The completion of the Human Genome Project (HGP) which sequenced the whole entire human genome has propelled a shift in healthcare toward using an individual's genetic makeup to better tailor medical treatment.

Citi Global Healthcare Research

Update: Immunotherapy is the treatment of a disease through leveraging the patient's own immune system. In cancer treatment, newer potent T-cell mediated therapies eliminate or slow the growth and spread of cancerous cells by preventing the tumor from evading immune detection. An important component to the success of these therapies is the identification of patients with T-cell infiltrate at the tumor micro-environment at baseline. This is primarily done through predictive immuno-assays which can lead to the development of optimized rational immunotherapeutic combination regiments that are tailored for each patient. Please see the "Immunotherapy" section of this report for more details.

Mobile Payments

April 2013: With almost 6 billion mobile phone subscribers globally, the rise of Mobile Payments can have material and widespread financial and social considerations. Multiple constituents – consumers, entire industries, as well as governments – are likely to be affected by this trend.

Ashwin Shirvaikar, CFA
US Computer & Business Services Analyst

Update: The dramatic growth in the use of mobile computing and connectivity is one of the defining attributes of our time. The most obviously manifestation of this is in the proliferation of mobile phones and tablets and the simultaneous and exponential growth in their usage to connect to other humans, as well as to systems and applications. The use of a mobile phone for "showrooming", paying for a coffee or a train ticket and mobile gaming are existing examples of consumer-based mobile Internet usage, though our belief is that we have only just scratched the surface in terms of use cases.

Mobility can enable a significant paradigm shift in terms of how a wide range of businesses and governments operate. We envision that the process these entities went through about 12-18 years ago as the Internet became a bigger part of our lives, will likely be repeated – this time with mobile. Said another way, developed markets spent the last 12-18 years going "E" (as in e-commerce) from a primarily physical world and over the next 5-7 years we will likely transition rapidly to "M" (as in m-commerce). At the same time we recognize that there are many markets, for example China, that are leapfrogging directly to a "primarily mobile" world from a physical world. Regardless of where we are coming from, we know mobility is a crucial part of how we will transact in the future.

Why Should We Care?

Datapoints showing the uptake of m-commerce are increasingly positive

M-commerce represents change, and with change there is often some level of disruption. But incumbents who embrace the change can stay relevant and even increase their market opportunity.

- Nielsen reported that 91% of US consumers have their phone within arm's reach 24/7.
- comScore said in August 2013 that one-third of US monthly visitors to the average digital retailer website came exclusively on mobile platforms.
- IBM Digital Analytics Benchmark indicated that during the fourth quarter of 2013, online sales were up 10% year-over-year and mobile accounted for 35% of all online shopping traffic – a 40% increase year-over-year.
- According to Internet Retailer magazine, in 2013 mobile retail commerce in the US was approximately $34 billion, up ~63% from 2012.
- Mobile 500 reports that mobile retail was likely 12-13% of all US E-Commerce sales, up from just more than 9% in 2012.
- More than half of Amazon customers shopped using a mobile device during the 2013 US holiday season.

The increased use of mobile devices for purchases, as evidenced by the data, points above, has led the main payments networks who are already dominant in the offline world – Visa, MasterCard, American Express and Discover – to introduce ongoing m-commerce initiatives and increase their investment in the online space. Although the vast majority of payment transactions globally are still cash-based, the

proliferation of the mobile phone, the higher penetration of smartphones and the growth of social media are all factors that should support and possibly accelerate the digitalization of money.

Mobility Enhances the Entire Commerce Value-chain

The transition from e-commerce to m-commerce is a move from desk-top based retailing to mobile retailing. In many parts of the world, businesses and consumers are leapfrogging from the physical/ offline world straight to mobile without the interim e-commerce stop. The trend is accelerating due to the existence of key enablers that are making the requisite technology investments, whether in broadband or in more advanced handsets or in consumer and enterprise applications. In addition, the trend is exhibiting "legs" because customer needs are being met.

- **Retail:** there are many examples and statistics of how consumers use their mobile devices to comparison shop and find out more about the products they're shopping for while they are in a store – popularly known as "showrooming". For a while, this was widely viewed as a negative development for retailers, but now some examples have begun to emerge of retailers who have adapted successfully to this trend. According to a May 2013 comScore survey, the average top 50 retailer can extend their desktop audience by 45% by addressing the mobile-only consumer.
- **Banking and Financial Services:** It may seem that banks are more protected against the competitive threats from technology and other companies due to regulatory reasons, but the risks are real. It seems banks realize both the risk and the opportunity – both Aite and Ovum report that in 2014, bank information technology budgets will focus on mobile banking features. Beyond this, bank IT investments include "digital wallet", "omnichannel" and customer-data analysts, all of which have strong mobile commerce connotations.
- **Payments:** This is a lucrative function of most financial institutions and it is no surprise that payments profitability serves as a beacon for a wide range of non-financial entities including telecom companies and Internet companies.

