



DISRUPTIVE INNOVATION

Ten Things to Stop and Think About

Citi GPS: Global Perspectives & Solutions

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DISRUPTIVE INNOVATION

Ten Things to Stop and Think About

Charles Holland Duell, Commissioner of the U.S. Patent and Trademark Office from 1898 to 1901, purportedly said “Everything that can be invented has been invented.” With the benefit of hindsight, it’s easy to find amusement in his words as the world that closed the 20th century was a much different place from the one that began the century, primarily due to innovation. Fast forward to 2013 and scholars are arguing that the golden days of innovation are behind us and although there will still be inventions and discoveries, they will pale in comparison with the great innovations of the past.

Whether or not you believe that future innovations can do the past justice, innovation provides a channel for organizations to adapt and respond to a changing environment. It can accelerate the growth of new businesses and provides corporates the coveted opportunity to create a sustainable competitive advantage. Disruptive innovations are the game changers and the ultimate Holy Grail as they meaningfully change the way customers live their lives and interact with the world.

For an organization to move from “hits and misses” to highly predictable innovation outcomes and disruptive market offerings, a disciplined approach with a standardized process needs to be implemented as the best innovators combine rigorous process discipline with creativity and inspiration. It is a mission critical process but few companies get it right from start to finish.

In the pages that follow, we give thought to the process of innovation for an organization by identifying the elements of success, the stages of innovation and the benefits of implementing an Innovation Lab strategy. The end-game for an organization is to execute quickly and effectively so as to increase their flexibility and ability to adapt to both a changing industry and client landscape.

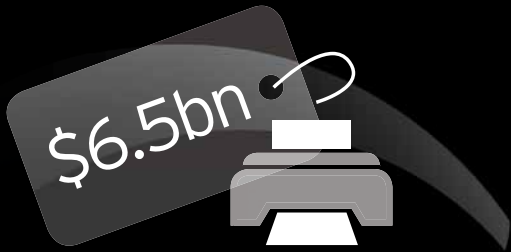
We then attempt to identify 10 ‘disruptive innovations’, new technologies or ideas which we believe will help create a new market and potentially disrupt an existing market or displace an earlier technology in an investable timeframe. Although the technology sector historically dominates the group — we note the advancement of 3D printing, software as a service (SaaS) and software defined networking (SDN) — technology advancements are driving innovation in a wide-range of industries.

The advent of e-cigarettes has given the tobacco industry the first innovation in decades while advances in sequencing instruments has reduced the cost of whole genome sequencing to levels where personalized medicine is no longer science fiction. In Energy, new technologies in subsea processing and fracking have made previously unrecoverable resources accessible and are driving the future of transportation, while technology advancement in solar will change how power is generated. Finally, everyday activities like how we bank and even watch TV going forward will be significantly different from even the last decade due to innovation.

In the end the attribution of the invention quote to Mr Duell was debunked. Instead, we find he was a visionary:

“In my opinion, all previous advances in the various lines of invention will appear totally insignificant when compared with those which the present century will witness. I almost wish that I might live my life over again to see the wonders which are at the threshold.”

There's big opportunity out there



The **3D printing** market is expected to be worth **\$6.5bn** by 2019



The **e-cigarette** market could have compound annual **growth of near 50%**



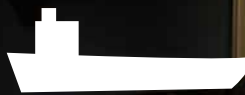
US sales for **compressed natural gas (CNG)** vehicles could surpass **100,000** by 2020

100,000,000
10,000

The **cost per genome** in DNA sequencing has fallen from \$100m in 2001 to < \$10k today



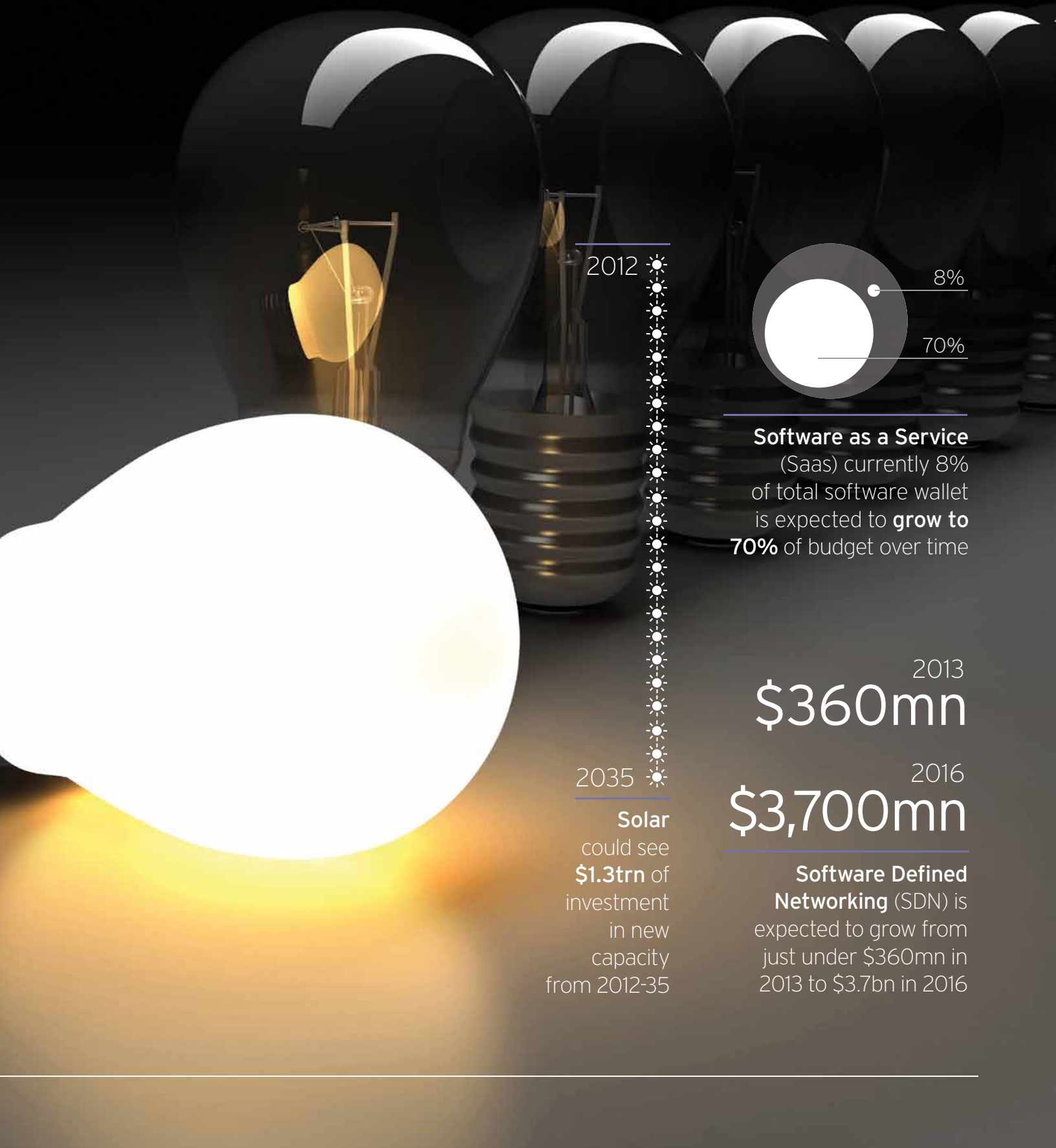
Pay **TV industry** only added **200k subs in 2012 vs. 2mn at its peak** while **streaming subs** are increasing **exponentially**



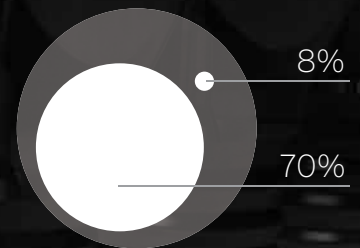
Subsea processing equipment has potential to be a **\$100bn pa** market by the next decade



Mobile Payments could see a transaction value of **\$1trn by 2016**



2012



Software as a Service
(SaaS) currently 8%
of total software wallet
is expected to **grow to**
70% of budget over time

2035

Solar
could see
\$1.3trn of
investment
in new
capacity
from 2012-35

2013

\$360mn

2016

\$3,700mn

**Software Defined
Networking** (SDN) is
expected to grow from
just under \$360mn in
2013 to \$3.7bn in 2016

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Disruptive Innovation — Intro

'You cannot discover new oceans unless you have the courage to lose sight of the shore.' — **Andrew Gide**

Naveed Sultan

Global Head of Treasury & Trade Solutions
Group, Citi

In today's evolving world, institutions are required to continue to increase their relevance to clients and demonstrate that they bring broad, proactive thinking and solutions focused on innovation to improve the efficiency of operations. We at Citi aim increasingly to add value to our client's businesses by delivering commercially relevant innovation, best in class products, services and new business models, aligned with our client's needs. We need to invest continually in innovation in order to stay both competitive and enhance our value to clients.

Establishing a clear definition of innovation, agreeing what 'success' looks like, and tying innovation strategy to innovation execution through a well defined process, allows us to extend our current infrastructure, enhance our core technologies, and build new channels: all leading to the development of adjacent and disruptive innovations.

What is Innovation?

Many assume that innovation refers only to a new product or service, driven by new technologies. While disruptive innovation is the focus of this report, Citi's definition of innovation is more comprehensive and encompasses the day-to-day improvements and re-engineering efforts that maintain the competitiveness of our core business, as well as initiatives designed to take the business into the 22nd century. For us innovation can be simply defined as: *Something NEW that creates VALUE.*

To unlock new value, the innovation process at Citi is a set of techniques used to create new solutions. The process starts with the people and clients for whom we are innovating. We begin by examining the needs, aspirations and behaviors of the people and clients that we are developing solutions for.

Why Innovate?

Innovation is the best way to adapt and respond to a changing environment, which based on the past few years, will likely be the 'norm' for the years to come. Innovation can accelerate the growth of new businesses and prototype pipelines. It makes a positive difference to bottom lines and positive impacts on customers' lives. Innovation provides businesses the coveted opportunity to create a sustainable competitive advantage by:

- *Ensuring future growth and shareholder value* – The stock price includes an expectation of future growth. Some of the sources of this expected growth are known. Looking three years out, most businesses know where the majority of that projected growth is going to come from. However, looking 5, 7, 10 years out, most commercial entities would likely admit there is a gap between planned growth and expectations already built into the stock price.

The growth that is needed to meet or exceed investors' expectations must come from *new opportunities*. This is a constant challenge for any company and one reason why a robust innovation pipeline is imperative.

- *Addressing changing customer needs* - The financial services industry has seen several disruptive entrants in the past decade. These non-traditional competitors are relentlessly obsessed with solving customer pain points. They're exceptionally good at designing for that customer and are nimble and able to get to market quickly.

The development of a product/market fit and designing an experience that is simple, intuitive and in an almost seamless manner addresses the customer's known and unknown needs, is a great strength of many new start-ups, and a capability that large established entities must work to develop quickly.

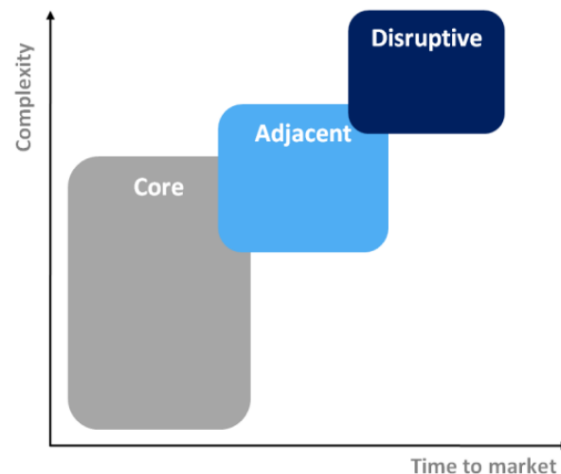
- *Monitoring the competitive landscape* - Large firms cannot dismiss new competitors as the latest 'fad', or as irrelevant to a given industry. Many of these disruptive innovators have begun to change meaningfully the way customers live their lives and interact with the world. This has created a whole new set of expectations that influences not only how customers think about their relationship with existing market players, but also the way in which they expect to interact.
- *Disruptive — the new normal* - Looking at the competitive landscape from our point of view at Citi, many of these new competitors have had tremendous impact and are here to stay. They are looking to grow just like Citi, and looking at our customers to identify opportunities. If we are to remain relevant to our customers and defend against competitive threats, we must acknowledge and embrace the ways in which the world has changed. We must learn from what these new entrants have done well in order to deliver value beyond what customers expect today.

Types of Innovation

There are various paradigms for innovation however we adhere to a framework that aligns with three distinct innovation categories— Core, Adjacent and Disruptive — based on the dimensions of time to market and complexity. Time to market represents the organizational objective but at the same time, must be sensitive to the industry or client's readiness, above and beyond the time that is required to scale the given innovation.

Complexity represents both the internal organizational and the external ecosystem in which the given innovation is launched into.

Figure 1. Categories of Innovation



Source: Citi Treasury & Trade Solutions

- *Core projects* are characterized by having few unknowns in terms of the customer, the solution and the project charter. In addition, the existing business model remains relevant and does not require adjusting.
- *Adjacent projects* necessitate the leveraging of an existing customer base, offering or delivery model. The existing business model for adjacent projects may be ill equipped to deliver what is required for adoption of the new innovation and therefore may need adjusting. In addition, the project charter contains a number of unknowns.
- *Disruptive projects* will typically require a different skill set from the current status quo as the customer and solution are unknown, the business model is likely to require adjustment and the project charter contains a significant number of unknowns.

The short-term success of core innovation often provides the organizational confidence to focus increasingly on the adjacent innovations and subsequently disruptive innovations. The collective innovations at all three stages contribute not only to short-term product and solution innovation, but help equip companies to develop a longer-term culture of innovation – this is where sustainable competitive differentiation is created.

The Process of Innovation

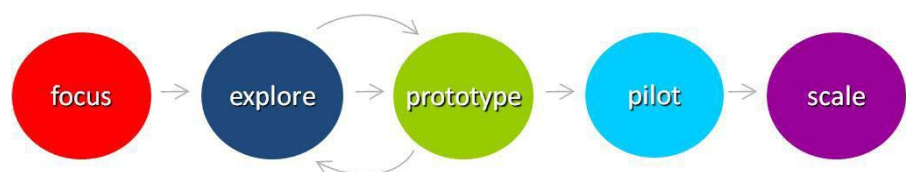
'If I had 60 minutes to solve a problem, I'd spend 55 minutes defining it, and 5 minutes solving it.' — **Albert Einstein**

Innovation is a process, and the best innovators combine rigorous process discipline with creativity and inspiration. There are no shortage of good ideas in current organizations, however, successful innovations are not based on the merit of the idea, but rather based on how well the idea is executed.

We view innovation in five distinct stages which follows a commonly accepted process that most companies follow in some form. When looking at the innovation process a critical differentiator is the speed at which a given organization executes the process. 'Fail and learn fast' is a quote that many innovative and successful firms employ. Those who execute fast will have a better opportunity to learn, iterate and succeed.

The innovation execution needs to be asynchronous and fast. As an organization, rapid innovation reduces the cost of failure while increasing the flexibility to adapt to the change of the industry and clients.

Figure 2. Stages of Innovation



Source: Citi Treasury & Trade Solutions

The absence of a standard process in an organization doesn't necessarily mean that they will be without innovation. But it does suggest that innovation will be unpredictable as idea generation is typically dependent on a small group of key experts or influencers. This leads to random market "hits and misses" and could result in underperforming returns and imitative offerings. Given the right environment, a company will start to progress toward qualified innovation by implementing a few standard processes but where gaps may remain in the process discipline. Ideas will tend to be incremental with few, if any, breakthroughs, tending to result in a marginal return on investment but with fewer negative surprises.

The next step towards a more disciplined innovation approach where standardized processes are put in place and there is a high level of process adherence. At this stage, customer understanding drives requirements and while outcomes are predictable, financial performance can be average and competitive offerings tend to be just on par with others. Fast and effective innovation involves the implementation of efficient processes and approaches, collaborative cross-disciplinary efforts and robust client engagements that are used to drive unique value. Outcomes tend to be more highly predictive and are generally accompanied by superior financial performance and market expansive offerings.

The final stage of innovative maturity is reached when a market-leading innovation is achieved that combines tailored processes and approaches. The innovation is open and can be leveraged for new ideas and advances around new business models. This stage is defined by highlight predictable outcomes, high return on investment and disruptive market offerings.

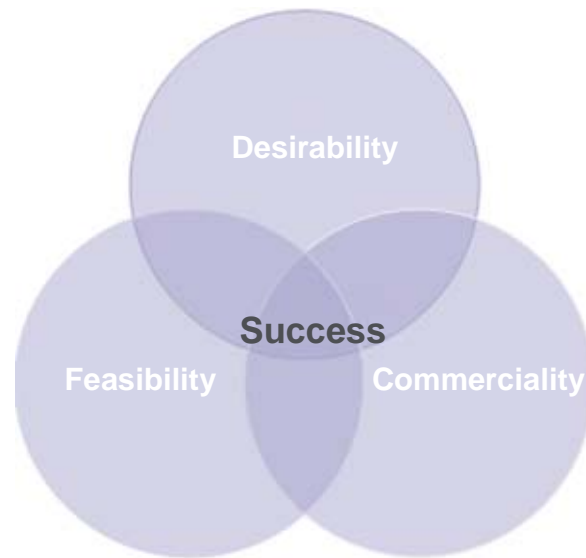
Innovation is a mission critical process but few companies get it right from start to finish. The key is to challenge poorly constructed operational plans, push back where there is a lack of customer centricity, improve the analytical approach where there is poor insight or foresight, ensure that any lack of accountability is addressed and eliminate slow commercialization by bringing new agile techniques to the table.

Elements of Innovation Success

An effective innovation strategy cannot be achieved in isolation, but rather must be the result of both internal and external viewpoints. Ensuring there is customer insight at each stage of the development process enables an organization to deliver relevant solutions that are desirable (i.e., what does the user/ client really want?), feasible (i.e., what is technically and organizationally possible?) and commercially relevant (i.e. what is the business case?). Not all customers know what they want, so it is critical for any innovating entity to identify what will solve their business needs.

An often difficult but key question to ask is if the problem that is being solved is something that the organization can and should solve, and if investment of resources is justifiable from a business perspective. The solutions that emerge at the end of the innovation process should exist at the center of the three lenses – the need to be desirable, feasible and commercial.

Figure 3. Stages of Innovation



Source: Citi Treasury & Trade Solutions

Internal viewpoints also play an integral role in defining a company's innovation strategy. The key is to apply the learning from this feedback by creating a unique experience for customer, learning to maximize investment synergies through the building of new platforms rather than simply doing projects, and by testing the feedback using the gated and standardized innovation process and ultimately use these insights to inform strategy and investment decisions.

The Innovation Lab

One way to improve the delivery of disruptive market offerings is through the use of innovation labs that are directly linked to strategy and to the business. These labs can also be challenged to identify and deliver on solutions that bridge the earnings growth gap required to outperform the market, drive cultural change, manage innovation portfolios, and ultimately identifying new revenue opportunities.

Labs can also be centers to attract and rotate organizational talent and be places where the client is at the centre of innovation thus ensuring a client centric, not client led, customer experience is delivered.

How an Innovation Lab Benefits Stakeholders

For **customers**, an organization's association with innovation can make it a market creator versus a market follower, and provides customers high visibility into potential new products and services. This association ultimately results in positive net promoter scores, active client engagement throughout the core, adjacent and disruptive innovation lifecycles, improved usability of products and services and reduced servicing costs aligned with research and thought leadership.

For **product groups**, innovation and specifically the innovation labs provide a resource to execute rapid prototyping to define and test concept and business models. A lean start-up model improves speed and reduces investment costs. Standardized processes and methodologies are applied to improve the predictability of outcomes. From this perspective the labs can be used effectively to inform the product roadmap, to differentiate products and services from those of competitors and thereby improving return on investment as well as product and service margin.

For **executives, analysts and shareholders**, innovation bridges the revenue gap through delivery of a portfolio of new product and service concepts, thereby improving the predictability of future revenue streams. Labs are integral to the innovation disruption by being a horizontal function, independent of individual businesses to exploit where appropriate the best short, medium and long term net new revenue realization opportunities. Performance is measured by the aggregate portfolio value of all innovations and the specified time horizon over which they are balanced so transparency is enhanced and duplication of effort is avoided. High performance companies must continuously assess their strengths, weaknesses, opportunities and challenges from the perspective of all stakeholders to achieve market leading innovation.

Figure 4. Citi Innovation Lab, Dublin



Source: Citi Treasury & Trade Solutions

Citi Innovation Lab – An example in client engagement

In an effort to deliver accessible, digital solutions in an increasingly information-driven business, Citi's Trade & Transaction Solutions Group established Innovation Labs in Dublin, Singapore, and San Francisco. The Innovation Labs leverage new web, mobile, supply chain and analytics technologies to engage clients more innovatively and to create more effective solutions and products for them. Because client engagement is fundamental to the research and development of new projects, Citi's Innovation Lab is fully interactive and globally linked, enabling clients to "test drive" new banking solutions through live demonstrations with situation analysis.

A key concept to effectively delivering client engagement is **User Experience** (UX or UE) which examines the user's emotions about using a particular product, system or service. User experience highlights the experiential, affective, meaningful and valuable aspects of human-computer interaction and product ownership. Additionally, it includes a person's perceptions of the practical aspects such as utility, ease of use and efficiency of the system.

In the Citi Innovation Lab, Dublin, a User Experience Design Practice has been established with two streams: 1) a Practice Development stream focused on creating and continuously improving user-centric design processes, providing governance, creating and managing design guidelines, and measuring user experience through usability and compliance metrics; and 2) a UX Development group that focuses on creating easy to use and intuitive interfaces which are consistent across channels.

Together, the practices is a four step process including 1) design research, 2) UX specification, 3) usability testing, and 4) Hi-Fi visual design. The mission is to deliver world-class user experiences which are adopted across applications, channels, and devices.

Another key element of client engagement is **Design Thinking**, which refers to the methods and processes for investigating ill-defined problems, acquiring information, analyzing knowledge, and positing solutions in the design and planning fields Design thinking is a methodology for practical, creative resolution of problems or issues that looks for an improved future result. In this regard it is a form of solution-focused thinking, starting with the goal or what is meant to be achieved instead of starting with a certain problem. Then, by focusing on the present and the future, the parameters of the problem and the resolutions are explored, simultaneously.

A final element is **Agile Software Development** which consists of a group of software development methods that are based on iterative and incremental development, where requirements and solutions evolve through collaboration between self-organizing, cross-functional teams. It promotes adaptive planning, evolutionary development and delivery, a time-boxed iterative approach, and encourages rapid and flexible response to change.

In the Citi Innovation Lab, Agile software development greatly enhances teamwork, communication, quality and collaboration throughout the delivery of projects. Small focus teams with daily stand-ups working on completing an achievable subset of the overall solution in a specific timeframe can make possible early delivery of key solution components. Feature components can then be demonstrated to the client, facilitating early feedback, and gaining assurances that implementation is on track and meeting the client's requirements.

Measurement

An integral part of any innovation process is a robust set of leading and lagging metrics, the most critical of which is ultimately net new revenue. These metrics should tangibly measure the value innovation is contributing to the organization. Three components of innovation measurement include portfolio mix, innovation rate and cultural/customer impact.

The **portfolio mix** is measured in terms of 1) Innovation impact - the results and impact from innovation projects and how effectively we are scaling and supporting new solutions deployed in the market, 2) Portfolio value - the growth of a portfolio's value relative to aggressive growth targets and how effectively we are allocating resources appropriately against these growth targets, and 3) Portfolio balance – defining the appropriate balance of an innovation portfolio and how the focus should shift over time.

The **innovation rate** and process effectiveness can be measured by (1) speed to margin – how effectively we are removing barriers to help speed the realization of commercial/client value from the project and what the appropriate development time for the project is and (2) the innovation hit rate which measures how robust our pipeline is and how effectively we are balancing time and risk for the near and long term.

Organization conditions and culture can be measured by (1) examining brand awareness through net promoter scores and by how effective we are in differentiating our innovation solutions and thought leadership in the marketplace and with our customers.

By creating the right mix of innovation structures and matching them to the appropriate functions and metrics, companies can effectively organize to innovate and closely monitor performance. The cultural and organizational characteristics developed through this process serve to differentiate a company and provide a competitive advantage in the area of innovation.

All about Competitive Landscape and Successful Execution

In the end, Innovation success is equal parts creativity, process and execution. Innovation is a process, and the best innovators combine rigorous process discipline with creativity and inspiration. In today's organizations, there is no shortage of good ideas, but successful innovations are not based on the merit of the idea, but rather on how well the idea is executed. Those who execute quickly and effectively will have a better opportunity to learn, iterate and succeed. The innovation execution needs to be asynchronous and fast. As an organization, rapid innovation reduces the cost of failure while increasing the flexibility to adapt to the change of the industry and clients.

3D Printing

Graeme McDonald
Japanese Machinery & Shipbuilding Analyst

We believe 3D printing has the potential to rewrite the rules of global manufacturing, with an impact that could be as significant to the industrial sector as the now pervasive adoption of the Toyota Production Systems and Lean Manufacturing principles. The term 3D printing is defined as the fabrication of a product through the deposition of a material or binder using a print head, nozzle, or other printer technology. The basics of 3D printing — stereo lithography — were patented about thirty years ago. However a combination of falling prices for hardware, easier to use software with more complex design capabilities and the internet, has allowed 3D printing to be used more widely among both industrial companies and individuals.

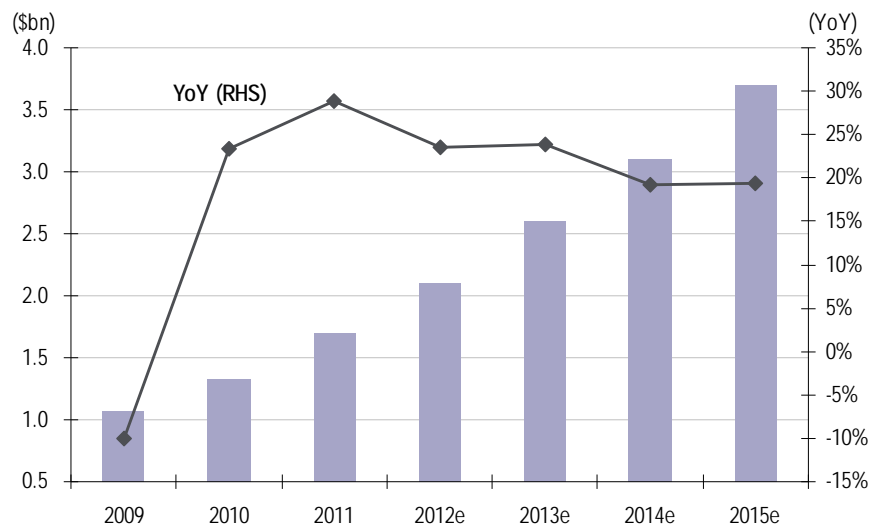
3D printing is especially useful for high value add products in individual or small lots

We think 3D printing represents a novel way of fabricating prototypes and on-demand parts, especially for high value added products in individual or small lots. Over the past 2-3 years, 3D printing has been described in the media as the next industrial revolution and it is a classic example of a disruptive innovation, that is, an innovation that helps create a new market and eventually goes on to disrupt an existing market, thereby displacing an earlier technology. As one of the leading suppliers of 3D printers noted in their most recent financial release, “Our financial results reflect the strong demand for our products, driven by the rapidly growing interest in additive manufacturing worldwide as more companies recognize how our technology can reshape the way their products are designed and manufactured.”

Market estimates for 3D printing are as high as \$5 billion by 2017

The market for 3D printing was estimated to be worth about \$1.7 billion in 2011, of which \$643 million came from service providers (also known as service bureaus), \$502 million from systems (of which personal 3D printers accounted for only \$26 million), and \$327 million from materials. By 2019, Wohlers Associates expects the market to be worth \$6.5 billion while a separate forecast by the US Consumer Electronics Associates expects the market could be worth \$5 billion by 2017.

Figure 5. 3D printing market



Source: Wohlers Associates, Citi Research

3D printing is an additive manufacturing process

How Does 3D Printing Work?

In very basic terms, the first step in making an object with a 3D printer is to produce a digital model using a computer aided design (CAD) program. Once the product or prototype has been designed using 3D printer software, the model is divided (or sliced) into thousands of layers that are then sent to the printer. 3D printers use a number of technologies to “print” an object such as fused deposition modeling (FDM), multi-jet printing, selective laser sintering (SLS) or electron beam melting (EBM). The most popular material used to “print” an object using the FDM method is ABS plastic, while the SLS and EBM methods can use nickel based super alloys, titanium or ceramics. Assuming that ABS plastic is used and using the digital file as a template, the printer builds the object layer by layer. After each layer is finished the tray supporting the device is lowered and the next layer is applied — hence 3D printing is also referred to as additive (layer) manufacturing. Using SLS technology, a laser is applied to solidify or fuse the layered materials into the finished piece.

The range of materials used in 3D printing is broad but the main types are photo polymers and laser-sintered polymers, and specific examples include ABS plastic, nickel based super alloys, titanium, ceramics, and even chocolate. While there are a number of specialist suppliers of materials for the 3D printing industry, we note some of the systems manufacturers also sell materials. The fact that these makers have a captive audience is one of the strong points of their business models and helps to explain their high margins. Not surprisingly, this is an area that the printer makers are keen to protect.

Initial Sweet Spot for 3D Printing

The aerospace industry is a natural fit for 3D printing

In 2011, 24% of the 3D printing market was made up of parts for final products, with the aerospace industry at the forefront of the drive to develop new parts using both plastics and metals. The technology is still nascent, but several aerospace companies commented on the ability of 3D printing to reduce cost and weight. Indicative of the potential for this technology in the aerospace industry, it has been said that in the future, 50% of parts used in a jet engine could be manufactured by 3D printers. Another important application is orthopedic implants such as hip cups. In general, this technology is more geared to high value, low volume parts which means that take-up in industries like autos, for example, has been relatively slow.

Who Could Lose Out?

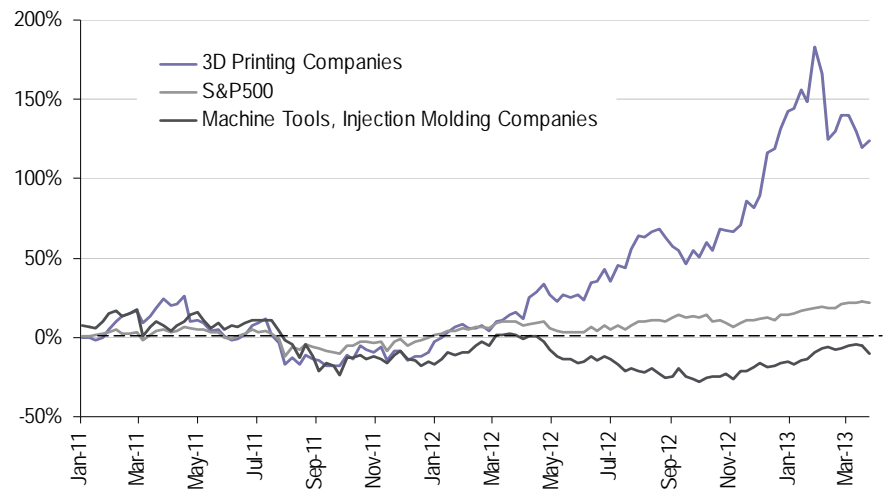
Traditional manufacturing equipment companies could be hurt...

It seems that the winners of this technology are fairly obvious, including but not limited to the listed manufacturers of 3D printers, materials and CAD software. But who are the potential losers? Although the time frame is possibly quite long, we would suggest that sectors that could lose out from the growth of 3D printing would include machine tools (used to manufacture dies and molds) and plastic injection molding companies — both are examples of the more traditional form of subtractive manufacturing — suppliers of foundry equipment, and possibly also operators of industrial warehouses as there would be less need to hold parts as inventory. We also note a comment by Chris Anderson in his 2012 book “Makers: the new industrial revolution” about the disruptive threat 3D printing posed to makers of plastic toys.

Though the industry remains small and pure-plays are scant, 3D printing has experienced considerable momentum and outperformance over the past year. The average stock price of 3D printing/ additive manufacturing companies is up 125% from January 2011 to April 2013 compared to an average decline of 10% for a basket of traditional manufacturing players in the machine tools and injection

molding sectors. We believe early 2012 was when the potential of 3D printing achieved mainstream appeal to investors and the divergence in stock prices growth rates has continued to roughly widen over time. Over the near term, 3D printing stocks should continue to show superior growth over traditional manufacturing competitors. That said, the industry is still in its high growth phase, but as new competitors enter the market, we could see fiercer competition begin to dilute both margins and the growth potential of existing players.

Figure 6. Average stock price growth of 3D printing companies v. competitors since Jan 2011



Note: 3D printing companies basket includes DDD, SSYS, ADSK, DSY-FR, ARCM-SE, and XONE (post-IPO)
Source: Bloomberg, Citi Research

...as could low-cost manufacturing countries like China

Having steadily weakened over the last several decades and during the 2008 recession, the US machine tool manufacturing sector has seen much of its global market share poached by lower-cost foreign competitors, such as the Chinese manufacturing sector as a result of its cheaper labor. We expect China to be at a greater long-term risk from the emergence of 3D printing as this new technology is an even lower-cost production methodology and the country currently ranks as the number one producer of machine tools worldwide. Conversely, the US manufacturing sector as a whole could be a net beneficiary of 3D printing due to the country's relatively large population of educated workers that are better suited for advanced manufacturing technologies.

What Could Go Wrong for 3D Printing?

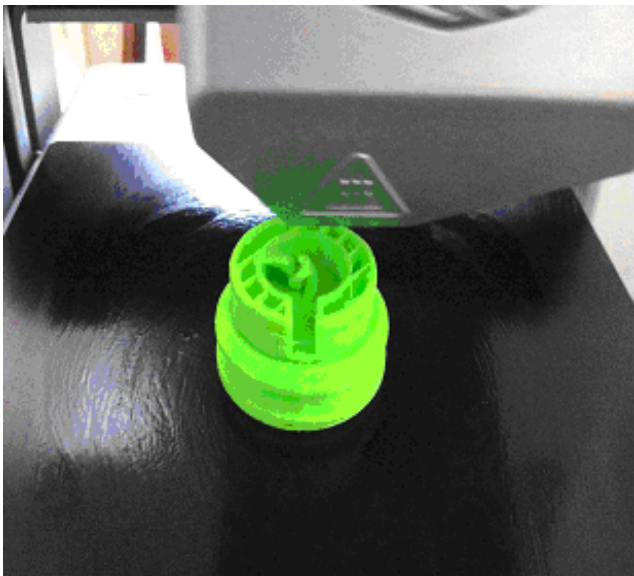
In a recent conversation with the Japanese subsidiary of Proto Labs, we were told that they own a number of injection molding machines and computer numerical control (CNC) machine centers, but did not use 3D printers to produce custom parts for prototyping or short production runs due to the high cost and limited choice of materials. There is a clear preference at the company to use standard materials from established suppliers and they do not want to be tied into using captive materials. However, a strong case can be made that the manufacturing processes of Proto Labs are possibly more complementary rather than competitive. Proto Labs noted that there are differences in the quality of the finished part and also the surface finish but given the extent of innovation in this industry over the past few years, it would be wrong to believe that makers cannot address these issues while at the same time also continue to increase the range of materials to customers.

Improvements to time and surface finish will be necessary to spur full blown adoption

Another issue for 3D printing is speed, a key concept for any manufacturer. A simple example shows this clearly. In January 2013 Citigroup Japan hosted a small event for investors on 3D printing. On the basis that “seeing is believing”, we set up a 3D printer and tried to print out a ring from a CAD file that had already been set up. The printing process took just under twenty minutes and attendees were impressed by the quality of the end product. What was perhaps less impressive, however, was the actual time taken and also the surface finish. To us, it was a reminder that while the technology works and could have a place in some industries, the drawbacks of time and finish mean for now at least, the chances that it will be fully adopted by the auto industry for mass-produced components and parts are misplaced.

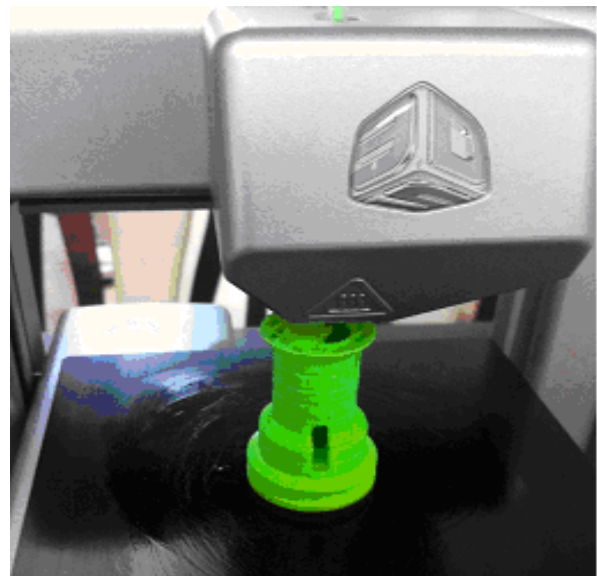
Reports in the media suggest that we are at the starting point of a new era of manufacturing, that 3D printing represents a new paradigm for mass-customization of products and that the only barrier to growth are an individual’s own imagination. That may all be true, but what is also clear is that market players and new entrants need to be careful around areas like infringement of copyrights and patents, due to possible negative headline risk from court battles. Separately, other potential liability issues have been raised in a situation where individuals using 3D scanners or even apps on a smartphone can download and print out popular trademarked characters for sale. Other risks to the industry could involve the headline risk of someone being shot by a 3D printed gun or someone being injured while living in a 3D printed house.

Figure 7. Printing a chess pieces, stage 1 (using ABS resin)



Source: Citi Research

Figure 8. Printing a chess piece, stage 2



Source: Citi Research

Adam Spielman

European Tobacco & Beverage Analyst

Vivien Azer

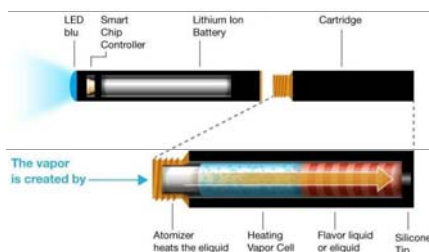
US Tobacco & Alcoholic Beverage Analyst

E-cigarettes

E-cigarettes are battery-operated devices that are meant to mimic the experience of smoking a traditional tobacco cigarette. The devices are made up of three components:

- A rechargeable lithium ion battery;
- A flavor cartridge which contains the flavored liquid (there are currently a wide variety of flavors available, from apple to whiskey); and
- An atomizer (which heats the cartridge to create vapor).