The list of vertical industries and commerce functions affected by this transition to e-commerce is a long one – retail has increasingly gone mobile; a mobile banking presence is already a reality for many banks and the functionality available within it is increasing; quick-service restaurants are adopting the trend; consumer finance functions (including mobile money transfer) are a crucial part of the change.

Energy Exploration Technology

April 2013: North American shale expansion has been driven by the ability to access abundant shale plays across the continent, made possible by technological advances in hydraulic fracturing and horizontal drilling. In addition, offshore exploration and production is set to provide 46% of incremental global oil/ gas supply this decade with new technology in subsea processing set to lower the cost of exploration in offshore fields.

Ryan W Kauppila
European Oil Services Analyst

Update: Following the significant exploration success in the pre-salt layer on the Brazilian continental shelf in offshore Brazil, the industry is stepping up activity to target analogous plays along the West African Margin. After a period of significant seismic acquisition, the industry is about to embark on the highest-impact exploration campaigns globally, targeting the pre-salt play in offshore Angola.

This push for exploration has been helped by drilling efficiencies that have driven deflation at the Brazilian project. We believe the modular nature of the pre-salt developments can deliver on projected timetables and budgets and in aggregate, we see pre-salt costs well contained. Efficiency gains in drilling have been the primary driver of cost deflation to-date and we remain optimistic on further gains. Average 2013 pre-salt drilling times were 55% faster than 2010, and operators suggested further progress in the first quarter of 2014.

At present, drilling represents >50% of pre-salt development capital expenditures and this is where we see the greatest scope for cost reduction. Pre-salt drilling costs have falling ~40% over the past five years, reflecting faster drilling times, better-than-expected flow rates and improvements in well design and equipment. Going forward, as more homogenous development wells become an increasing proportion of wells drilled and as the technology continues to improve, we see scope for continued reduction in drilling times and a ~20% further cost decline by 2020.

There is an ongoing investment in R&D in the Brazilian pre-salt fields to obtain greater standardization to drive costs down further using technologies such as subsea processing and automated floating production storage & offloading (FPSO) with smaller topsides. Additionally, enhanced recovery techniques such as water-alternating gas or CO_2 injection should help increase the ultimate resource recovery per FPSO module. We believe these initiatives can be rolled out across the modular development and achieve further efficiencies.

Oil to Gas Switching

April 2013: Over the past few years, global automakers have been witnessing a convergence of regulatory and consumer demand around improving fuel economy, striving for energy independence and reducing emissions. Fuel economy requirements are increasing and requiring a greater mix of non-conventional technologies, such as alternative fuels, electrification and even hydrogen fuel cells.

Anthony Yuen
Global Energy Strategist

Update: Outside of the quest for greater fuel economy, there has also been a push to substitute natural gas for oil in transportation due to the unforeseen ripple effects of the US shale revolution. This push is set to accelerate with liquefied natural gas (LNG) already challenging diesel's heavy duty truck use -- especially in China -- while bunker's seaborne market and compressed natural gas (CNG) are set for exponential growth not only in markets such as Brazil, Egypt, Iran and India, but in Russia and the US as well.

Gas could erode oil's dominance in transportation; 25% market share in the heavy-duty trucking sector is possible

The switch from oil to natural gas in transportation is not a question of 'if?' but a question of 'when and how much?' Currently CNG and LNG have low penetration rates in the US freight truck market. However, by 2020 we expect penetration to rise to 25%, which will begin to have a noticeable impact on the cost structure of trucking. We acknowledge that certain applications, like buses and refuse trucks, are well down the path of adoption (i.e. 80% of Waste Management's new truck purchases in 2012 were natural gas powered) and there appears to be clear applications in which natural gas makes sense and adoption rates should be solid.

North America uses about 16-mb/d of oil for the transportation sector but with low natural gas prices, all but the aviation segment of the transportation sector provides attractive opportunities for natural gas. The potential conversion to CNG or LNG fuel is quite large. Assuming a cost differential of $2/gallon between utilizing natural gas and diesel, the annual savings from switching amounts to nearly $50 billion of cost savings. While utilizing natural gas as a transportation fuel presents numerous operational and financial challenges that may limit the addressable market, we believe that gas powered trucks are positioned to grow in market share for the foreseeable future.

The infrastructure needs for conversion to natural gas may not be that great given the focus on high tonnage, heavily traveled routes

The infrastructure needed to capture a sizeable portion of the market could be smaller than commonly thought. Looking at major trucking, rail and marine barge corridors, we note that there are certain key routes across the country along several key highways, as well as a couple of routes from West to East and along the West Coast. Hence, targeting these trucking, rail and marine routes can capture a majority of the market. With the trucking sector, LNG could make inroads in the class 7 and 8 trucks, while CNG can also capture part of the class 3 to 7 segment and possibly class 8 trucks in special shorter-haul markets. Light-duty tricks in the class 1 and 2 portion could also convert from oil to natural gas, particularly for fleet vehicles or ones that have convenient access to CNG refueling stations.

Historical Parallels in New Fuel Adoption

Historically, fuel substitution in the transport sector follows an "S-curve", which features a rapid transition period once some critical mass has been reached. A prime example of classic "S-curve" adoption is the diesel-for-gasoline substitution in the truck fleet that began in the late 1950s through the 1970s. The market share of diesel-fueled heavy-duty trucks went from the 10% range in the 1950s to more than 80% in the 1970s, taking up a majority of new sales in merely 20 years. A similar example is the transition of locomotives in rail transport. Within 20 years – from 1940 to 1960 – the total market share of diesel-electric locomotives rose from 5% to 95%. By the end of the 1970s, most of the Western countries had completed the replacement of steam locomotives.

The adoption of natural gas as a fuel would almost certainly follow an S-curve, with the use of natural gas accelerating as more consumers switch over to the fuel. By 2025, as much as 1-mb/d of oil demand for transportation could be displaced in the US. The base case assumes that about 50% of new heavy-duty truck/ vehicle (HDV) sales in the US would be natural gas-powered, in addition to the growth of natural gas vehicles and natural gas-powered marine transports elsewhere globally.

Over the Top Content

April 2013: We analyzed the television broadcasting market and looked at the disruptive affect that web-based video service was having on the traditional pay TV subscription model.

Arthur Pineda
Head of Pan-Asian Telecoms Research

Update: Television is not the only media-type that is being affected by content being delivered over an independent IP-based medium. The smartphone revolution has brought about a new risk for telecom operators as over the top content (OTT) offers a potentially cheaper way of communicating that bypasses traditional voice and SMS services.

Splitting the pie away from the telcos

OTTs have changed the way consumers communicate. In the past, a consumer paid a telecom operator for voice, short messaging services (SMS), aka texting, and data use with value fully captured by the telecom operator. Now, the relationship has changed. Consumers have the ability to divert their communications needs through an OTT provider which in turn reduces the value collection by the telco. Telecom operators still recognize value from their traditional services, but their ability to charge as much as they want has been compromised given the advent of competing products, which from a consumer standpoint could be far cheaper and convenient to use as compared to the traditional telco model

OTT communications services allow users to bypass the traditional cash cow voice and SMS services offered by telcom operators and communicate directly with other OTT users. OTT communications can be simplistically categorized into two major categories: 1) services provided by/ embedded into the handsets by operating systems (such as *FaceTime* by Apple iOS); and 2) third party communications services (such as *WhatsApp*).

Rapid OTT adoption due to low barriers or entry

Growth of OTT services has been rapid given the easy adoption of these services. OTT applications provided by OS providers are pre-installed on the handsets and most OTT applications are also easily purchased/ downloaded on smartphones. In order to start using such OTT services, users only need to have access to an internet connection for transmission of data packets. This can be done via 3G/4G networks or even via paid/ free WiFi services.

Value Capture Differentiation between Telcos and OTTs

OTT providers have revenue streams which are independent from the telcos, including: 1) revenue from application downloads; 2) revenue from sales of credits for communications services; 3) revenue from micropayments within value-added services such as sales of special emoticons or games; and 4) revenue from subscriptions.

Whereas telcos were able to collect revenues from end to end for messaging, voice and video in the past, this may change with OTT which serves to steal revenues from the telcos by allowing subscribers an alternative and typically far cheaper means to facilitate service by piggybacking on the data network. OTT revenues are, after all, structured differently and OTT cost models are far lower.

Investors have been concerned about the threat posed by OTT players to traditional telco's. The reason is simple – the value capture for the communication services of both telco operators and OTT players is different. Telco operators typically generate revenue via direct usage of their services. OTT players capture a slice of the revenue pie by leveraging on data to provide competing voice and messaging services to the users. While this means growth in data usage for telco operators, users switching to OTT services could cannibalize telco operators' voice and messaging revenues.

The economics are far different and in favor of the OTT

Very little infrastructure investment (with corresponding cost elements) is actually done by the OTT provider as they merely piggback on the existing telecom networks. This allows them to operate on a totally different cost structure relative to the traditional telco which had to plant money on the ground to operate a network. Unless telcos are able to price data use correctly and collect on the appropriate network usage levels, OTT players may serve to cannibalize their traditional revenues.

Proper Data Pricing to Fend Off Revenue Cannibalization by OTT Players

To avert OTT-driven cannibalization, telcos need to price their data plans appropriately and pass on the cost of OTT-based network usage to customers given their inability to charge the OTT players themselves.