Figure 9. The anatomy of an e-cigarette

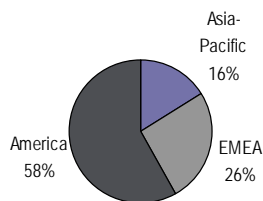


Source: Lorillard reports and Citi Research

E-cigarettes are sold as both disposable products (that generally offer the equivalent of 30-40 cigarettes) and as well as reusable systems (where consumers purchase the battery, charger and other accessories, and then buy additional cartridges to refill the e-cigarette).

While research on the health impacts of these products remains relatively new, early indications suggest that e-cigarettes offer smokers lower levels of toxicity, and are thus perceived to be a safer alternative to traditional cigarettes. Specifically, new studies suggest that the vapor expelled from an e-cigarette is 9x to 450x less toxic than the smoke expelled from a traditional cigarette.¹

Figure 10. The US accounts for a majority of e-cigarette sales...



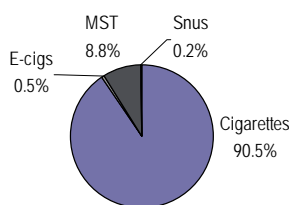
Source: Linarch reports and Citi Research

In addition to potentially offering smokers a less dangerous alternative to traditional cigarettes, e-cigarettes also offer smokers more freedom of use (for now, as discussed in more detail below). While the use of traditional cigarettes is highly restricted (with indoor smoking bans becoming increasingly prevalent around the world), current restrictions around e-cigarettes remain lax, allowing consumers to use the products in many places where traditional cigarette smoking has been banned. Nicotine levels in an e-cigarette vary significantly, from 0mg to 48mg (roughly equivalent to the strongest cigarettes).

From Concept to Reality

The concept of e-cigarettes was first introduced in the 1960s, and was first commercialized in the mid-2000s. Since then, there have been numerous e-cigarette brand introductions around the world (with an estimated 200 brands available in the U.S. alone). Indeed, with the proliferation of e-cigarette brands around the world, the category (while small) has exhibited tremendous growth, having reached an estimated over \$1 billion in sales globally in 2012, with a majority of these sales coming from the United States. In the U.S., while the market now stands at over \$500 million in sales, the product category remains small relative to the total tobacco industry.

Figure 11. ...but e-cigs small piece of the pie



Source: Lorillard reports and Citi Research

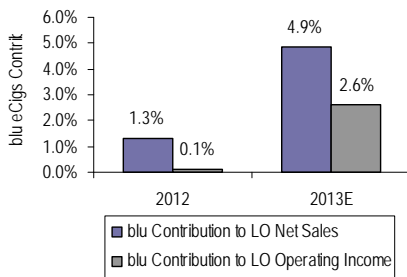
What Does the Market Know?

E-cigarettes have become an increasing focus for investors, especially in the U.S., given 1) the relative absence of innovation seen in the tobacco industry, and 2) the product's increased visibility since Lorillard's acquisition of *blue eCigs* in April 2012. Indeed, while still a small contributor to Lorillard's sales and profits, (1.3% of sales and 0.1% of profits in FY12) with the company opting to offer specific financial disclosure of this business it will continue to garner increased investor attention.

¹ <http://tobaccocontrol.bmj.com/content/early/2013/03/05/tobaccocontrol-2012-050859.abstract>

Further, we expect this will become an increasing focus for global investors, as Reynolds American has introduced their own e-cigarette brand, *Vuse*, into test markets in the U.S. and we expect they will be rolling out this product into the broader market in the near future. Further, Philip Morris recently announced that they will also be rolling out their own e-cigarette in the US in 2H13. Internationally, we expect British American Tobacco (BAT) to continue marketing its brand *Intellicig*, while its *Nicadex* product is expected to get marketing authorization from the Medicines and Healthcare Products Regulatory Agency in the UK in 2Q13.

Figure 12. blu is small but fast growing for Lorillard

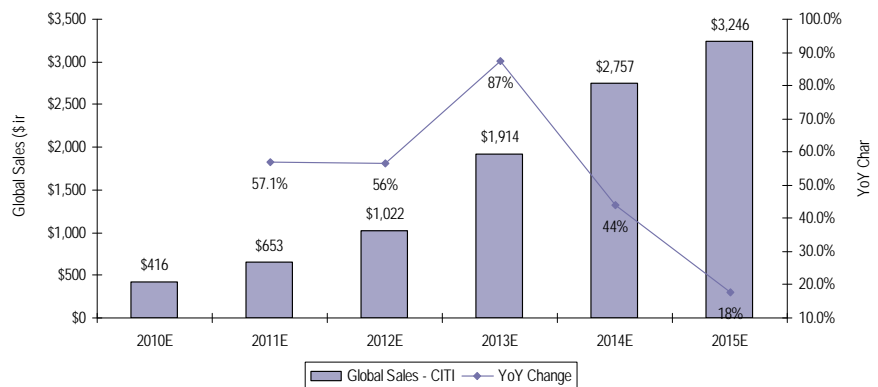


Source: Lorillard reports and Citi Research

How Big Could this Opportunity Be?

Given the tremendous growth that we have seen for the e-cigarette category (though admittedly off a small base), the outlook for growth in the e-cigarette market looks to be promising, as we estimate that the category could grow at a near 50% compound annual growth over the next few years. To put this into context, the tobacco industry generated nearly \$800 billion in sales globally in 2012. In the US, where there are 44 million adult smokers, e-cigarettes make up less than 1% of this \$100 billion category.

Figure 13. Promising category growth outlook



Source: Linarch Reports and Citi Research

Considerations: We believe regulation will be the single biggest driver of the e-cigarette industry over time (as discussed in the next section). We also believe the following factors could be key drivers of category growth:

- **Consumer adoption.** While estimates vary, research indicates anywhere from 1-in-5 to 1-in-8 U.S. smokers has tried an e-cigarette over the last year (in the UK the equivalent figure is about 1-in-15). Similarly, we see varying statistics around consumer retention, with Lorillard indicating 25% of consumers who tried an e-cigarette rejected the technology, while other accounts indicate that this figure is much higher. A key factor in terms of driving outsized growth for the category going forward will be better conversion of trial to repeat use. Technology will be a primary catalyst as over time we expect that as products improve (in terms of the consistency and efficacy) and as new products like Reynolds American's *Vuse* and Philip Morris' new e-cigarette become available in the marketplace, e-cigarettes will continue to evolve and better meet consumer needs.
- **Use profile.** In addition to better adoption, the type of consumption seen will also be a key factor for growth (e.g., will consumers increasingly use e-cigarettes as a complementary product or as a complete substitute for cigarettes). Currently, a notable proportion of e-cigarette use (~40%) is reported to be complementary, while 25%-30% is reported to be substitution.

- **Retail distribution.** While e-cigarettes are widely available for sale on the internet, increased penetration with the formal retail trade should continue to drive higher visibility for these products. Indeed, when Lorillard acquired *blu*, the product had distribution in roughly 10,000 retail outlets (vs. the ~300,000 total tobacco retail outlets that exist in the U.S.). The company finished 2012 with distribution in over 50,000 outlets (with authorization to expand to an additional 25,000 outlets as of February 2013). The receptivity of retailers to these products both speaks to the growing level of consumer interest and also to the additional opportunity that exists for further retail expansion (as we believe that the trade would like to see consolidation among the strongest players).

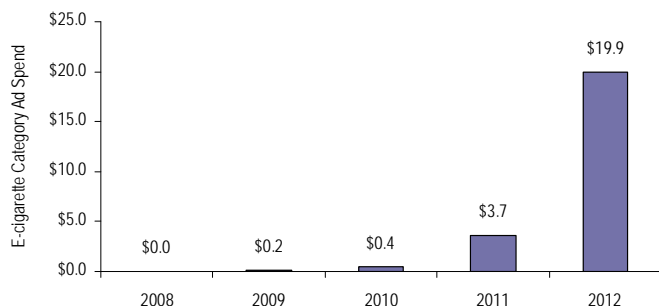
Figure 14. Ad mix is driving visibility

	2010	2011	2012
TV	1.1%	3.8%	17.9%
Magazine	0.0%	56.9%	71.9%
Newspaper	8.3%	9.5%	3.8%
Radio	4.6%	0.1%	5.5%
Other	86.0%	29.7%	0.8%

Source: Kantar Media and Citi Research

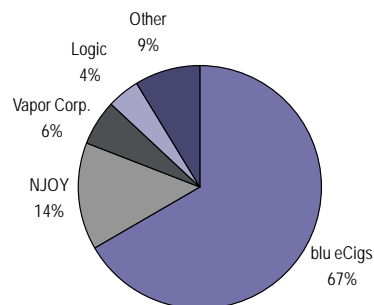
- **Ad Spending.** We've seen a notable increase in e-cigarette ad spending in the U.S. over the last five years — including a ~700% YoY increase in 2011 and a ~400% increase in 2012. This is unsurprising given that advertising is currently unregulated. Notably, we've seen an evolution in terms of the advertising medium being utilized as magazine and television ads now account for nearly 90% of all spending. We believe the increased use of traditional media — particularly television — should drive increased visibility and consumer reach.

Figure 15. Advertising spending has risen dramatically...



Source: Kantar Media and Citi Research

Figure 16. ...with Lorillard's *blu* having a significant share of voice



Source: Kantar Media and Citi Research

Figure 17. E-cigarette pricing varies widely

	blu eCigs
Starter Kit	\$69.95
Flavor Cartridges (5 pk)	\$12.00
Disposable (1 pk)	\$10.99
	NJOY
Express Kit	\$21.99
Flavor Cartridges (5 pk)	\$21.99
Disposable (1 pk)	\$9.99
	Logic
Flavor Cartridges (5 pk)	\$22.99
Disposable (1 pk)	\$10.95
	Vapor Corp
Starter Kit	\$24.95
Flavor Cartridges (5 pk)	\$12.95
Disposable (1 pk)	\$9.95

Note: Vapor Corp is for the Krave brand
Source: Company reports and Citi Research

- **Price Competition.** At present, the packaging options and pricing models for the major e-cigarette offerings vary significantly (see Figure 17), reflecting the manufacturers' desire to appeal to both committed users and also to new entrants to the category. And, while cost per unit varies across the board, disposables are generally priced in-line with traditional cigarettes (on a stick equivalent basis) while kits provide cost savings over time.

What are the Barriers to Entry?

The primary barriers to adoption of e-cigarettes, both in the U.S. and in international markets, are regulatory initiatives. Not surprisingly, we have seen greater regulation of the product over the past few years as e-cigarettes have grown in popularity.

- **U.S. Regulation.** While e-cigarettes are not currently regulated at the federal level in the U.S., the FDA has indicated its intention to issue a proposed rule deeming certain tobacco products (which we expect will include e-cigarettes) to be subject to the Tobacco Control Act. A note in the FDA's agenda indicates that the deeming regulations will "specify additional restrictions" which we believe may include a ban on certain flavors as well as restrictions on internet sales and advertising.

At the state level, we've seen much more activity. At least 15 states have banned the sale of e-cigarettes to minors (including Indiana and Mississippi in 2013) while at least two other states (New Jersey and North Dakota) have banned the use of e-cigarette in all enclosed public spaces and workspaces. Furthermore, we are now seeing legislative proposals for e-cigarettes to be subjected to state excise taxes (Oklahoma being the most recent example).

- *International Regulation.* Internationally, the regulation of e-cigarettes varies markedly. In a number of major cigarette markets (including China, India, Russia, South Korea, and most markets in the EU) the sale and use of e-cigarettes is legal. In contrast, the devices have been banned in a number of other markets including Brazil, Hong Kong, Malaysia, Mexico, and Singapore. And we continue to see developments on the regulatory front, as Turkey's Health Ministry recently reported that it is considering a ban of e-cigarettes and the U.K. Government is currently holding a consultation on e-cigarettes with plans to regulate and license the products to be announced at some point in the future.

Figure 18. A number of major markets strictly regulate e-cigarettes

COUNTRY	CIGARETTE VOLUMES (bns of sticks)	% OF WORLD VOLUMES	REGULATORY SUMMARY
Australia	19.0	0.3%	Health Ministry must approve e-cigarettes as therapeutic good in order to be sold
Brazil	87.0	1.5%	E-cigarettes banned
Canada	32.2	0.5%	Health Ministry has advised against the use of e-cigarettes
Hong Kong	3.9	0.1%	E-cigarettes banned
Malaysia	14.6	0.2%	E-cigarettes banned
Mexico	33.6	0.6%	E-cigarettes banned
New Zealand	5.7	0.1%	Health Ministry must approve e-cigarettes as registered medicine in order to be sold
Philippines	102.2	1.7%	Health Ministry has advised against the use of e-cigarettes
Singapore	3.0	0.1%	E-cigarettes banned
Turkey	99.2	1.7%	Health Ministry considering ban of e-cigarettes

Source: Company reports and Citi Research

Looking ahead, the EU's proposed revisions to its Tobacco Products Directive include a requirement that certain non-tobacco, nicotine-containing products (including e-cigarettes) obtain authorization as a medicinal product if they exceed a certain nicotine content threshold, which is currently well below the level of almost all e-cigarettes. While the revisions are not expected to take effect until 2015 or 2016, they are likely to remain a point of focus given that 1) the EU represents a significant opportunity for e-cigarettes, as it accounts for over one quarter of the global cigarette profit pool (ex. China), and 2) the regulatory actions taken by the EU may influence those of other countries around the world.

Winners and Losers

We believe the answer to this depends on regulation, and currently the future state of this isn't clear, either in the U.S. or elsewhere. However, we think it is likely that over time the regulatory hurdles will increase, both due to FDA regulation and the EU Tobacco Products Directive. If this turns out to be right we think the existing companies will benefit, as they have the economic resources to conduct the clinical and other research necessary to obtain marketing authorizations. In the U.S., we know Lorillard and Reynolds American have existing products. Internationally, BAT has said it has at least one product for which it is expecting marketing authorization soon, and we believe one of Philip Morris's next-gen vehicles is also likely to receive an authorization.

Genomics & Personalized Medicine

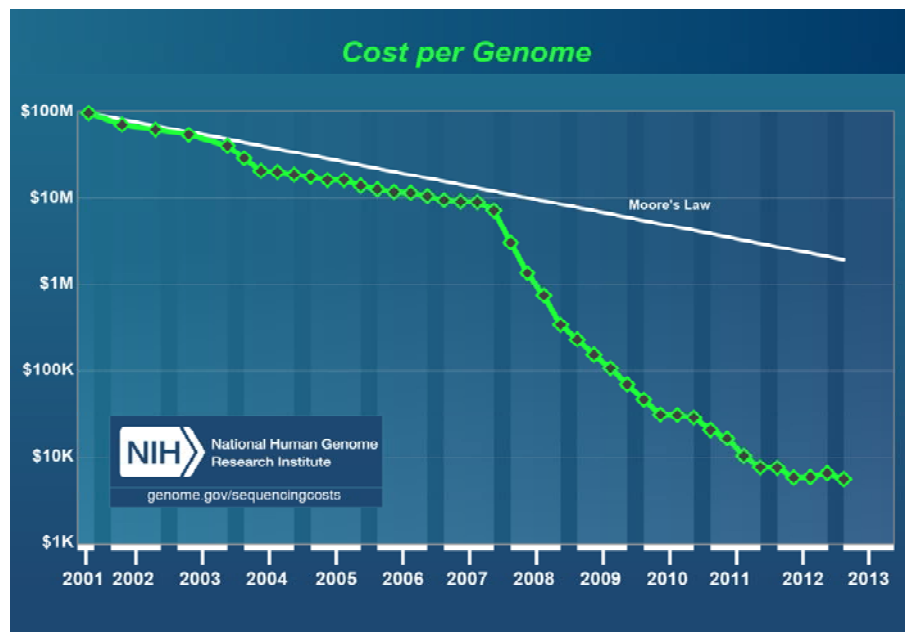
Amit Bhalla

US Life Sciences and Med Tech Analyst

Between the summer of 1998 and mid 2000, stock returns for the biotechnology sector grew over 630% (vs. the S&P 500 up over 60%) on the hope that deciphering human DNA would quickly lead to broad breakthroughs in medicine. The Human Genome Project (HGP) — which established the sequence of the first whole human genome — was completed in 2003 and during the past 10 years the project, while immensely critical to advancing science, has proved that tying DNA structure to curing disease was more complex than originally expected. However, over the past decade, the pursuit of tying an individual's genomic makeup to disease has been unwavering driving the growth of the Life Science Tools & Diagnostics sector.

At that time of the HGP, the cost to sequence the genome was \$3 billion and since then, sequencing costs have been dropping at rate twice as fast as Moore's Law² (see Figure 19) leading to whole genome sequencing (WGS) costs under \$10,000 today and a shift in healthcare toward using an individual's genetic makeup to better tailor medical treatment. The field of *personalized medicine* is still in the early innings of development (with some notable successes already taking place), but understanding the functional/clinical relevance of the human genome/DNA will continue to be key as this industry develops. In the context of personalized medicine, we see three broad groups that play an integral role and will be impacted as this industry evolves: (1) technology providers (those companies who manufacture sequencing machines and reagents kits to allow the science to take place), (2) pharmaceutical/diagnostics companies (who take the understanding of genetics & disease and develop diagnostic tests & medications), and (3) the end users (the doctors, patients, and payers who are ultimately treated more effectively at lower costs to the healthcare system).

Figure 19. Decline in cost per human genome vs. Moore's Law



Source: National Institutes of Health

² Moore's Law is a guide in long-term planning that sets targets for research and development based on an observation that integrated circuits in computing hardware doubled every two years.

What is DNA Sequencing?

The human genome is the entirety of an organism’s hereditary information — the Human Genome Project tried to unlock it

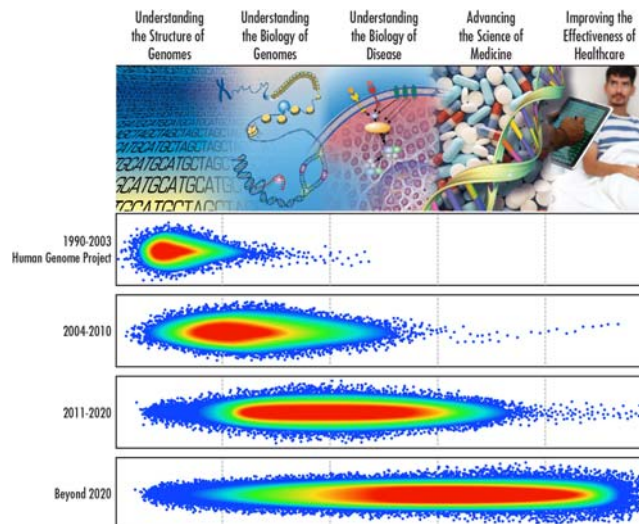
As way of background, deoxyribonucleic acid (or DNA) is the molecule that encodes the genetic information used to instruct the development and function of living organisms. The information in DNA is stored in four different chemical bases called nucleotides (abbreviated as G, A, T, and C), and together, they encode the 3 billion bases in the human genome. Evidence of hereditary patterns was first observed by Gregor Mendel in 1865, but the structure of DNA was not described until 1953 by James Watson & Francis Crick. It wasn’t until 1977 before Frederick Sanger developed technology that allowed the four bases of DNA to be read. By the completion of the Human Genome Project in 1990, the idea of the “\$1,000 genome” was beginning to evolve but still far from reality.