For the pre-paid models, we see that some telcos have attempted to price data in such a way that it is accretive to average revenue per user (ARPU). The "sachet" approach to pricing data (small doses, high margins) allows telcos to price up. Malaysia and the Philippines have adopted this tactic to deflect revenue cannibalization effects. To avail of mobile data, users will typically have to pay an add-on plan on a daily/ weekly/ monthly basis. If users were to regularly avail of these data plans, ARPUs could expand, potentially offsetting/ exceeding the negative effects of OTT cannibalization.

Post-paid players have also started to rationalize their data use by reducing bundled data allowances and offering higher prices to access faster speeds. Singapore, for instance, had reduced data allowances from 12GB to 2-4GB as subscribers moved

to tier pricing. Australia's Optus has also moved to rationalize data bundles starting in 2013, reducing data allowances by 500MB from previous levels. Rising OTT usage and the potential corresponding rise in mobile data use (assuming subscribers use the mobile network and not WiFi) allow the telco to monetize as subscribers pay more for their data use.

The SaaS Opportunity

April 2013: The secular growth of software-as-a-service – an Internet-based software delivery model – has been significantly ahead of the overall software market, and we expect this trend to continue.

Walter H Pritchard, CFA
US Software Analyst

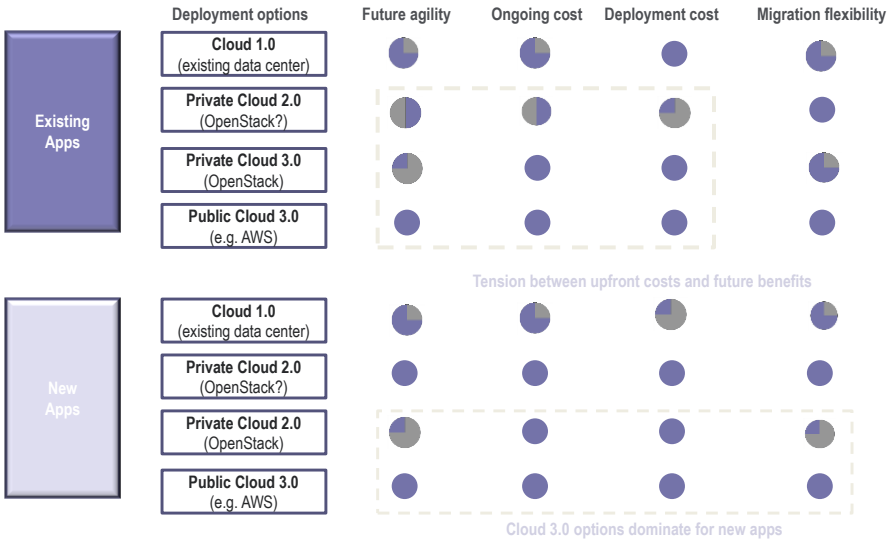
Update: Increasingly, demand for applications is being driven by the line of business (LOB) owners, who historically relied on their internal IT departments who have often failed to deliver on software development projects in a timely or satisfactory manner. These LOB owners were first to latch onto SaaS. SaaS not only takes advantage of the ubiquitous web-based client, but is run as a service by the vendor, enabling customers to immediately have access to new capabilities with little up-front investment. These benefits, among others, have enabled SaaS as a category to take share from traditional on-premise software. This ability of SaaS applications to keep up with the requirements of faster-moving LOBs has parallels to drivers of cloud infrastructure adoption including agile development and "DevOps". It is indeed LOBs that are increasingly trying to differentiate themselves from competition with technology and driving IT to deploy cloud infrastructure (or going outside of IT by consumer public cloud capacity). As some commentators have noted, LOB application owners are multiplying: "every company is a software company" (recent Forbes article) and 'software is eating the world" (entrepreneur Mark Andreessen).

LOB ownership of software development is driving downstream changes in software development and deployment methodologies. SaaS companies have delivered more innovation in a shorter period of time than on-premise competitors and consequently have driven incremental adoption of software. However, SaaS vendors don't cover the multiplying range of applications that enterprise customers are beginning to demand. As a result, demand for Infrastructure as a Service (IaaS), raw cloud-based computing resources used as building blocks of modern applications, has exploded.

How Quickly will Apps Move to the Cloud?

Enterprises face several options in dealing with their current set of applications, which today likely reside in a private data center in a Cloud 1.0-like environment (i.e. virtualized).

Figure 51. Deployment Options for New and Existing Apps



Source: Citi Research

Costs of Moving to Cloud are High

Traditional applications might ultimately never move to the cloud since the cost/benefit economics are less compelling. The cost of re-writing applications for anything other than Cloud 1.0 (which requires minimal if any work) can be very high and traditional enterprises have fewer resources trained to write applications on cloud platforms that are resilient and optimized for the environment of cattle-like servers. This developer expertise is scarce and mostly resides at web 2.0 companies that are using Cloud 3.0 technology to build cutting edge consumer apps. Some applications such as ERP applications might never move to the cloud in its current form, as the economics will not make sense.