Next-generation sequencing helped rapidly advance sequencing capabilities and reduce costs

In 2007 new sequencing technology emerged (called NGS or next-generation sequencing) which then led to more pronounced declines in cost from the \$10 million cost for WGS at that time. Two companies, Applied Biosystems (now Life Technologies) with its SOLiD platform and Illumina with its Genetic Analyzer (GA), helped rapidly advanced sequencing capabilities and accelerated the reduction in the cost per genome. While the cost of WGS is not yet at \$1,000, sequencing technologies continue to advance with new products from Life Technologies (the Ion platform) and Illumina (HiSeq/MiSeq) and new companies have entered the market as well (e.g., Pacific Bioscience, Qiagen, Oxford Nanopore, etc.). And with the boom in sequencing data generation has come the need for better information management solutions and the growing field of bioinformatics.

While the pure academic/government research sector continues to shift towards sequencing-based research benefitting companies involved in sample preparation, DNA sequencing instruments, and analytics, the data generated is now being utilized to develop companion diagnostics for pharmaceuticals and screening tests for inherited diseases and mutation analysis (e.g., non-invasive pre-natal testing and cancer sub-typing). While these applications are still in early stages, the technology is already providing less invasive disease screening options for patients, allowing physicians companies to make targeted therapeutic decisions, and providing payers a potentially long-term cost-effective solution.

Figure 20. Genomic applications timeline



Source: National Institutes of Health

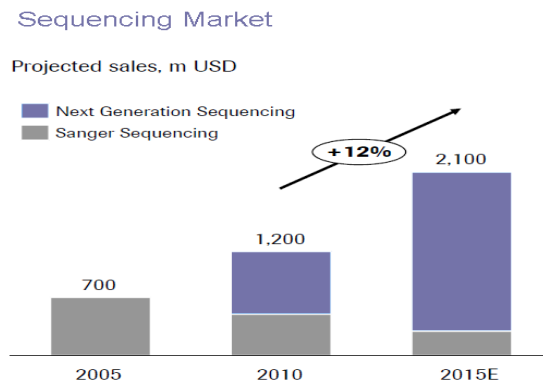
The Sequencing Workflow

In the research setting, the sequencing workflow begins with an assessment of sample quality followed by sample preparation, sequencing, data storage, and data analysis. Sample quality assessments are completed to ensure that the quantity and integrity of the DNA sample is adequate for sequencing – sample prep steps can include sample isolation, purification, and library preparation. Following determination of sample quality and subsequent sample preparation, the sample is ready to be sequenced on a sequencing instrument.

As sequencing instruments get smaller and less expensive, placements in labs and eventually the clinical / hospital market will increase

The instrument market itself has also bifurcated into two system types: bench-top systems and production instruments. Production instruments such as the market-leading *HiSeq* from Illumina offer high throughput sequencing capabilities that enable large genome centers to support multiple research groups. The production instrument market has most recently focused on Academic/Government research labs but could see some expansion in pharmaceutical markets in the identification of drug targets. Future growth in the instrument market is likely to come from bench-top instruments including the *Ion PGM* and *Ion Proton* from Life Technologies as well as the *MiSeq* from Illumina. While bench-top systems lack the throughput capabilities of production instruments, they offer similar levels of accuracy and improved ease-of-use as well as faster time to results. The smaller size and lower costs of these systems will also lead to placements in individual labs and eventually directly into the clinical/hospital market.

Figure 21. Sequencing market size

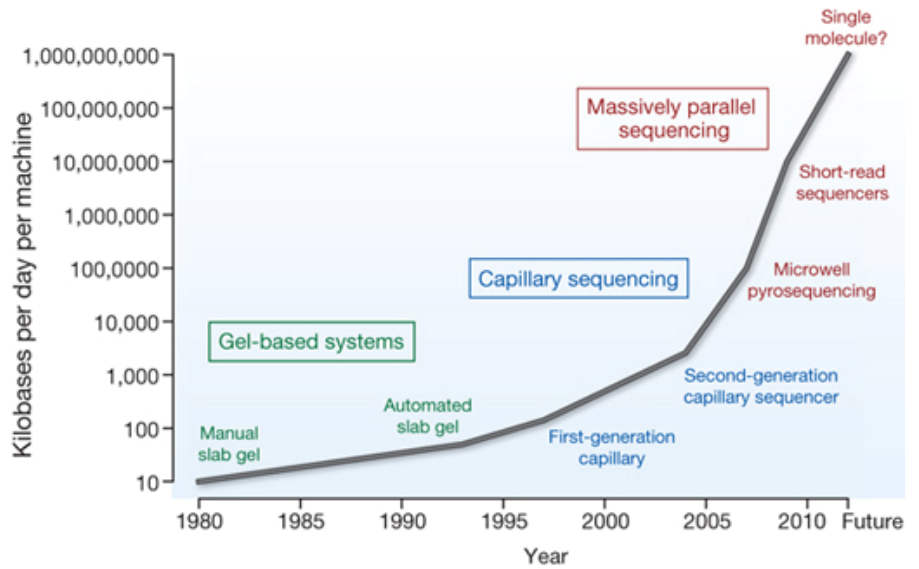


Source: Company data; Roche

Data coming from sequencing instruments is increasing and storage solutions are required

As both the costs of sequencing have declined and the instrument capabilities have increased, the data generated from sequencing instruments continues to grow, presenting challenges from both a data storage as well as analysis perspective. From a data generation perspective, the Wellcome Trust has estimated that the sequencing data generated per instrument per day has increased from less than 10 kilobases to over 100 million kilobases per day. With these significant data requirements, data storage companies including cloud computing resources (as storage moves off-site) will likely benefit from large scale whole genome sequencing. As data storage requirements and the known complexity of the genome increase, data analysis through bioinformatics becomes critical to drive clinical utility.

Figure 22. Sequencing data output



Source: Wellcome Trust

Clinical Applications – Pharmaceuticals & Diagnostics

While knowledge of the genome may still be in early stages, practical applications of sequencing are already beginning to migrate into clinical practices. Cancer, inherited diseases, and companion diagnostics represent the near term opportunity with future possibilities of expansion into full disease risk profiling based on genomics. For patients, the opportunity around sequencing can be reflected at different milestones in treatment whether 1) initial screening to identify a predisposition to disease, 2) screening upon disease or symptom onset, 3) testing at therapy initiation to determine the appropriate pharmaceutical, and 4) monitoring during treatment for disease progress.

Cancer genotypes analysis helps patients and providers make decisions on potential therapeutic options

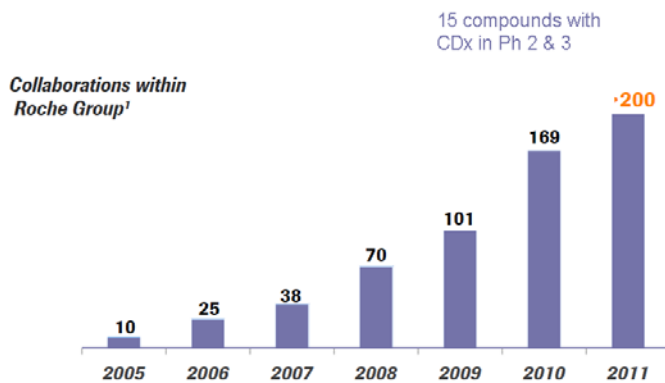
- Cancer:** The National Cancer Institute estimates that 1.6 million people were diagnosed with cancer in the U.S. in 2012, that over 12 million are living with cancer, and that the lifetime risk for cancer is approximately 40%. In the U.S. alone, the opportunity for cancer testing is estimated to be \$3.5 billion in just breast and colon cancer with another \$1 billion opportunity in early cancer detection. Companies such as Myriad Genetics, Genomic Health, and Foundation Medicine are using cancer genotype analysis to help patients and providers make decisions on potential therapeutic options. These tests are able today to identify subtypes of tumors that can indicate the origin of disease and the potential for therapeutic response. Future tests may allow the monitoring of tumor recurrence over the life cycle of a cancer and even the hereditary risk of cancer.
- Inherited Diseases:** Sequencing allows the detection of inherited diseases and even screening for chromosomal abnormalities. The U.K.'s Royal College of Physicians has estimated that 2-3% of births will have congenital or genetically determined abnormalities with up to 5.5% developing a genetic disorder by age 25 and even up to 60% developing a genetic-related condition at some point in a lifetime. The most common inherited diseases include Mendelian disorders, which are inherited directly (e.g., cystic fibrosis, sickle cell anemia, and Huntington's disease). In addition, a significant commercial opportunity has

developed in non-invasive pre-natal testing to detect chromosomal abnormalities including trisomy 13, 18, and 21 with companies including Illumina (with Verinata), Sequenom, Ariosa, and Natera offering testing options. While these tests are not yet detecting inherited diseases, this is the next evolution that would offer even more clinical value to both patients and providers.

Approximately 80% of pharma companies are currently investing in personalized medicines with up to 50% of current clinical programs including companion diagnostics

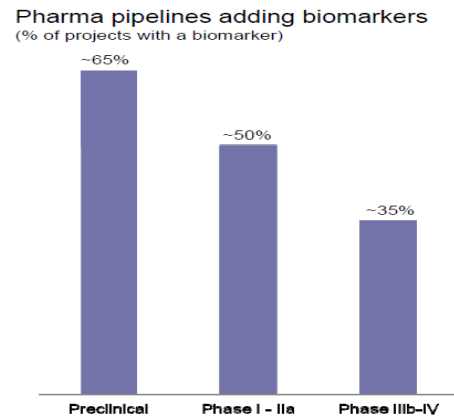
■ **Companion Diagnostics:** Companion diagnostics represent an application of genomics where patients can be stratified based on genetic profile to achieve positive results with a drug therapy. The companion diagnostics market is expected to reach \$1.5 billion by 2015 as pharmaceutical companies continue to transition to biomarker or genetic based therapies. Approximately 80% of pharmaceutical companies are currently investing in personalized medicines with up to 50% of current clinical programs including companion diagnostics. From 2000 to 2010, pharmaceutical R&D spending grew at a CAGR of +7% to \$45B with genomics related R&D growing at a CAGR of +33% and now accounting for 20% of R&D spending. While the initial focus for companion diagnostic development has been in oncology, other high economic value/scientific probability are in autoimmune drugs and anti-infectives, as well as asthma, diabetes, growth factors, statins, and CNS drugs. Companies actively involved in companion diagnostic development include Qiagen, Roche, Life Technologies, Abbott, and Agilent Technologies.

Figure 23. Roche companion diagnostic (CDx) collaborations



Source: Company data Note: Including R&D collaborations and CDx projects

Figure 24. Pharma biomarker prevalence



Source: Company data, Qiagen

Figure 25. Qiagen selected companion diagnostic (CDx) partnerships

Project	Partner	Indication	Biomarker	Status
Eribitux (cetuximab)	BMS / Lilly / ImClone	Colorectal cancer	KRAS	U.S. regulatory approval in July 2012
Vectibix (panitumumab)	AMGEN	Colorectal cancer	KRAS	U.S. submission (PMA) in H2 2011
PF-00299804 (dacomitinib)	Pfizer	Lung cancer (NSCLC)	KRAS	In development
Iressa (gefitinib)	AstraZeneca	Lung cancer (NSCLC)	EGFR	CE-IVD kit in Europe and other non-U.S. markets
(afatinib)	Boehringer Ingelheim	Lung cancer (NSCLC)	EGFR	U.S. submission (PMA) planned for 2012
Early-stage compound	Lilly	Blood cancer	JAK2	In development
Various projects	Roche	Not disclosed	Various	NEW (October 2012) In development

Source: Company data

Effective use of genomic information and diagnostic testing should enable more effective patient care and lower overall healthcare costs

Impact on the Healthcare Market – The End Users

As sequencing applications move into the clinical market, they are beginning to have an immediate impact for patients, providers, and payers. This new technology offers advantages over current clinical options, and we expect market growth will likely continue in the double digits as patients and providers see advantages in the delivery of healthcare and as providers begin to understand the long-term cost-effectiveness of personalized medicine. With the US healthcare system focused on cost reduction, we believe the effective use of genomic information and diagnostic testing should not only enable more effective/efficient patient care, but reduce overall healthcare costs.

- *Patients.* From the patient's perspective, sequencing applications offer the opportunity for individually tailored treatment programs as well as non-invasive screening options (especially in the case on pre-natal testing). Cancer screening, tumor, and mutation analysis are able to identify new therapeutic options for patients that fall outside of the typical treatment paradigm and even match patients to clinical trials with developmental stage drugs. While patients are the key beneficiaries from personalized medicine, the primary challenge will be in data privacy and the potential for genetic discrimination.
- *Providers.* Similar to patients, providers will also see benefits to the use of sequencing applications in making better clinical diagnoses and identifying patient risks and responses to pharmaceuticals. Integration of personalized medicine into clinical practice may be a challenge. Physician understanding of genomics is limited today, which makes bioinformatic data synthesis critical for clinical utility. And even though sequencing applications offer diagnostic benefits, economic incentives still favor more invasive options over simple blood draws, which physicians could be reluctant to lose as a means for revenue generation. However, as the reimbursement landscape evolves to include more "episode of care" reimbursement, the clinical-effectiveness of these tests will likely further accelerate adoption.
- *Payers.* While the US spends roughly \$3 trillion per year on healthcare, diagnostics represent less than 5% of this spend but impact over 70% of healthcare decisions. Even though sequencing applications can disrupt the healthcare market by offering the ability to alter treatment patterns and eventually identify individualized assessment of disease risk, reimbursement still remains a concern. While Medicare is unlikely to have sequencing-based reimbursement codes available until 2015, the current landscape even for molecular diagnostic codes could be a harbinger of the potential for sequencing-based tests. However, as the tests gain acceptance and begin to generate greater evidence on the ability to reduce long-term healthcare costs, payers will likely begin offering greater support to these applications.

Disruptions to the Delivery of Healthcare

Despite the challenges facing adoption of sequencing in the clinic, genomic medicine is becoming a reality. Even though the understanding of genomic data and the relationship it has to healthcare status remain in an early stage, current applications in cancer genetics, non-invasive pre-natal testing, and companion diagnostics are already demonstrating the potential of sequencing technology. As genomic research evolves, the price of sequencing continues to decline, and bioinformatics improves, the healthcare system should be able to realize the benefits of personalized medicine.

Mobile Payments

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Simon Weeden
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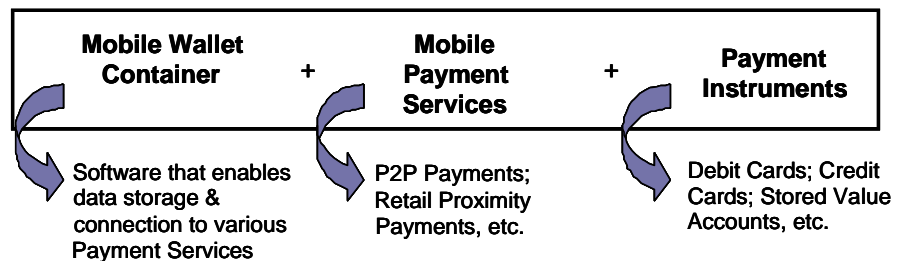
Philip Stiller, CFA
 US Specialty Payment Processing Analyst

With almost 6 billion mobile phone subscriptions globally, the rise of Mobile Payments can have material and widespread financial and social consequences. Our analysis indicates that multiple constituents – consumers, entire industries as well as governments – are likely to be affected by this trend.

What is a Mobile Payment?

A Mobile Payment is a payment initiated from a mobile device — such as a phone or tablet — or a payment accepted by a mobile device. To make this simple description more useful, we define the various components of a Mobile Payment in Figure 26: the mobile wallet container; mobile payment services and payment instruments.

Figure 26. Mobile wallet definition and components



Source: Citi Research, "Upwardly Mobile II", Nov-2012

The mobile wallet container is basically the software that handles credentialed access to both the payment services and payment instruments and also stores relevant information.

There are three generic types of payment services (i.e., functionality) that a mobile wallet should enable (listed below). It is worth noting that these are not the only functions of a mobile wallet and we expect that as the acceptance of mobile phone-based credentials becomes more widespread, there will inevitably be more uses.

- *Retail Remote Payments* – these are e-commerce transactions done using the mobile web browser on the phone;
- *Retail Proximity Payments* – this is what most people visualize when they think of mobile payments, i.e., using the phone as a payment device. The other form of such proximity payments is to actually use the phone as a "cash register" or a payment acceptance device. So, there are actually two kinds of retail proximity payments – one introduces mobility to the consumer side and the other introduces mobility to the merchant side.
- *Person-to-Person (P2P) payments* – this has proven to be a critical use case in emerging markets, but we believe that the creation of an interoperable, inter-bank system can actually make this a "killer app" in developed markets as well.

Here Now, but More Room to Grow

The Mobile Payment opportunity differs in Developed and Emerging markets

Mobile Payments is a reality in some markets and it is the future in others. Generally speaking, the Mobile Payments opportunity in Emerging Markets is likely to evolve quite differently from that in the Developed Markets.

- In Emerging Markets, we can leapfrog from a cash-based society to mobile payments - not very different from the communications industry where we went from post offices to mobile phones without stopping for the wire-line infrastructure to be laid out. Here, the ubiquity of mobile phones can help governments, businesses and individuals overcome a set of pressing and persistent issues, i.e., the general lack of access to financial services, computers and internet connectivity. This is a "blue sky" opportunity and typically there isn't any established competition to worry about. M-PESA in Kenya is generally considered as one of the most successful Mobile Payments ecosystems in the world with clients representing 60% of Kenya's population. In-country remittance is likely to be the "killer app" in many Emerging Markets.
- As for Developed Markets, the general take-away is that while the opportunity is large, there are incumbent payments industry players as well as a range of contenders and co-operation between these groups is not a given unlike in many Emerging Markets where the presence of a dominant financial services player or telecom resulted in quicker progress. Relatively high levels of bank penetration as well as smartphone penetration in Developed Markets means the evolution of Mobile Payments will be different than in Emerging Markets. Japan, the most advanced in Mobile Payments in Developed markets, is considered a relative success story with 55% penetration of mobile-payment enabled phones. Transit and retail applications are typically important in Developed Markets and are likely to be the "killer app".

Figure 27. Comparing successful "country-level" implementations

	Japan	Kenya
Main Mobile Wallets	Edy (BitWallet), iD (NTT DOCOMO), Suica (JR East)	M-PESA (Safaricom)
Active Mobile Wallets	~21 mil	~15 mil
% of population	~17%	~37%
Cash Use in Economy	~87%	~94%
Main Use of Wallet	Payment in Store, Vending Machines, Transit	Peer-to-Peer Payments (Remittances)
Technology Used	Contactless (RFID)	SMS (Text-based)
Funding Sources	Prepaid and Postpaid	Prepaid
Revenue Sources	Merchants	End Users
Revenue Types	Merchant Discount Rate, Float	Cash Out Fees, Transfer Fees, Float

Source: Citi Research, "Upwardly Mobile I", Mar-2012

How Well Known is this to the Market?

Newsflow in the Mobile Payments space is very heavy — averaging 16 announcements per day

Mobile Payments is an incredibly exciting and fast-moving field. Citi's Mobile Strategy team has said they see and analyze an average of sixteen Mobile Payment announcements each day. Not every one of these is significant, but the list includes new product announcements, new partnerships, reports of progress (or lack thereof) on existing deals and initiatives.

Because of the pace of innovation and the high profile nature of many of the companies involved, we believe investors are generally well aware of this trend. That said disparate camps on the pace and end-states of this change do exist, which make it an area worth exploring.

How Big Could the Opportunity Be?