In fact, further evidence of this is the fact that many SaaS companies remain in a Cloud 1.0 environment. Many of these early SaaS companies began their businesses with a hosting model first or before public cloud resources became commonly available. Products such as Taleo Enterprise Edition, ServiceNow, SAP's SuccessFactors, and many other SaaS companies were built in a Cloud 1.0 model utilizing traditional virtualization models, traditional relational databases, etc. The fact that these SaaS companies have not re-written for a next-generation cloud model underscores the difficulty of adopting a next-generation infrastructure.

SaaS vendors with a Platform-as-a-Service (PaaS) offering would likely benefit from a quick evolution to Cloud 3.0. Specifically, they might benefit from 1) recognition by enterprises that building Cloud 3.0 is difficult, which might accelerate PaaS adoption over IaaS adoption as a way to minimize the effort in re-writing code; and 2) broader uptake of cloud applications at large that would be complimentary (and possibly integrated with) PaaS applications.

Software Defined Networking

April 2013: Software defined networking (SDN) will enable next-generation networks which are simpler in design and scale, as well as being more agile and customizable.

Ehud Gelblum, Ph.D
Head of US Technology Research

Update: While we believe software defined networking (SDN) and its loose carrier equivalent network functions virtualization (NFV) could change the complexion of several of the hardware markets (switches, routers, application delivery controllers, WAN optimization solutions, etc.), we believe it is premature to gauge the impact to specific companies in contrast to the recent hype cycle. Based on our experience, architectural changes in carrier and enterprise networks take years to transpire. We do expect SDN/ NFV architectural changes to occur more quickly this time, and we believe that many enterprises and carriers are actively considering how SDN and/ or NFV fits into their organizations strategically. Ultimately, we believe it could take another 1-2 years to have a clearer view on the impact to earnings and strategic positioning for individual companies.

We don't believe SDN is a risk to the Ethernet switching market because it moves value out of switches and increases the risk of commoditization

More specifically on switching, we do not ascribe to the simplistic thesis that SDN is a risk to the Ethernet switching market because it moves value out of the switches and into a separate software controller layer, making the switches dumbed-down hardware which are then subject to risk of commoditization and white box competition, following a fate similar to that of the server market over the past several years. This theory came into vogue in July 2012 when VMWare staked its claim in networking with the acquisition of software-based network virtualization startup Nicira for a notable $1.26 billion, while Cisco, the leader in the switching market, was noticeably silent on the topic at the time.

Even highly virtualized networks need physical switches to connect virtual networks to physical networks

The reality is that even highly virtualized networks still need physical switches to connect virtual networks to physical networks and move data across both networks, and these switches need to support the new emerging software control layer as well as support high speeds due to the sheer volume of traffic making its way through the network at a latency low enough to be useful – a task we believe it still very difficult to do. VMWare is partnering with Arista, Juniper, Brocade and others as further evidence that hardware still should have an important role in the network.

That said there are several efforts under way that could change the economics in the switching markets longer term. In April 2013, Intel announced a reference design for a top-of-rack switch being manufactured by Quanta; in May Facebook pivoted its Open Compute project to focus on opening up networking; and in June, privately held Cumulus Networks launched its switch operating system that runs on "white box" top-of-rack switches from original design manufacturers (ODMs).

The focus seems to be on making switches cheaper instead of address the real need to increase the flexibility and programmability of switching

While some of the large cloud providers may be interested in using white box switches – Google has built its own switches for years and just started building its own analog-to-digital converters last year – we ultimately believe it is too soon to gauge the impact of these developments with much accuracy. However, what strikes us is that these efforts seem to be focused on making switches cheaper and thus lowering capital expenditures, while possibly increasing the operating costs of integrating point products, instead of addressing the real need to increase the flexibility and programmability of switching to make it easier to reconfigure the networks on the fly.

Solar

April 2013: One of the key reasons why solar is only now becoming a disruptive innovation is that solar technology is getting significantly cheaper and that these dramatic cost reductions meant that solar was already competitive in many regions on a domestic level and even at utility scale versus combined cycle gas turbines (CCGT) in some higher priced markets. As discussed, the fact that solar keeps getting cheaper as technology advances and manufacturing becomes more efficient means that 'parity' will be achieved in an increasing number of markets in a relatively short timeframe.

Jason Channell
CleanTech & Alternative Energy Analyst

Update: Solar is starting to see uptake globally. Germany has seen profound changes in its energy markets, most notably in the loss of all of peak demand to solar on sunny days. What is most serious about this is that this peak used to be provided almost entirely by gas, and it is this that has caused some gas-fired power stations in Europe to run for less than 10 days in 2012.