Market size estimates have a wide range but indicate a massive emerging opportunity

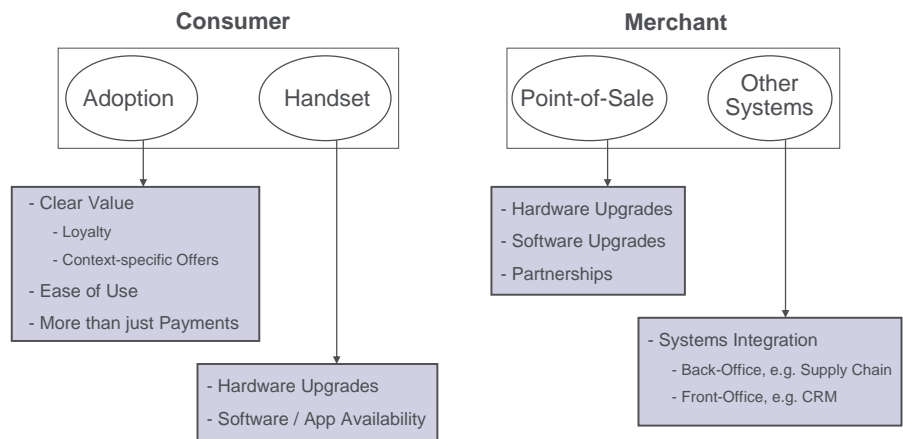
A wide range of growth estimates exists for Mobile Payments. Juniper Research predicts \$670 billion in transaction value by 2015; the Yankee Group projects \$545 billion in payment value by 2015 and Canada-based IE Market Research Corporation estimates \$1 trillion of transaction value by 2016. Some of the difference in these estimates is due to differences in the type of transactions being measured and some of it is likely due to differing assumptions about the evolving economics of Mobile Payments. In spite of the differences in the magnitude of Mobile Payments market size, there is no denying that Mobile Payments represents a massive emerging opportunity.

What are the Barriers to Adoption?

Regardless of the specific technology, several milestones must likely be passed on both the consumer and merchant side on the road to widespread Mobile Payments adoption and they are illustrated in Figure 28 below. The question of infrastructure roll-out has less to do with the consumer side of adoption in developed markets and instead is more based on the following points:

- Changes that may be needed for the handset;
- Changes at the POS; and
- For multi-location retailers with a more sophisticated IT set-up, the Mobile Payments system needs to be integrated with other existing systems.

Figure 28. What needs to happen for Mobile Payments adoption in Developed Markets



Source: Citi Research

The table below explains why none of the technologies offer a seamless and ready implementation path.

Figure 29. Regardless of technology choice, the Mobile Payment path is not easy

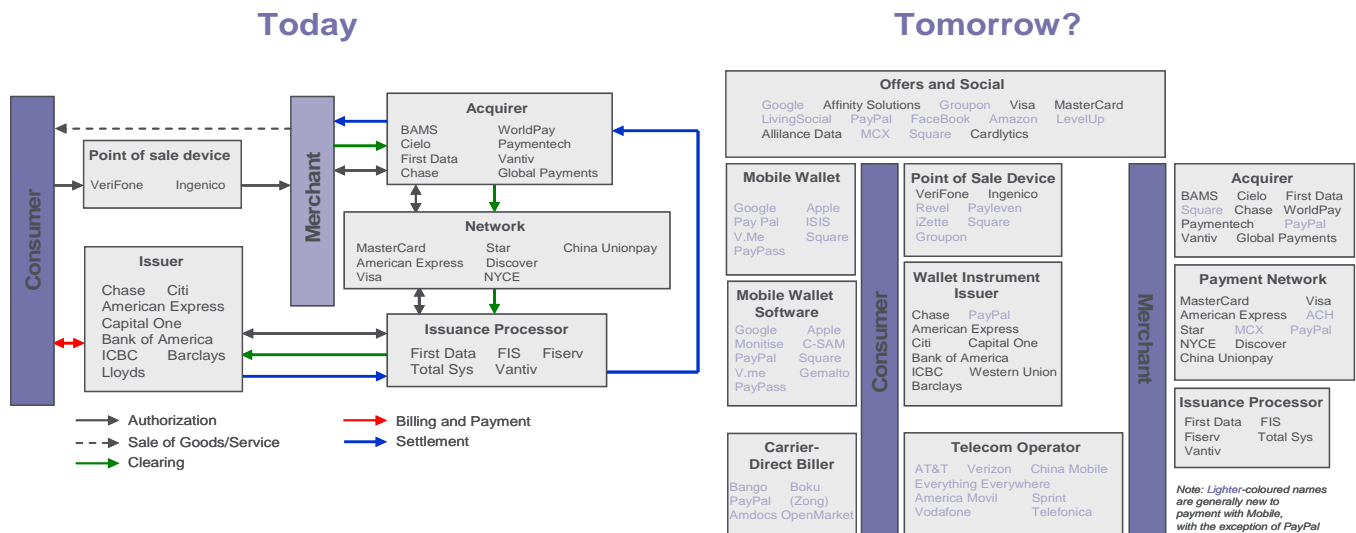
	NFC	Cloud/ WAP	QR Codes	SMS	RFID
Handset Hardware Upgrade	Required. Software Upgrade	No	No	No	Required
Handset Software Upgrade	May be Integrated	Download App	Download App		Required
POS Hardware Upgrade	Required	No	Required. Software Upgrade	No	Required
POS Software Upgrade	Required	Required	May be Integrated	Required	Required
Ecosystem Partnerships	Required	Required	Required	Required	Required
Systems Integration	Required	Required	Required	Required	Required
Marketing Rollouts	Required	Required	Required	Required	Required

Source: Citi Research, "Upwardly Mobile II", Nov-2012

Winners and Losers

A good starting point is to consider what the traditional card payment ecosystem looks like and how it works. The left side of Figure 30 below illustrates this. When Mobile Payments are introduced into the traditional retail POS process illustrated above, it results in a much more complex outcome. This is because, in addition to the traditional 4-party set-up – which includes the consumer, the merchant, the issuer and the acquirer – new classes of participants (roles) are introduced. Further, many new players are introduced into these roles, both in the new mobile-only roles and in the traditional issuer/ acquirer positions. Even more interestingly, there is a potential for new networks to be introduced. The right side of Figure 30 below illustrates our point – this is not a comprehensive list of participants but notice there are significantly more roles and role-players than before.

Figure 30. Potential evolution of traditional payment system in a world of Mobile Payments



Source: Citi Research, "Upwardly Mobile II", Nov-2012

There is a chance of disintermediation of current payment players, but the threat of it being widespread across the value chain seems overblown

The disintermediation question is asked about the card networks, about acquirers and most certainly about the point-of-sale (POS). Our general view is that it would be normal for some incumbents to have a less defensible position as mobility increasingly becomes a more common way to "do payments". But the threat of widespread disintermediation across the value chain seems to be overblown. Partly, our view is based on our experience studying similar phenomena in other markets previously. In this regard, we note that in the 1998-2001 timeframe there was considerable fear that Internet Consultants would replace traditional IT Consultants, but instead most of the pure-play Internet Consultants no longer exist while their capabilities have survived and thrived and are now being provided by those same traditional IT Consultants. There are other examples within the technology sector where some of the larger processors are the by-product of extensive M&A over time as they have used their balance sheets to absorb the capabilities of potential disruptors. Even in the retail sector, we see several examples of successful eCommerce strategies being adopted by retailers to combat the real fear of disintermediation. Partly, it is a matter of competitive response and time-frame, i.e., incumbents are not sitting idle and the pace of change is often measured in years, which implies that incumbents often have time to react. And finally, we note that the incumbents have access to significant capital to defend their turf. Eventually, it seems quite likely that the disruptors will probably succeed more in influencing incumbent behavior – sometimes by being acquired by them – rather than by becoming a large independent player themselves.

Energy Exploration Technology

Ryan W Kauppila
European Oil Services Analyst

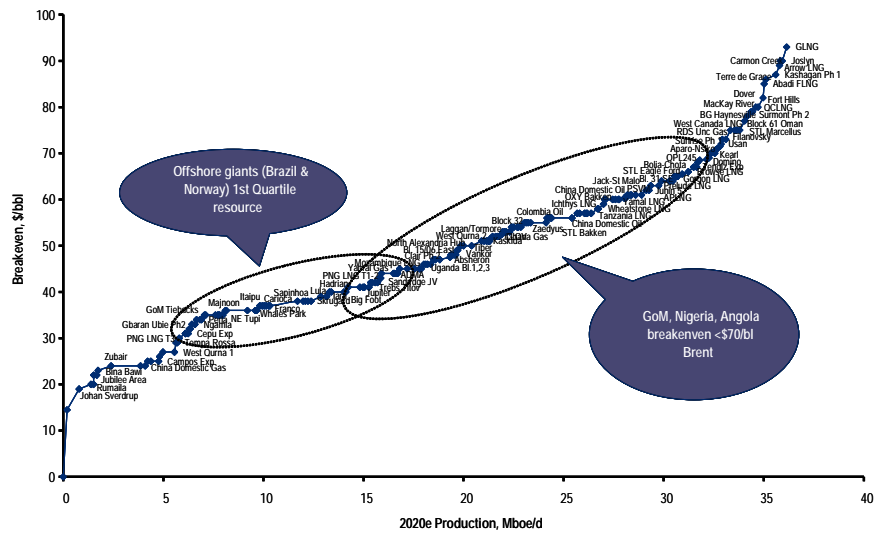
Robin Shoemaker
US Oil Equipment & Services Analyst

North America has been the fastest growing oil and natural gas producing area of the world for the past 5 years. This 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. With the U.S. accounting for only 13% of recoverable shale gas worldwide, new advances could see the shale revolution expand globally. Although shale has been the big story, 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.

Shifting More Equipment to the Seafloor

Offshore oil and gas looks to play an important role in the quest for more affordable energy. Already this decade, offshore oil and gas production accounts for 45% of incremental supply, reflecting both a material resource base and comparatively attractive economics (breakevens < \$70/barrel). Subsea processing technologies hold great promise in helping to lower the cost of oil production — expanding the accessible resource base and greatly reducing the required capital spend.

Figure 31. Subsea processing may materially lower the cost of offshore oil and gas supply



Source: Citi Research

Subsea processing has the potential to:

- Increase overall field recovery rates;
- Enable production in deeper water/ harsh environments;
- Enable lower quality reservoirs; and
- Significantly reduce overall capital expenditure.

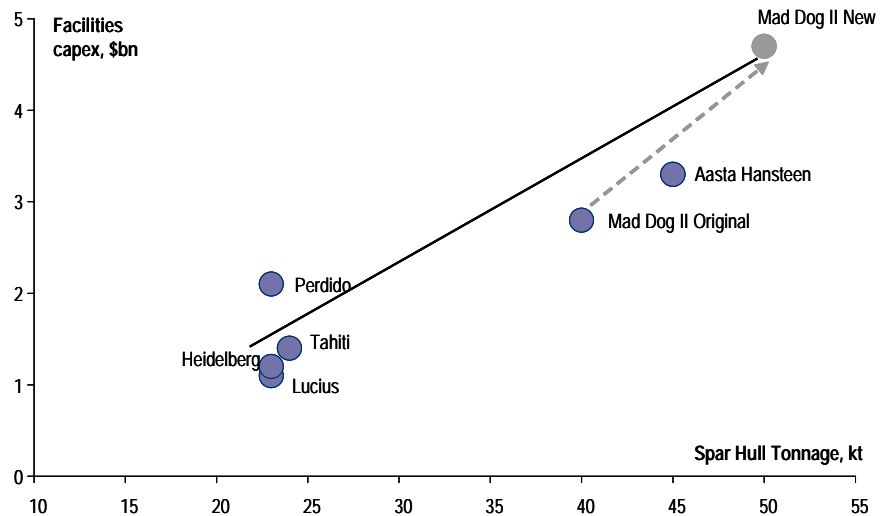
Currently, most offshore fields rely on large, costly fixed or floating platforms located at sea level to house the necessary oil and gas production equipment. Deeper water and/ or more complex environments require a heavier, more complex platform, with costs rising exponentially (Figure 32). Subsea processing involves

locating more of this equipment directly onto the seafloor, increasing the efficiency of production equipment and reducing platform complexity. Subsea equipment may include water removal/ re-injection, boosting (artificial lift), oil and gas separation, and gas treatment and compression.

Subsea started in the 1990s with deployments expanding steadily over the years

The first subsea processing technology — boosting — surfaced in the mid-1990s and is now generally regarded as an available technology for offshore developments. For more complex subsea separation, the first development was installed in 2000 at Statoil's Troll field on the Norwegian Continental Shelf, where water was successfully separated from the well stream and re-injected into the reservoir at the sea floor. Over the past decade, oil-gas separation technologies have been deployed to various degrees in Brazil, the Gulf of Mexico and West Africa. The first subsea gas compression project is currently under development on Statoil's Asgard field, again on the Norwegian Continental Shelf, with first production expected in 2015.

Figure 32. Production facilities capex increases exponentially for large SPAR* developments



Note: SPAR is a type of floating oil platform typically used in very deep waters.
Source: Citi Research

Barriers to Adoption are Steep

Subsea processing equipment has the potential to be a \$100 billion per annum market by the next decade.

Large integrated oil companies are slow to adopt new technologies

The large integrated oil companies are the most likely adopters of advanced subsea processing technologies. However, due to long lead-times associated with the oil and gas supply chain (10+ years from discovery to first oil), technology adoption tends to be incremental and slow in comparison to other industries. Additionally, operators tend to be acutely risk-averse with respect to unproven development concepts, a characteristic made even more prominent by the Macondo oil spill in the Gulf of Mexico in 2010.

Barriers to adoption are steep as end-customers tend to use proven suppliers

Given both the engineering intensity of subsea processing equipment and the desire by end-customers to use proven suppliers, entry barriers look steep and established equipment makers have a significant advantage.

Increased subsea processing architecture would likely mean lower demand for platform fabrication capacity (shipyards), riser/ pipeline manufacturers, and heavy-lift/ offshore construction vessels.

Another Innovation is More Efficient Hydraulic Fracturing

Hydraulic fracturing has already revolutionized oil & gas exploration...

Hydraulic fracturing is the key to extracting oil and gas from low-permeability shale reservoirs. Specially engineered fluids are pumped at high pressures into horizontally drilled wells, causing vertical fractures to open in the rock which then serve as flow channels for oil and gas production. Proppants (such as sand) are mixed with the fluid to keep the flow channels open after the fracturing fluid has been withdrawn from the well. Hydraulic fracturing has transformed the U.S. oil and gas industry. However, current methods are wasteful and inefficient. They require enormous amounts of pumping horsepower and large quantities of fresh water and proppant. Another limitation is the relatively low recovery of oil and gas in place through current hydraulic fracturing methods.

...but new technologies are increasing productivity and decreasing waste

To combat these limitations, a new series of technologies is being developed and field tested that fundamentally change the way propped fractures generate conductivity, thereby aiding oil and gas flow and increasing well productivity. This suite of technologies is referred to as HiWay, a Schlumberger trademark. HiWay employs special blenders and control systems to pump proppant in pulse, creating stable and infinite-conductivity flow channels within the fractures. The results achieved thus far are impressive. Introduced in 2010, HiWay technologies already have been employed in 10,000 fracturing stages and more than 80 customers in 15 countries have used HiWay. Schlumberger reports that the average HiWay channel fracturing job has increased oil and gas production by more than 20% while requiring 40% less proppant and 60% less water than conventional hydraulic fracturing technologies. The horse power needed for pumping operations also has been reduced by up to 20%.

Reducing the Environmental Impact of Shale Drilling

Environmental impact is a key to increased expansion of shale drilling

The most controversial aspect of oil and gas shale resource development is its environmental impact. In order to stimulate shale wells through hydraulic fracturing, thousands of gallons of water and many tons of sand proppant must be trucked to the well site. In the most active shale basins in North America such as the Eagle Ford and Bakken, large convoys of trucks continuously haul sand and fresh water to remote well locations. The severe wear and tear on rural roads and the millions of pounds of carbon dioxide emissions from truck engines are major concerns. Competition for fresh water supplies often creates conflicts with neighboring communities, as does the growth of sand mining and sand transportation networks. HiWay has the potential to reduce the environmental impact of shale resource development by cutting back on the consumption of water and proppant and by shrinking the size of truck fleets that haul the basic materials consumed in hydraulic fracturing operations.

HiWay Service Offering Gains Traction, But Slowly

Uptake of HiWay has been slow in North America but higher internationally

The many demonstrated benefits of HiWay compared to conventional fracturing methods would suggest a more rapid uptake of this technology than is actually occurring today. Ironically, Schlumberger has had more success in gaining customers for HiWay in the international markets—where shale resource development is in its infancy—than in the large and growing North America market. The suite of HiWay technologies has been field tested in the Williston, the Haynesville, the Eagle Ford, the Barnett, and several other North America shale plays. In every field test to date oil, condensate, and/or natural gas production

volumes increased with HiWay compared to offset wells that were completed using conventional hydraulic fracturing techniques. Schlumberger has documented and published the results of these field tests. Nonetheless, only a handful of key customers have supported the introduction of HiWay. Part of explanation for the slow progress in gaining customers in North America may be that the pricing of conventional hydraulic fracturing services has fallen sharply over the past year, reducing the incentive to try something new and different. Today fracturing service companies are bidding for work at extremely low margins in order to stay in the game and keep their fleets active and their work force intact. The uptake of a new technology such as HiWay probably would be faster in an environment of rising prices for conventional hydraulic fracturing services.

Barriers to Shale Resource Development could Fall with HiWay

HiWay has the potential to spur the pace of global shale resource development and prevent energy prices from escalating

The future of shale resource development on a global basis hinges on further gains in the recovery of oil and gas reserves in place and on significant reductions in the environmental impact of drilling and completing wells. Certain states in the U.S. as well as certain foreign countries currently ban hydraulic fracturing out of concern for its potential impact on the environment. The risk-reward tradeoff inherent in shale resource development could become more broadly acceptable as the quantities of materials consumed in the fracturing process are sharply reduced. HiWay has the potential to spur the pace of global shale resource development which, in turn, could help to boost oil and gas production and prevent energy prices from escalating in a way that would be harmful to the global economy.

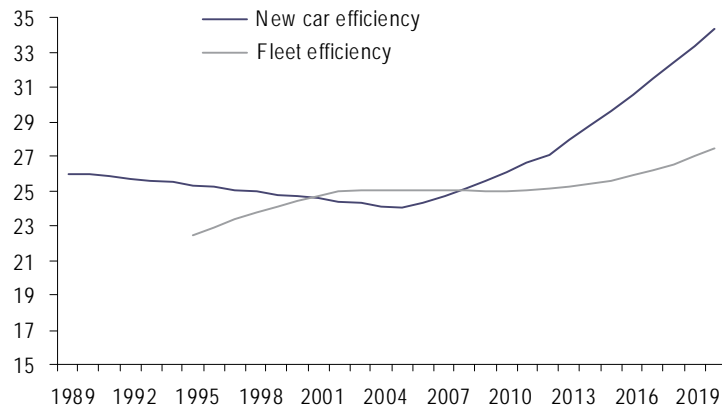
Oil to Gas Switching

Seth M Kleinman
Head of Energy Strategy

Itay Michaeli
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Vehicle fuel efficiency has improved markedly since 2007 when the U.S. passed the Energy Independence and Security Act of 2007 which increased the Corporate Average Fuel Economy (CAFE) standards as part of President Bush's "Twenty in Ten" challenge to reduce gasoline demand by 20% in 10 years. Similarly, robust mandates have been passed in several other key car markets since then — including the EU, Japan and Canada. We do note that according to the Global Fuel Economy Initiative, global light duty vehicle (LDV) fuel economy only improved by 1.8% per annum from 2008 to 2011. However, given the increasing focus on fuel economy in some key non-OECD member countries, including China, and the fact that enacted fuel economy standards around the world mandate annual fuel economy improvements of up to 4.7% for LDV fleets, we are comfortable with a forecast of LDV annual fuel economy improvements of 3-4%.

Figure 33. US New car and fleet fuel efficiency - mpg



Source: EPA and Citi Research

Fuel economy requirements are increasing, requiring a greater mix of non-conventional technologies

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. After much back and forth, global regulatory requirements are now largely enacted through the middle of this decade, and it's clear that proposals through 2025 call for even greater stringency, likely requiring a greater mix of non-conventional technologies such as alternative fuels, electrification and perhaps even hydrogen fuel-cell. Our work over the years has concluded that, as of now, there is no clear "winning" path for technology choices.

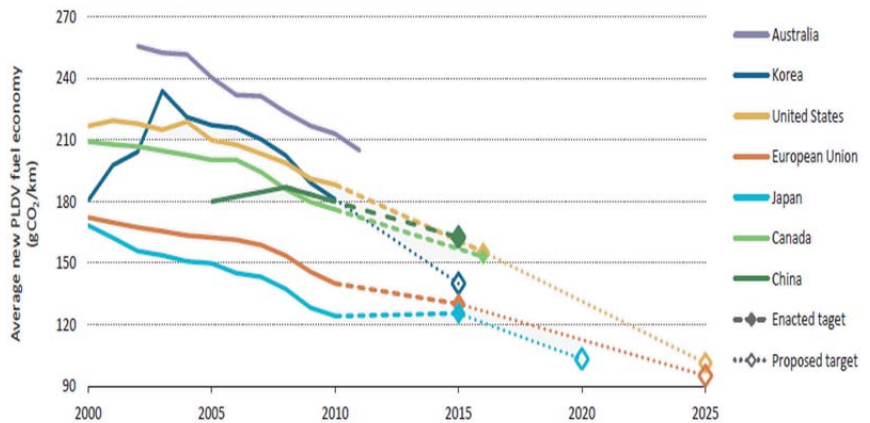
Deciding on a technology is difficult for automakers due to changing consumer reaction and long product cycles

For automakers, the decision to implement one technology over another is complex. For one, choosing a technology package to achieve one goal (say, improving gas mileage) may not necessarily mate perfectly with achieving another (say, energy independence or improving well-to-wheel emissions). The consumers themselves are also an issue, especially in the U.S. where demand for fuel efficiency has historically tended to rise/ fall with gas prices (at least in the short-term), yielding a conundrum where high gas prices damage the very affordability needed to adopt newer technologies. Also, long automotive product cycles essentially force automakers to make large bets on a few chosen technologies a number of years before market implementation. This makes overnight game-changers less likely as automakers carefully spread their investments over years. This is why monitoring up and coming companies is critical, as they are arguably more capable of introducing technologies faster than large volume automakers, at least in the initial phase. One

last issue worth noting is that global automakers are increasingly looking to achieve global scale through common parts and global platforms, so one region's regulatory hurdle may influence product decisions in another where the regulatory framework may be different.

So far, it appears that automakers are adopting different strategies and pathways towards satisfying regulatory and consumer demand. Part of this stems from varying competitive advantages (Europeans with diesel, Japanese with hybrids) and part simply stems from different thinking around customer acceptance.

Figure 34. National fuel economy mandates



Note: United States and Canada LDVs include light-commercial vehicles, SUVs and passenger vehicles.
Source: IEA

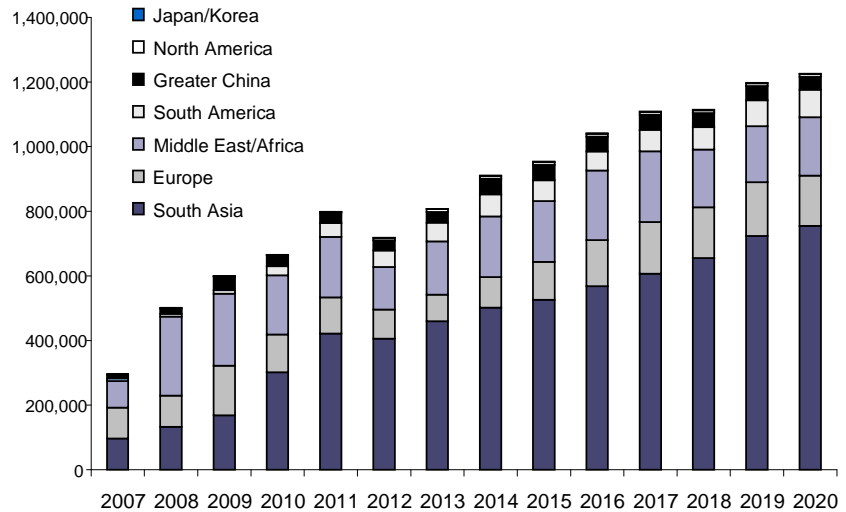
Natural Gas Vehicles (NGVs)

Iran is the world's leader in NGVs due to sanctions limiting the import of gasoline

Sanctions limiting Iran's ability to import gasoline have resulted in Iran becoming the world's leader in natural gas fuelled vehicles. Since 2005, the number of NGVs has jumped from below fifty thousand, to almost 2.9 million in 2011. The exponential growth in NGVs is expected to continue on a global basis with countries such as China continuing to ramp up their refueling infrastructure (from 1,350 stations at end-2011, China's Transportation Authority is reportedly targeting 20,000 by 2020 to sustain the growth in compressed natural gas (CNG) and liquefied petroleum gas (LPG) vehicles which might have topped 1 million at end 2011, up from just 127,000 five years earlier).

The list of cities around the world converting some or all of their taxi fleets to LPG is long and growing: New York, Las Vegas, Hong Kong, Baltimore, Pittsburgh, Columbus (Ohio), most of Japan, Grand Rapids (Michigan), London. If we assume that natural gas vehicles globally continue to rise at 20% pa, versus the 25% pa growth rate observed over the last 10 years, this would cut global oil demand for transportation by 2 mb/d by 2020 from the business as usual scenario.

Figure 35. Global CNG vehicle outlook



Source: Citi Research

Where does CNG fit in the U.S.?

Few dedicated NGV offerings in the U.S. today, but a shift is starting

Today there are only a few dedicated natural gas vehicle (NGV) offerings in the U.S. market, led by the Honda Civic NG and the General Motors Express/ Savana van. Another popular offering is the bi-fuel vehicle, which can shift between compressed natural gas (CNG) and conventional gasoline to maximize range and minimize dependence on infrastructure. Bi-fuel vehicles are a particularly popular configuration with heavy-duty pickup trucks where a greater share of fleet ownership exists (allowing for greater miles driven and better access to infrastructure). Another option for consumers is retrofitting existing vehicles into either NGV or bi-fuel. Retrofitting costs can range from \$12-\$18,000 and can depend on desired fuel tank capacity.

Key advantages include:

Key advantages are energy security, low fuel cost, lower emissions and possibly being a bridge to fuel-cell hydrogen vehicles

- **Energy security:** The most obvious advantage for CNG is making great strides towards the reduction in foreign oil dependency and the resulting gains in U.S. energy security. We believe consumers have become more appreciative of this issue in light of geopolitical conditions and the number of oil spikes observed in recent years with their immediate impact on consumer confidence.
- **Low fuel cost vs. gas or diesel:** On an apples-to-apples basis, CNG as a fuel is 30-50% less expensive than gasoline or diesel fuel and is more stable.
- **Lower emissions:** A 20-30% reduction in carbon dioxide emissions and 75-95% reduction in nitrous oxide, compared with older gasoline vehicles. Arguably not the greenest, but green enough.
- **Bridge to FCV:** Lastly, it has been argued that CNV is an ideal bridge solution towards the eventual deployment of future fuel-cell hydrogen vehicles (FCV).

Challenges include infrastructure, energy density and the large cost premium

The most glaring challenges are:

- **Infrastructure:** There are currently about 1,300 CNG fueling stations across the US, a small percentage of the number of gasoline stations. While the list is growing, only about 50% of the stations are open to the public. Refueling at home is one solution to this, but it's unclear to what extent. Note that Honda does not recommend Civic NG customers refuel at home as moisture and other contaminants risk harming the fuel system, placing a customer's warranty at risk of being denied. We believe that this is a clear issue that must be addressed.
- **Energy density:** Lower energy density means a lower mile per gallon (MPG) rating, the necessity for a larger tank (compromising space in the vehicle) and a partial offset to the lower cost of the fuel. Going back to the diesel example, it's also a slight consumer education hurdle as auto dealers would need to reconcile to customers the high cost premium against the lower MPG equation. Consider that the Civic NG is rated 7% lower in city/ highway MPG than the Civic HF.
- **Large cost premium:** Current premiums on NGVs range from \$7-\$12k, which is higher than advanced gasoline engines (i.e., EcoBoost), most diesels and close to many hybrid vehicles. We believe this is too expensive for mass consumer acceptance.

Forecasts are small for CNG vehicles but incentives could drive sales

Light Vehicle NGV Penetration Outlook

Considering some of the challenges mentioned above and the small product offering in the U.S., renowned 3rd party forecasters have yet to anticipate strong penetration gains of CNG vehicles, albeit demand should grow over time. Forecasting firm IHS estimates that global CNG (both dedicated and bi-fuel) are likely to grow from 0.9% of global auto production to 1.1% by 2020. A more optimistic U.S. scenario outlook, which assumes breakthroughs in 2018 coupled with incentives in supportive states, suggests that U.S. sales for CNG vehicles could surpass 100,000 by 2020.

Premiums need to decrease before adoption increases

What Needs to Happen for Adoption?

No matter how green the technology is or its impact on energy independence, consumer payback must be part of the equation. We believe the current premiums on CNG vehicles, ranging from \$7-\$11k, need to come down closer to \$2-\$3k. This will take time and the path is uncertain, but greater penetration of CNG vehicles in heavy trucks could be a first step in eventually bringing down the costs for light vehicle consumers. Infrastructure availability is already improving and home refueling solutions could be made more feasible over time. Thus, this hurdle is less of a concern to use over the medium-term.

Over the Top Content

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Forty years ago, U.S. households received free, simple, ad-supported TV. Sure, the options were limited: you received just a handful of broadcast channels. But, hey, it was free.

In 1976, Ted Turner launched the first U.S. cable channel: WTBS. Others followed Mr. Turner's lead. By 2012, the typical U.S. cable TV package had 200 channels. The pay TV firms paid nearly \$38 billion a year for this content. And, nearly 80% of U.S. households were paying \$75 a month – that's \$82 billion a year – for video. As a result, the pay TV industry has emerged as the largest and most lucrative segment of the entire U.S. media ecosystem. But, can these salad days last?

The industry seems to think so. Content firms are increasing content fees (fees that are paid for by the pay TV firms) 8-10% per year. In addition, those stodgy free-to-air TV stations are jumping onto the pay TV gravy train. How? They're beginning to charge pay TV firms for the same signal that's free (if consumers are technically savvy enough to stick an antenna on their roof). Many TV stations think they can get \$5 a month for each 'free' broadcast channel. If true, 'free' TV will inject another \$20 billion in cost into the ecosystem.

But, trouble may be brewing on the horizon.

Most consumers watch just 5-10% of the channels that they pay for. ESPN and the regional sports channels suck \$120 a year out of every household. But, only 20% of households regularly watch sports. And, due to contractual restrictions, the pay TV distributors are not allowed to sell channels on an a-la-carte basis. These packaging restrictions push consumer prices higher by thwarting pay TV firm's efforts to segment the market. In effect, U.S. consumers are paying a lot of money for content — particularly sport content — they don't watch. But, the alternative — rabbit ears and four broadcast networks — is a tough pill to swallow when you've developed an addiction to Game of Thrones and Mad Men.

In parallel, however, Adam Smith has been working diligently. Improved Internet infrastructure now makes it possible to stream crystal clear video over the web. Start-up firms like Roku have sold 5 million boxes allowing consumers to stream web video right to their large, flat panel TV screen. And, a number of smaller firms (Netflix) and divisions of larger firms (Hulu, Amazon Prime and YouTube) have begun to stream older TV shows and movies over the web. More recently, these same firms have begun to invest in original content as well. And, these new web-based firms charge just 1/10th the price of a traditional pay TV subscription, typically \$8 a month. And, of course, Apple has been selling individual TV shows and movies to augment these low-end subscription-based services.

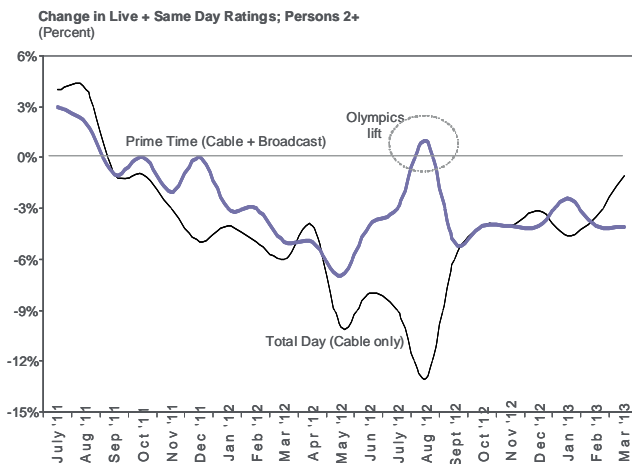
As a result, the industry is facing its most vexing period in its forty year history. Will consumers turn-off their traditional pay TV subscription and migrate to a lower cost, web-based video service? If they do, the entire pay TV ecosystem could come crashing down like, well, a House of Cards.

How close is OTT to becoming reality?

How close is the over-the-top video threat? It's hard to say with precision. But, there are some ominous signs:

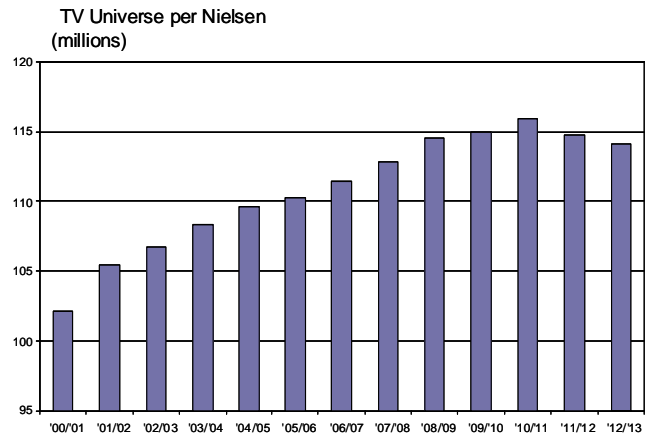
- First, Nielsen reports that the ratings on traditional TV have been falling during the last 12-18 months. Of course, as ratings fall, advertising revenues decline and the utility the consumer derives from their \$75 pay TV subscription falls.

Figure 36. TV ratings



Source: Nielsen and Citi Research

Figure 37. TV universe, per Nielsen (households in millions)



Source: Nielsen and Citi Research

- Second, Nielsen reports that the number of households with a TV has declined for two consecutive years.
- Third, the pace of pay TV net adds is increasing at a slower pace than the rate of growth in occupied housing units. To wit: In 2012, the pay TV industry only added 200K subscribers. This is down from the halcyon days when pay TV additions were 2 million a year.

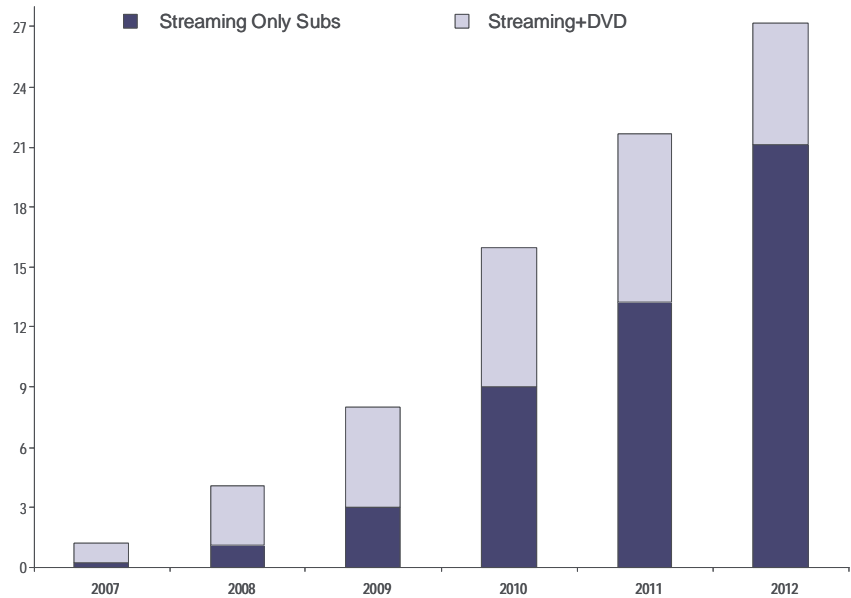
Figure 38. Pay TV net adds (subs in 000s)

	2007A	2008A	2009A	2010A	2011A	2012A
	Full Yr	Full Yr	Full Yr	Full Yr	Full Yr	Full Yr
Cable Video Net Adds	(1,018)	(789)	(879)	(1,740)	(1,413)	(1,356)
+ DBS Video Net Adds	1,553	688	1,361	696	496	281
+ Telco Video Net Adds	964	1,702	1,938	1,643	1,507	1,298
= Total Video Net Adds	1,499	1,601	2,420	599	590	223
Cable Video Net Adds	(68%)	(49%)	(36%)	(290%)	(239%)	(608%)
+ DBS Video Net Adds	104%	43%	56%	116%	84%	126%
+ Telco Video Net Adds	64%	106%	80%	274%	255%	582%
= Total Video Net Adds	100%	100%	100%	100%	100%	100%

Source: Company Reports and Citi Research

- Fourth, in tandem, subscriber figures for firms like Netflix are rising. At the end of 2012, over 27 million households streamed Netflix.

Figure 39. Netflix subscriber (sub) growth



Source: Company reports and Citi Research

How well known is it to the market?

The investment community is well aware of the theoretical risks posed by web TV. In other words, investors know that the infrastructure is able to deliver web-based TV. And, the investment community is well aware of Netflix's subscriber growth. But, fewer investors are aware of the decline in TV ratings. And, fewer still are aware that pay TV subs are not keeping up with household formation. In effect, the trends are not yet obvious enough – or definitive enough – to cause Mr. Market to think media's terminal multiples should be compressing. Indeed, they have been expanding — over the past few years, media multiples have expanded to multi-year highs.

Figure 40. Historical Media forward 1-year price/ earnings multiples

	DIS	TWX	CBS	VIAb	SNI	DISCA	Avg
18-Apr-2013	17.4x	15.9x	15.0x	13.8x	18.5x	22.7x	17.2x
31-Dec-2012	14.6x	14.9x	14.8x	11.2x	17.2x	23.7x	16.1x
30-Dec-2011	12.9x	12.8x	14.3x	10.5x	14.9x	17.1x	13.8x
31-Dec-2010	15.3x	13.8x	17.6x	12.0x	22.3x	24.0x	17.5x
31-Dec-2009	17.0x	15.4x	26.4x	12.8x	23.5x	23.9x	19.8x
31-Dec-2008	10.8x	9.8x	5.3x	7.7x	12.3x	13.1x	9.8x

Source: FactSet and Citi Research

And, what makes the multiple expansion so interesting is that it's occurring against a backdrop of flat EPS estimates. That is, 2013 estimates have not changed appreciably for most media firms since December.