On current Citi Research forecasts, China is expected to be the largest solar market in terms of annual installations, however the sheer scale of the Chinese energy market means that solar capacity is likely to have less of an effect on the overall power market. Of more interest given its importance in global energy markets is Japan. In response to the Fukushima nuclear incident, Japan's energy mix has changed almost overnight, with oil being burned and gas being imported and used at $16/mmbtu (with gas price in context at <$4/mmbtu in the shale-driven US market). With this demand for new energy sources in response to the closure of the nuclear plants, Japan introduced what is the world's most attractive subsidy scheme for solar.

While Citi Research is forecasting 7GW for Japan in solar capacity in 2013 in their most optimistic scenario, Bloomberg New Energy Finance sees as much as 9.4GW being installed in 2013. In context, a large nuclear plant is perhaps 1GW, so if these figures are correct, Japan would have installed the equivalent of 9+ nuclear power plants in the space of one year. While the load factors are very different (nuclear power plants run almost continuously) with solar generating far fewer units, it is once again the fact that solar generates at times of peak demand which makes it so disruptive.

Perhaps what is most important about the rapid rise of solar in Japan is Japan's importance in terms of global energy markets and pricing disparity. Much of the next wave of liquefied natural gas (LNG) projects (at the top end of the global integrated cost curve) are in Australia, and are being pursued on the basis of oil-linked pricing, largely driven in turn by the demand of Japan for gas in the wake of Fukushima. We should bear in mind that at the current installation rates, it may not be that long before solar could 'take the edge' off of gas demand, with potentially large implications for marginal demand and pricing in the region, and hence on the returns of some high cost gas projects (especially with the potential for some nuclear plans to come back on line).

Beyond Japan, another area worthy of note is the southern states of the US, where solar economics work well with peak demand from air conditioning and given attractive insolation rates. However, utilities in the US seem to be more aware of this effect and in many cases have embraced the technology as part of a more diverse energy mix, rather than suffering from third party installations as have utilities in Germany.

What are the Implications and Opportunities of Solar on the Grid?

One implication of the emergence of solar as a material form of generation is that much of it is distributed generation (i.e. it is at the point of use) -- for example on the rooftop of a house. One implication of this is that this power itself does not necessarily go through the grid (though it may, the other way, if exported back), resulting in lower grid usage. However, the grid must still be maintained, and hence lower utilization is likely to push per unit charges higher, with yet another upward pressure on bills.

When distributed generation is combined with local storage (potentially in the much longer term from electric vehicles), we could ultimately see the utility industry split into centralized back-up rate-of-return generation , much as it was throughout the pre-liberalization, with much smaller 'localized' utilities with distributed generation and storage managing local supply and demand, potentially even on a 'multi-street' basis.

In much the same way as storage could smooth generation, demand response could also have much the same impact on load, i.e., at times of excess generation (or limited demand) dishwashers, washing machines, tumble dryers, etc. could be switched on, thereby smoothing the demand curve across the day and once again reducing the need for low-load-factor or stranded generation.

Hence, if local generation and storage could be combined with demand response technology, the energy transmission system would be transformed. One implication is that while the total number of units travelling across grids might be reduced, the control and monitoring systems at a local level would be significantly greater (as potentially would metering requirements). This would drive demand for investment in smart grid applications and equipment which utilities could potentially harness (as could others).

Appendix: Author Bios

Erik J. Bass, CFA joined Citi Research in September 2012 as the Senior Analyst covering the Life Insurance sector. Prior to Citi, Erik spent 7 years as an Associate Analyst covering the Life sector at J.P. Morgan, where he had lead coverage for select small and mid-cap insurers. He began his career as an analyst in the J.P. Morgan Private Bank. Erik has a BA degree in Business Economics from Brown University and is a CFA charterholder.

Todd Bault, FCAS, has been a Managing Director for Citi since September 2013, and heads up the US P&C Insurance practice for Citi Research. Todd has worked as an equity analyst covering the insurance industry for the last 13 years, most recently as Partner and Global Risk & Insurance Analyst for SSR (2010-12), a boutique research firm. Prior to this, Todd was US Non-Life Insurance Analyst for Sanford C. Bernstein (1999-2010), and from 2004-08 he was the #1 rated non-life insurance analyst as determined by Institutional Investor magazine. Prior to joining Citi, Todd was Chief Marketing Officer for Extraordinary Re (2012-13), a startup attempting to bring liquidity to insurance contracts. Before his Wall Street career, Todd was SVP & Chief Actuary for Odyssey Re (1998-99), and held numerous positions at global insurer St. Paul Companies (1988-98). Todd has an MS degree in Mathematics from Michigan State University, a BA in Math and BFA in Music from the State University of New York at Buffalo, and is a Fellow of the Casualty Actuarial Society.