Figure 41. Consensus FY13 EPS changes in 2013 (\$ per share, %)

	DIS	TWX	CBS	VIAb	SNI	DISCA	Avg
19-Apr-2013	3.45	3.68	2.99	4.70	3.60	3.38	3.63
28-Mar-2013	3.45	3.68	2.98	4.70	3.59	3.40	3.63
28-Feb-2013	3.45	3.68	2.99	4.70	3.59	3.40	3.64
31-Jan-2013	3.41	3.66	2.92	4.69	3.73	3.41	3.64
31-Dec-2012	3.42	3.66	2.92	4.72	3.78	3.38	3.64
memo: chg from 12/31/12	1%	1%	2%	0%	-5%	0%	0%

Source: FactSet and Citi Research

What are the barriers to adoption?

With robust Internet speed and numerous devices capable of getting web-based content to the TV, there are no longer any obvious barriers to adoption. The question is a bit more nuanced: When will consumers decide that the costs associated with traditional pay TV services are simply too high relative to the low-cost alternatives – like Netflix - that are readily available.

Who are the winners?

If consumers elect to eliminate their video subscription *en masse*, there are no winners in the traditional pay TV ecosystem. Content firms will lose content fees and advertising fees. Direct broadcast satellite (DBS) firms will be fighting for subscribers in an ever shrinking pool of households. And cable firms will need to raise the price of Internet access to offset the declines in video subscription revenues.

So who are the winners? Any firm that provides consumers an alternative to the closed video ecosystem that dominates the market place today.

Is the Sauce for the U.S. Goose also Sauce for the European Gander?

There are of course parallels with the U.S. experience, but also several critical differences. Going through some of these in turn:

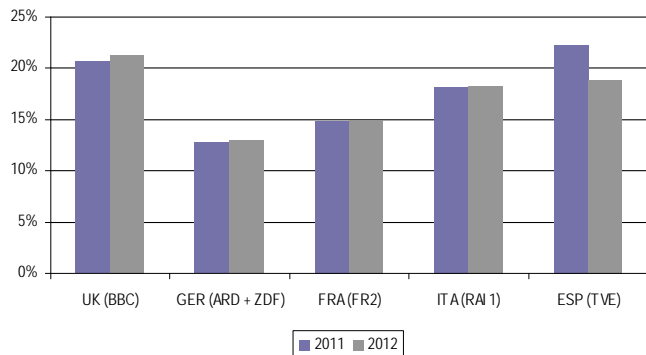
- *Europe has more of a free TV culture.* In particular, it is worth highlighting the role of both state broadcasters and regulation has played in this.

Looking at the former, the BBC in the UK, France Televisions in France, RAI in Italy, ARD/ZDF in Germany have all been bastions of free-to-air (FTA) service provisions and each of these entities has been able to provide quality content for free. Using the UK as an example, it is worth noting that in this context, long-running series like *Mad Men* or *24* actually started on free-to-air. It is also notable that with some of these entities deriving 100% of their funding from license fees/taxes, 'revenues' have not only been relatively robust, ensuring consistently high quality content, but also channels are unencumbered by advertising.

This, plus the impact of the latter (i.e. regulation like the European 'Television without Frontiers' directive), means that even the commercial TV companies have limits on the amount of advertising that is shown. Across Europe this is capped at 9 mins per hour across the day and 12 mins per hour at peak time.

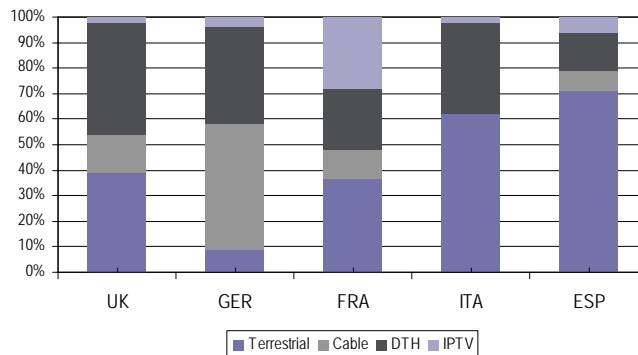
Both of these factors, in our view, have been important in as far as it has meant that consumers haven't been and aren't being forced into the arms of pay TV channels.

Figure 42. Audience share of State broadcasters in major European markets



Source: Citi Research

Figure 43. Penetration by platform across major European markets



Source: Citi Research

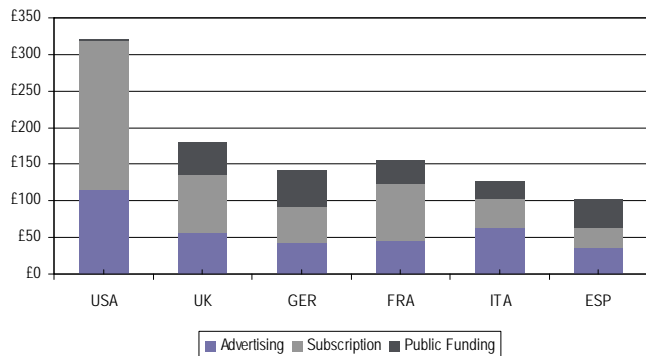
■ *Pricing in pay TV is low.* In most of the large European markets premium pay TV is in reality a minority sport. Even where it is more significant — e.g. UK and technically Germany — the cost is relatively low and viewership on these platforms heavily skewed to the FTA families of channels.

Whereas U.S. consumers are being forced into the arms of new, OTT platforms like Netflix, Hulu, Roku, and the economics of this move can begin to make sense — especially in single-person households — the economics simply don't stack up in many European markets.

This is either because the role of an aggregator is superfluous (content can be easily sourced via a small number of channel catch-up services, as is the case in the UK) or because the new services are trying to introduce a charged-for model in a market where the same content can be sourced for free from legitimate platforms.

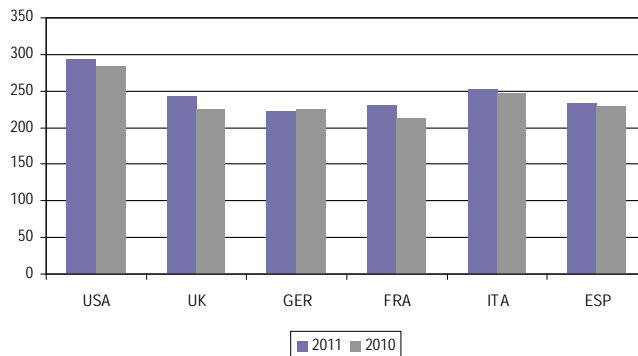
As a consequence of this, linear TV viewing is still stable in many European markets and non-linear consumption — so far — largely additive.

Figure 44. TV Revenue per head (US vs. Europe) (£ per capita)



Source: Ofcom and Citi Research

Figure 45. Daily TV viewing per head (minutes)



Source: Ofcom and Citi Research

So, Does this Mean Europe is Immune?

While we think the likelihood of material disruption from OTT/cord-cutting etc. is low today, some historical perspective is required. While the situation in Europe isn't like the U.S. today, there are parallels with the U.S. five to ten years ago. What is interesting is to consider what has happened in the U.S. in the intervening period. Share prices of each of the components of the U.S. value chain have performed well, whether that be DBS provider, cable company, channel business (cable net or network), telephone company or content/media conglomerate.

So Who Lost Out?

The U.S. consumer of course! Unfettered by stringent regulation, the consumer has consistently suffered high pricing for media/communication services and has now been squeezed to the point the pips are beginning to squeak. As above, this is not the case in Europe. Indeed far from it. There are, however, some things we do think will migrate across the Atlantic.

First, we think the phenomenon of re-transmission fees will appear in Europe, albeit in a less aggressive mutation. We expect increasing carriage revenues both for pay TV and HD versions of existing channels to grow and, where relevant, lower feed-in/transmission fees. Second, we think the pricing (and even maybe) the regulatory environment will improve. Both mean the deal for the consumer could get worse.

Cord-cutting, OTT-viewing, unbundling etc. are not a major feature of the investment debate in Europe in 2013. Indeed, absent the tightening of regulation, there is decent scope for pricing on average to move up, benefiting platforms/channel businesses/content owners all at the expense of the consumer. This perhaps explains the headlong rush of U.S. cable nets/operators into M&A in the region.

By 2020, though, things may be very different.

The SaaS Opportunity

Walter H Pritchard, CFA
US Software Analyst

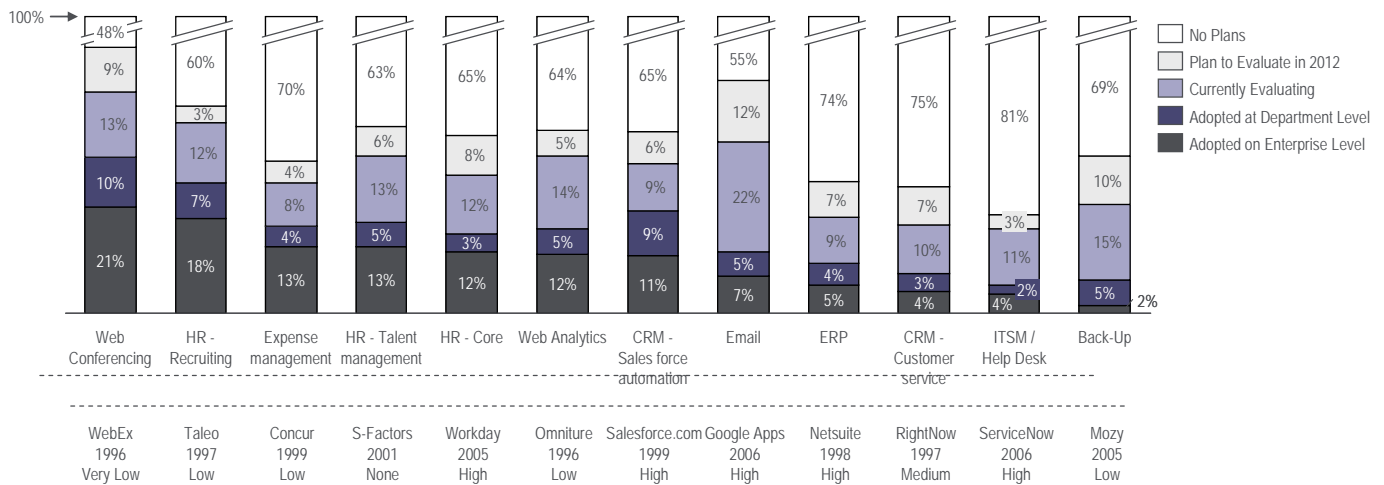
Ashwin Shirvaikar, CFA
US Computer Services & IT Consulting Analyst

Software-as-a-Service (SaaS) is an Internet-based software delivery model, where customers using standard web browsers access software running from public data centers. Delivered as a service, the software is written to serve thousands of customers simultaneously. SaaS has seen secular growth significantly ahead of the overall software market, and we expect this trend to continue. Traditionally, software code was purchased separately from the infrastructure needed to run the software, and then subsequently installed and configured in the customer's own data center ("on premise" software). SaaS is typically sold as a subscription in contrast to traditional on premise software, where customers purchase a right to use the software in perpetuity ("perpetual license"). As a result, SaaS pricing is variable, transforming what used to be a capital expenditure into an operating expense.

SaaS is Still Early, 9x Penetration Ahead

In our recent proprietary survey³, respondents estimate that SaaS has captured 8% of their software wallets so far and expect to increase spend to 70% of their budget over time – a nine-fold increase. Moreover, customers have historically underestimated the potential for SaaS to replace parts of their software footprint. SaaS has deeply penetrated some areas such as talent management software and customer relationship management (see figure below), but in some of the largest software categories such as enterprise resource planning (ERP), penetration hovers in the low- to mid-single digits.

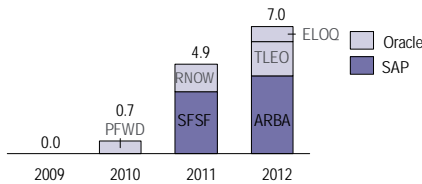
Figure 46. . Penetration of SaaS into various software segments (based on Citi CIO Survey)



Source: Citi CIO Survey (2012) and Citi Research

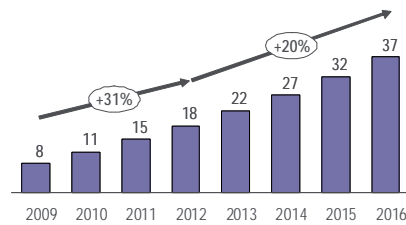
³ An extensive report on the proprietary survey, "SaaS Moneyball: Forecasting SaaS Adoption", dated 27 March 2013 is available on Citi Velocity.

Figure 47. Software giants have accelerated their cloud M&A (in \$ Billions)



Source: Citi Research

Figure 48. SaaS market size (in \$ Billions)



Source: IDC

The Market is Increasingly Recognizing the Growth of SaaS

Traditional companies have increasingly recognized the SaaS threat and opportunity. On premise software companies have accelerated their investment in SaaS companies (Figure 47). In addition, even traditional industrial companies are choosing to enter the software space with SaaS acquisitions. Companies such as ADP have adapted their solutions and are calling them SaaS-based. SaaS is on the ascendant but the specific solutions can come from traditional services companies as well as from new bottoms-up SaaS companies.

Sizing the SaaS Opportunity

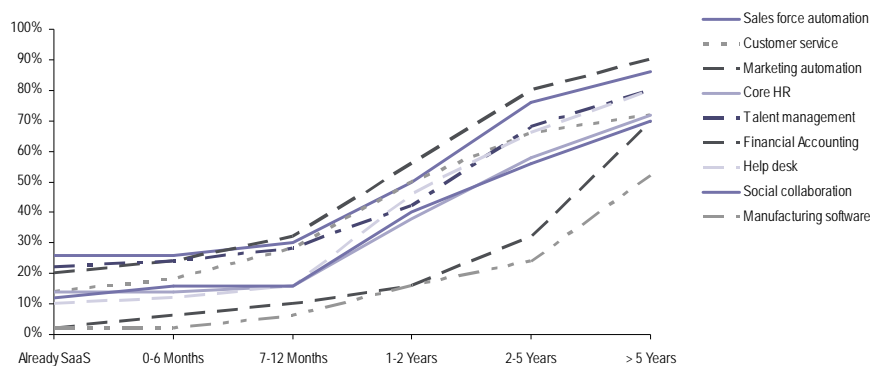
In 2012, the SaaS market grew 26% to become an \$18B market according to market research firm IDC. Customer relationship management is the largest opportunity, comprising over 30% of the market. Enterprise Resource Planning (ERP) is the next largest contributor, with traction in the Small Medium Business (SMB) space as well as certain vertical markets such as healthcare, where SaaS is increasingly the preferred delivery method for healthcare software. Overall however, SaaS is a very small portion of the large ERP market (\$50B).

Growth Vector #1: Penetration

We are clearly in early innings of this penetration game. With most software categories in the neighborhood of 10% penetration and with the largest software category of ERP in the low single digits, there is a clear growth runway ahead. SaaS is seeing significant new investment from both customers and vendors. New software purchases are largely dominated by SaaS vendors, both for new software categories such as talent management and for ripping out existing software. Buyers have changed from rogue departmental sales heads to Chief Information Officers (CIOs) awarding enterprise license agreements at brand-name companies. One SaaS company recently signed a >\$100M subscription booking with a large insurance company. Our discussions with systems integrators in the salesforce.com ecosystem point to a tipping point where enterprises have gotten comfortable with SaaS.

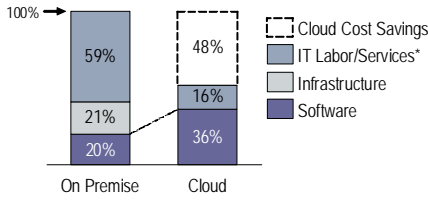
Figure 49. Survey respondents see an inflection point in SaaS adoption

When do you think the following functions could potentially be moved to a SaaS solution:



Source: Citi CIO SaaS survey (March 2013)

Figure 50. TCO comparison – IDC/vendor view



Source: IDC custom research for salesforce.com, from salesforce.com Analyst Day presentation

* Likely includes implementation costs only. SaaS often generates higher change management costs.

Growth Vector #2: Market Expansion

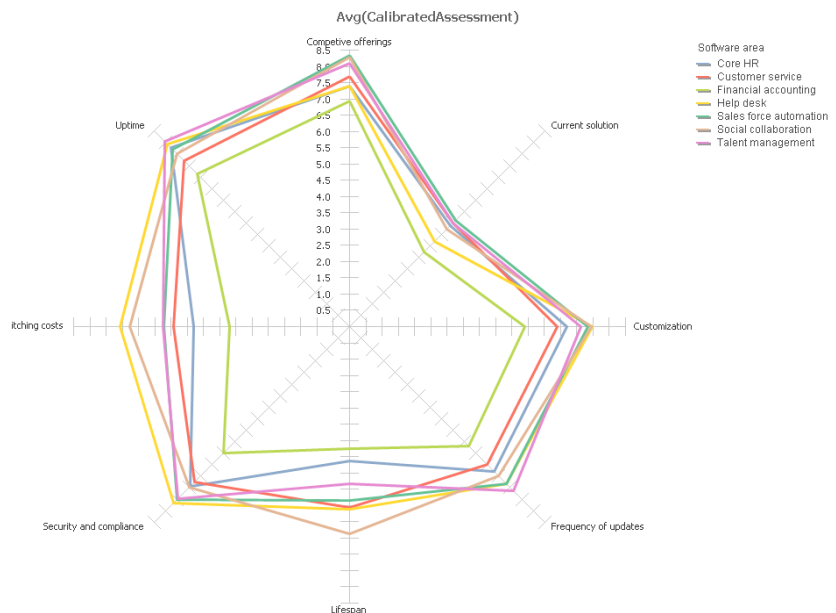
SaaS can be market expansive in one of several ways. First, the economics of SaaS allow customers to deploy software in a variable pricing model (per seat per month). This has the potential to expand the addressable market to businesses who otherwise would not consume software, such as SMBs or projects with short life cycles (e.g. film production). Second, SaaS can capture incremental software spending and therefore extract more software revenue than an equivalent on-premise solution (see Figure 50). There are several reasons SaaS can expand pricing, including the inclusion of infrastructure costs, additional functionality, and capturing value from more efficient delivery (i.e. less professional services, higher license fees).

Barriers to Adoption

There several barriers to adoption, including generally high switching costs in software and the relatively immature state of certain SaaS software packages. We examined some of these factors in our previously mentioned survey. In the survey, we asked respondents to rate seven software categories along eight slightly different market adoption characteristics that we think drive SaaS adoption: competitive offerings, satisfaction with their current solution, need for customizability, value of frequent upgrades, average lifespan, security requirements, switching costs, and uptime requirements.

In the chart below, we illustrate the assessments that respondents gave to these market characteristics in each of the seven software areas. While many of the lines blur, the standout software area is Financial Accounting, which scores lower than any of the other areas (green line on the inside) and confirms our qualitative intuition. In aggregate, our observation is that SaaS adoption is not being held back by the maturity of SaaS solution, uptime requirements of the application, security and compliance and customization needs while adoption is being held back by general satisfaction with current solutions and also the relatively long lifecycles of these installed solutions.

Figure 51. Financial accounting is the clear laggard in this game of Moneyball



Source: Citi CIO SaaS survey (March 2013)

Winners and Losers

We believe the move to SaaS in software will shift the landscape to some degree and create new winners and losers in the software market as well as the greater technology market. Winners include new SaaS vendors who are following the path of replacing aging on-premise software systems, as well as traditional software companies who can successfully make the transition to SaaS.