Andrew S Baum joined Citi, in September 2011, as the Global Head of Healthcare Research. Before joining the firm, Andrew was at Morgan Stanley for 14 years where he was the top ranked European Pharmaceutical Analyst in the Extel Poll for six years. Andrew and his team consistently ranked in the top three teams in external EU and global investor polls (Institutional Investor, Greenwich and Reuters). Before this, Andrew was a UK pharmaceutical and biotechnology analyst at Salomon Brothers. From 1994 to 1996, he was a practising physician at the Royal National Orthopaedic Radcliffe Hospital in Oxford (the medical centre of Oxford University) where he completed his residency. Andrew is a member of the American Heart Association, American Society of Oncology and the DIA. He is also a Fellow of the Royal Society of Medicine. Andrew holds an MA degree in Physiological Sciences and an MD degree from Oxford University.

Jason Channell joined Citi in 2011 to expand and consolidate globally the Cleantech and Alternative Energy product within Citi Research. Prior to joining Citi, he worked at Goldman Sachs for 5 years where he set up and managed the Cleantech group in equity research. He started his career as a buy-side analyst with Fidelity Investments, and has worked for ABN AMRO Hoare Govett where he obtained corporate broking experience, and has also worked for CA Cheuvreux. Over his career his coverage has centered around energy-related sectors (utilities, gas, alternative energy) and smaller companies. He has achieved high rankings

in both Extel and Starmine surveys, and his expertise has led to significant interaction with regulators and policymakers, most notably having presented to members of the US Senate Energy and Finance committees on energy policy. Jason holds a BSc (Hons) degree in Engineering Science and Management from Durham University.

Dr. Steven Englander is Managing Director and Global Head of G10 Strategy at Citi. Prior to rejoining Citi, Mr. Englander was Chief Foreign Exchange Strategist for the Americas at Barclays Capital. Previously, he spent eight years with Citibank/Salomon Smith Barney where he was Global Currency Economist based in London. Citi was ranked #1 in currency economics and long-term strategy every year that he occupied that position. Before moving to the private sector, he spent four years at the Organization for Economic Cooperation and Development as the Principal Economist in the Economic Prospects. Dr. Englander's career also includes time at the Federal Reserve Bank of New York, where he was Senior Research Officer and Head of the Domestic Research Department. He is frequently invited to discuss currency and economic developments on television and radio. Dr. Englander received his PhD from Yale University and his BA from McGill University.

Ronit Ghose is Head of the European Banks team and Global Sector Head for Banks in Citi Research. He is the lead analyst on HSBC, Standard Chartered and the Nordic Banks. Since joining Citi in 1997, Ronit has covered banks in the Benelux, Canada, Cyprus, France, Germany, Greece, Scandinavia, Spain and the UK. Ronit previously worked at the British Bankers' Association and as a research assistant in Parliament for Sir Edward Heath. Ronit has an undergraduate degree in Modern History (University of Oxford), a postgraduate diploma in Economics (University of London), and is a CFA charterholder.

Deborah Hopkins is Citigroup's Chief Innovation Officer, a position she was appointed to in 2008. Her mission is client-focused innovation. Based in Palo Alto California, she focuses on building partnerships with venture capitalists, start-ups, corporations, universities and thought leaders to support the development of new products, services, and business models. To maximize creativity and impact, Debby and her team work across Citi's business units, regions and the enterprise as a whole. She also serves as Chairman of Citi Venture Capital Initiatives, seeking investment opportunities that support and enhance her mission. Since joining Citi in 2003, Debby has served in a number of executive roles, including head of Strategy and M&A, Chief O&T Officer and senior advisor to the Global Investment Bank — a role she continues today. Prior to working at Citi, she held senior-level positions including Chief Financial Officer for both Boeing and Lucent Technologies and Vice President of Finance for General Motors Europe. Debby serves on the Board of Directors of QlikTech and the Advisory Boards of Stanford's Technology Venture Partners program and Riverwood Capital Partners. From 2000 top 2005 she was a member of DuPont's Board. She also serves on the non-profit boards of Citizens

Schools and the Green Music Center. *Fortune Magazine* has twice named her among the top 10 most powerful women in American business, American Banker has heralded her as one of the "Women to Watch" in the industry, and in 2011-13, she was named to the Institutional Investor's top Tech 50 list.

PJ Juvekar joined Citi Research in 1996, as an Analyst covering the Environmental and Canadian Oil and Gas sectors. He has been covering the Chemicals sector since 1999. In 2012, PJ was ranked #2 by Institutional Investor's All-America Research survey. This marked the 11th year in which PJ was ranked in the poll by Institutional Investor magazine. A chemical engineer, PJ earned an MBA degree from the Tepper School of Business at Carnegie Mellon University, an MS degree in Chemical Engineering from the University of Maine, and a BS degree in Chemical Engineering from UDCT at the University of Bombay. PJ currently serves on the Alumni Advisory Board of the Tepper School of Business at Carnegie Mellon University.

Mark May is a Senior Analyst at Citi Research, covering the Internet sector. His coverage includes large and SMID cap companies in the Internet media, advertising and e-commerce sectors. Mark joined Citi in 2013, and previously covered the Internet sector at Barclays, JPMorgan/Hambrecht & Quist, and Needham & Co. He is a graduate of the University of Texas at Austin, and is a Chartered Financial Analyst..

Graeme McDonald is a Senior Analyst covering the Machinery and Shipbuilding sectors. Prior to joining Citi Research in January 2010, he had covered the Machinery sector in Japan since 1998 at KBC Securities and HSBC Securities. Between 1994 and 1998, Graeme was based in London selling Japanese equities. He joined James Capel in September 1986 to cover the Japanese Construction, Housing and Real Estate sectors. Graeme received his BA in Human Geography from Reading University.

Itay Michaeli is a Director at Citi Research covering the US Autos & Auto Parts. He joined the firm in 2001. As a dual Equity and Fixed Income analyst, Itay's research encompasses the entire capital structure focusing on the equity, corporate bonds and CDS contracts of covered issuers. Itay has also previously covered the Aerospace & Defense sector for Citi. He previously served as a Senior Fixed Income Analyst covering Automotive, Aerospace/Defense, Supermarkets and Tobacco. Itay holds a Bachelor of Science degree in Finance and Accounting from the Stern School of Business at New York University.

Walter H Pritchard, CFA is a Director and Research Analyst covering the Software sector. Prior to joining Citi in 2009, Walter spent nine years covering software at Cowen and Company and SoundView Technology Group. Prior to equity research, Walter worked in investment banking, focusing on capital raising and financial advisory for technology companies. Walter holds a BA degree in Chemistry from Pomona College and is a CFA Charterholder.

Tsubasa Sasaki is an Analyst in charge of Thematic Research in the Technology sector. Mr. Sasaki joined the firm in 2008. He received his Bachelor's and Master's degrees from the University of Tokyo's School of Science and is a chartered member of the Securities Analysts Association of Japan (CMA).

Thomas A Singlehurst, CFA is Head of the European Media team. His focus is now primarily on covering the marketing services, professional publishing and broadcast stocks however across his career he has analyzed all the sub-sectors giving him the benefit of a broad view of the European Media space. Prior to joining Citi in June 2004, Tom was at Goldman Sachs, also in the European Media team. Tom graduated from Edinburgh University in 2001 with a first class degree in Economics and Politics. He is a CFA Charterholder.

Tim Thein, CFA covers the Machinery and Packaging industries for Citi Research. He was named as the best stockpicker in Machinery by Starmine in 2011. In his first year of eligibility (2007) covering Packaging, Tim was ranked #3 in the Institutional Investor magazine poll for the Packaging sector, and in 2008, was ranked #1 in the Greenwich Survey for Packaging. He joined Citi in 1999 as part of the Paper & Forest Products team. Tim received an MBA from Columbia University and his undergraduate degree from Boston College. He is a Chartered Financial Analyst and member of the New York Society of Security Analysts.

Kenneth Wong, CFA is a Research Analyst covering the IT Hardware and Software sector. Before joining Citi Research in late 2009, he had five years of experience covering software/internet companies at Cowen and Company. Prior to equity research, Ken began his finance career for a year at Bear Stearns in Private Client Services. Ken graduated from the University of California at Berkeley with a B.A. in Political Economy and a minor in Business Administration.

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Key Insights Regarding the Future of Disruptive Innovation

LABOR MARKET

Manufacturing employment in the three largest developed economies have been on a forty year downward trend due primarily to the growth of low cost manufacturing in emerging markets. / Advances in artificial intelligence, software and sensor technology coupled with lower computing costs and the growing influence of "Internet of Things" mean that the disruptive impact of robots will become increasingly more apparent in economic data and our everyday lives.

POLICY

Traditional banking, which relies on brick and mortar branches for customer service, has resulted in a large unbanked population in emerging markets. / Government policy that increases the digital readiness of a country coupled with the proliferation of mobile phones, has helped digital banking take a stronghold in emerging markets and increasing the level of financial inclusion globally.

SUSTAINABILITY

The recent increase renewables roll-outs – driven by a staggering reduction in costs for both solar and wind – is disrupting electricity systems by making conventional power plants uneconomical because as solar power is wasted . / Similar to the big drop in pricing for solar panels, the cost of next-generation battery technology has fallen dramatically, removing a prohibitive barrier to entry typically cited as why renewables would "never happen" .