We see four major impacts, which we have outlined in Figure 52 and gone into more specifics as to players impacted by these trends. At a high level, we believe the winners will see above market growth as a result of their leverage to SaaS while we expect the losers to see growth lagging the market or even declines in business over time. The key to the later will be whether SaaS truly expands the market or whether it is largely cannibalistic. If SaaS is taking share in markets that are zero sum, we'd expect the players on the other side of SaaS adoption are likely to see declines in revenue as SaaS takes hold.

Figure 52. SaaS trends and their impact on software and related companies

Trend	Dynamic	Winners	Losers
SaaS gains share	New entrants gain share on the back of SaaS adoption	SaaS players	On prem software incumbents
SaaS expands the market	SaaS creates new demand as costs are lower than traditional software and solution is better than manual of offline alternatives. Especially the case with smaller customers.	SaaS players	Offline competition
SaaS bundles infrastructure	Customers that purchase SaaS applications don't buy underlying infrastructure. SaaS providers pay less or use open source for middleware, database, operating system and hardware components.	SaaS players are able to capture some of this value	Infrastructure vendors see unfavorable purchasing concentration
SaaS requires less integration services	The need for traditional IT consulting and integration services with SaaS is generally a fraction of what it is for traditional on-prem software.	Smaller integration firms (mostly private) have gained share, also SaaS companies are able to pick up some of the prior consulting value in their pricing	IT services companies

Source: Citi Research

Software Defined Networking

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Software Defined Networking (SDN) has the potential to be an important and necessary game-changer in network architecture. It can help network designers address some of the most fundamental challenges they are facing as server virtualization continues to proliferate and bandwidth use continues to grow exponentially. SDN will enable next-generation networks which are simpler in design and scale, as well as being more agile and more customizable.

SDN is an advancement in network infrastructure defined by the separation of the Control Plane (the intelligence) from the Data Plane (the packet forwarding engine). Instead of having intelligence distributed across the network in separate boxes, SDN centralizes the Control plane in an overriding software layer which disseminates instructions to each router or switch.

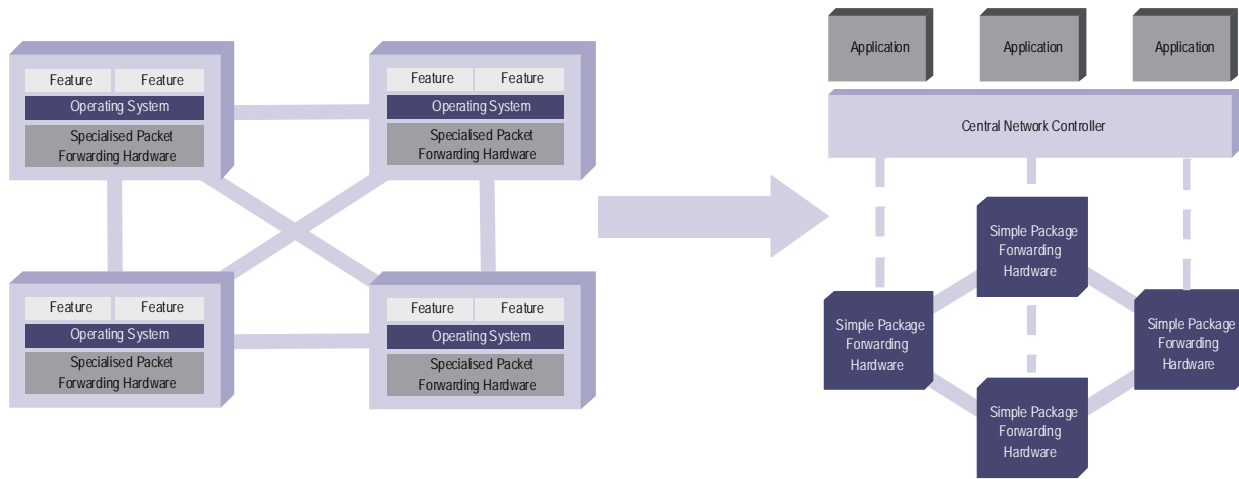
SDN is potentially disruptive to the current network for several key reasons:

- SDN reduces network operating costs by simplifying data paths through centralized control and increasing hardware utilization rates (Google claims they are nearing 100% utilization without traffic disruptions vs. standard industry utilization rates in the 30%-40% range).
- SDN allows networking resources to be re-arranged and re-allocated in real-time via software, rather than through re-engineering the network hardware. Operators can test new features on its network in real time and can launch new applications for employees or customers in significantly less time. Additionally, there are opex cost savings as less time and staff is needed for network management.
- The expensive part of a high-end router is the sophisticated control plane and custom silicon, so, by moving it all to a centralized control plane, SDN significantly reduces hardware costs by scaling IP across commoditized hardware.
- SDN provides some solutions to shortcomings of traditional networks, including continuity of service in mobile or when a server fails.
- SDN is also capable of creating virtualized multi-tenancy networks as a means of separating different users and isolating networks with particular performance guarantees which becomes important in an increasingly "cloudy" world.

There is controversy on the industry and economic impact of SDN

We describe SDN as "potentially" disruptive because there is some debate regarding its eventual impact. While the consensus is that the end goal of SDN is a more agile, responsive network architecture, its industry and economic impacts are still undetermined though hotly debated. One school of thought views SDN as a commoditizing agent for high margin network equipment. Under this view, the rich margin structure of the data networking industry will be decreased and disaggregated, with the profit pool moving primarily towards the software in the new control layer. The counter argument sees SDN as an incremental technology tool that will drive increased utility of networking assets and potentially drive purchases of more advanced equipment over time.

Figure 53. Development of Networking Towards SDN



Traditional Network of vertically integrated, closed, proprietary switches. The network intelligence is spread across the switches, each with its own forwarding table.

OpenFlow/SDN: Separation of Control and Data Plane, which feed instructions down to 'dumb' switches. Open Source interface between control and data plane. Applications sit on top of controller, and instructions are fed downwards.

Source: Citi Research

Evolutionary, Rather than Revolutionary

Deployments should move from data centers, to carrier and enterprise-wide areas

SDN deployments today are mainly focused on data centers where deployments of very high speed and flexible networks benefit most from an SDN as well as being new enough not to give rise to challenges in justifying legacy replacement. Notable current users include Google, Facebook, Verizon and Deutsche Telekom. Over the next 3-5 years we expect SDN deployment will see rapid growth off a very small based into a fairly narrow group of carriers and enterprises, followed by more extensive deployment only beyond that timeframe. Barriers to widespread adoption in the near term include a large installed base of legacy equipment, the inherently risk-adverse nature of operators and Enterprise IT departments, the need for more developed industry standards/openness and the lack of customer/channel knowledge and support services.

Broader adoption should be helped by open standards and open-sourced consortiums

We view OpenFlow (developing open standard for SDN) and the recent announcement of OpenDaylight (an open-sourced SDN consortium hosted by the Linux Foundation) as positive steps towards broader adoption. Through OpenDaylight, customers will be able to take OpenDaylight product/applications and purchase integration and support services from their vendor of choice. OpenDaylight members include Cisco, Juniper, Brocade, Ericsson, IBM, Microsoft, Citrix and BigSwitch, with first code expected to be released in Q3'13 and expected projects to include an open controller, virtual overlay network, protocol plug-ins and switch device enhancements.

SDN is forecast to grow to \$3.7 billion by 2016

The question for investors is whether SDN will follow a similar path as server virtualization

Barriers to adoption include increased complexity, the installed base, early stages of a standards body and customers getting up the learning curve and transparency in cost savings

Measuring the Opportunity

According to IDC, Software Defined Networking is expected to grow from just under \$360 million in 2013 to \$3.7 billion in 2016, an estimate which includes revenues from services as well as switches and routing. We believe those revenues will be split between three major sets of players

- startups like Big Switch, Plumgrid, Embrane and Vyatta
- traditional network vendors, including Cisco, Juniper and Alcatel Lucent
- big IT vendors like IBM, HP and Dell.

The debate among investors mirrors the debate within the networking industry: Will SDN commoditize the margin-rich networking industry and drive not just lower costs but also lower volumes (i.e., port demand)? Or will SDN follow a similar path as server virtualization, which actually saw an increase in demand for higher-end servers? The questions are well-known, but the outcome remains uncertain; regardless of viewpoint, we believe most investors expect the eventual impacts of SDN only to be realized three to five years from now.

Barriers to adoption suggest gradual industry transformation

There are several important barriers to SDN adoption that we believe will lead to a more gradual evolution of networking towards SDN. These include but are not limited to:

- Networks are valued for their consistency and predictability inherent in distributed network protocols. SDN adds flexibility to the network but also adds complexity and risk for early adoption. Operators will be gradual in implementation due to their inherent risk aversion.
- The installed base is a significant barrier to adoption as networking equipment is only replaced on as-needed basis. This dynamic favors incumbents such as Cisco, Juniper and Alcatel-Lucent
- The standards body and "openness" are still early in development. OpenFlow and OpenDaylight are addressing this issue but it will take time. Interoperability on a production basis (not just demo) will likely present a stumbling block, especially because it is against the interest of incumbent players for this to happen.
- Customers, Channel Partners and Support Services need to get up to speed on SDN. Language and cultural barriers need to be learned by data center personal, not just the developers and the network vendors. This is a multi-year process with education, certifications, qualifications as well as the build out of consulting and advisory departments. While we believe many CIOs and CTOs are well versed in SDN, it is a difficult concept for non-IT executives and we believe will take some time before CFOs feel comfortable enough to sign off on implementation.
- From a customer's budgeting perspective, cost savings from SDN are more difficult to quantify than with server virtualization since advantages are mostly on the management side which will likely translate into slower C-level adoption.

Home-court Advantage Likely to Dictate Major SDN Winners and Losers

Network vendors are the obvious group at risk but they have the advantage of an installed base that will not quickly be replaced

The most obvious group at risk is the network vendors since SDN promises to commoditize the hardware element of networking, likely pressuring margins as well as incremental port units. In a pure SDN network, where the intelligence is kept somewhere else, the routers quickly devolve into commodity products with commodity pricing (vs. typical gross margins of 65% currently). In the case of network commoditization, we would expect the likes of Cisco to be threatened by the merchant silicon vendors. However, given the networking silicon has been increasingly outsourced already and that these vendors themselves earn 50%-65% gross margins, we find it unlikely that they will lead a charge against the status quo. While we believe there is likely some pricing pressure, the actual impact on ports has yet to be seen.

After seeing what occurred in the server market, the major network players were quick to stay ahead of the SDN threat by launching their own SDN solution as well as bolster their SDN offering through M&A. Importantly, networking equipment incumbents have the advantage of an installed base which will not quickly be replaced. When customers are looking to roll out elements of SDN, the obvious SDN choice is the same as their existing hardware since cohesion is most likely achieved when the two solutions come from the same R&D lab.

Without question select startups will emerge as likely winners and the recent attraction of VC money into the SDN space clearly shows this enthusiasm. We think this will be a hard fight and likely winners will be narrowly focused and not go head to head against the larger networking equipment vendors by trying to provide end-to-end SDN solutions. As a caveat, we believe such sharing initiatives like OpenDaylight present more pressure on potential entrants (not less) since it lowers the economics of software and puts more value in services (design, build, operate) which require scale, relationships and installed hardware.

The Open Networking Foundation (ONF) expects a market will develop in which networking software companies develop off-the-shelf features for operators to use. While we expect this is a likely result, we do not expect this to represent a material percentage of the networking spend.

Customers represent the ultimate winners in SDN adoption

Customers represent the ultimate winners in SDN adoption, lowering network costs (mainly through opex) while increasing network efficiency. We believe telecom operators are best positioned given their size and ability to differentiate their service and cloud offerings through network improvements especially given the undifferentiated nature of most current carrier IP network offerings.

Solar

Jason Channell

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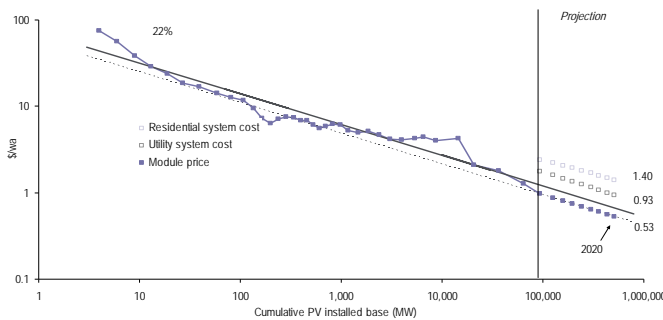
Solar Photovoltaics (as opposed to solar thermal) is the generation of electricity from semiconductor materials (most commonly silicon based); the photons in solar radiation from the sun excite electrons within the semiconductor material thereby creating a current. It is already competitive at a domestic level in many countries, and will become so in more very quickly due to its extremely rapid “learning rates”. Most disruptively, not only does it steal share of new electricity demand, it parasitically steals demand from previously installed generation, and does so at the most valuable ‘peak’ part of the demand curve. Its technological nature means that it will keep getting cheaper, while conventional fossil fuels are more likely to increase in production cost. The scale of the opportunity is enormous, with a \$1.3 trillion of investment forecast by the IEA over the next two decades, a figure which we believe to be very conservative.

How Close is it to Becoming Reality?

Costs have reduced quickly...and are likely to continue to do so

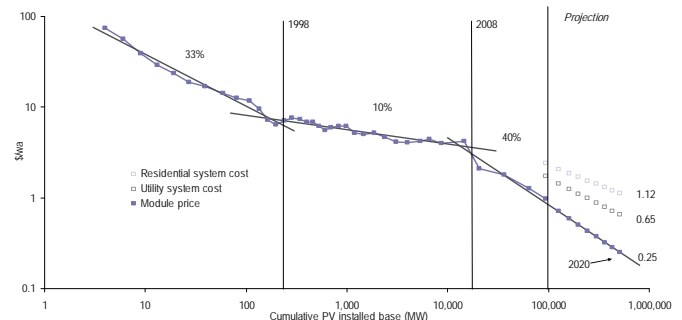
The biggest surprise in recent years has been the speed at which the cost of solar panels has reduced, resulting in cost parity being achieved in certain areas much more quickly than was ever expected. The key point about the future is that these fast ‘learning rates’ are likely to continue, meaning that the technology just keeps getting cheaper. At the same time, the alternatives of conventional fossil fuels are likely to gradually become more expensive (assuming that the ‘lowest hanging fruit’ in terms of reserves are exploited first).

Figure 54. Solar module price declines from 1972 show an overall learning rate of 22%...



Source: Citi Research, Bloomberg New Energy Finance

Figure 55. ...though in recent years that learning rate has increased to 40%.



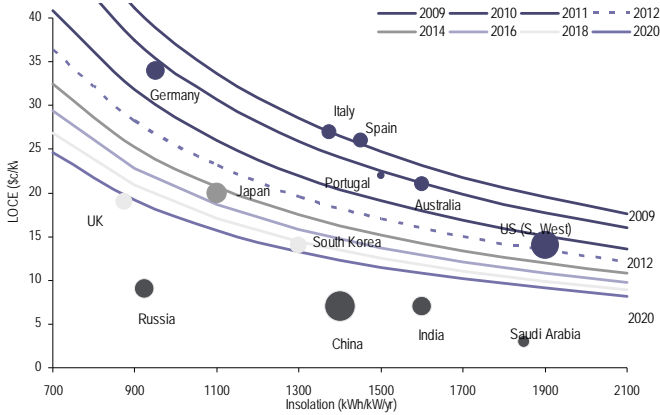
Source: Citi Research, Bloomberg New Energy Finance

As Figure 54 shows, plotting the prices of solar modules back to 1972 shows an overall learning rate of 22%; that is for every doubling of installed capacity, the price has fallen by 22%. However, as Figure 2 shows this learning rate shows three distinct phases, the post 2008 boom showing a faster learning rate of 40%, though some of the factors behind this increase such as the move of manufacturing to Asia and manufacturing margin squeeze to (beyond) zero are clearly not replicable.

Already cost competitive in an increasing number of regions

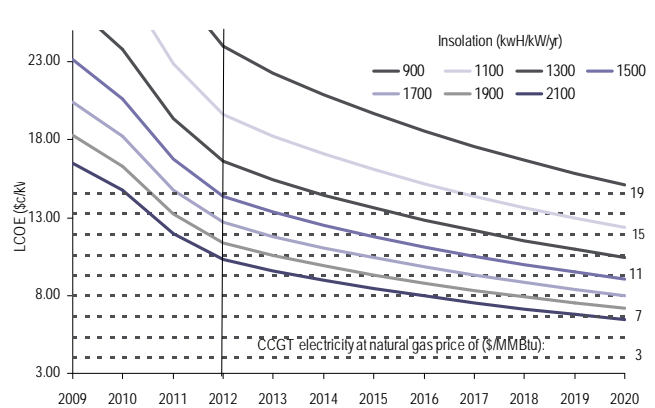
These dramatic cost reductions mean that solar is already competitive in many regions at a domestic level (Figure 56), and even at utility scale vs. combined cycle gas turbines (CCGTs) in some higher priced markets (Figure 57). As discussed, the fact that solar keeps getting cheaper as technology advances and manufacturing becomes more efficient means that ‘parity’ will be achieved in an increasing number of markets in a relatively short timeframe. We would also note that Figures 56 and 57 are calculated using the lower 22% overall learning rate; clearly if we were to use the 40% more recent learning rate, then parity would arrive more quickly in broader range of markets.

Figure 56. Domestic 'socket' parity has already been reached in Germany, Italy, Spain, Portugal, Australia and the SW states in the US



Source: Citi Research, Bloomberg New Energy Finance

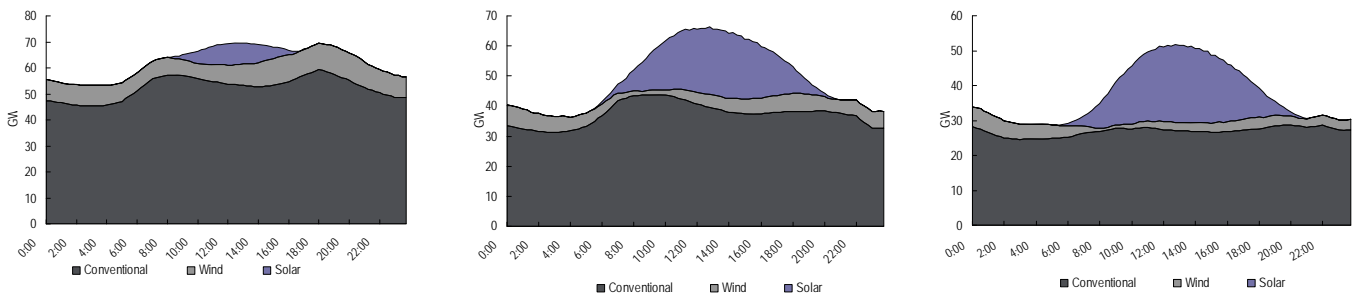
Figure 57. Utility scale solar is already at parity with CCGTs in higher priced gas, sunny markets



Source: Citi Research

Contrary to popular belief, solar is already having a material impact on energy markets. Figure 58 shows actual German electricity demand curves from various days in 2012, showing how that demand was met in terms of conventional generation (i.e. nuclear, gas, coal etc) and solar and wind. The surprising conclusion is that on hot sunny workdays and weekends, the peak (which would previously have been supplied by gas) has almost entirely gone over to solar. What is even more disruptive about this is that this is the most valuable part of the curve, as electricity prices are highest at period of highest demand. For other countries, the hotter/sunnier the climate, the more 'peaky' the load is likely to be due to air conditioning, characteristics which of course only serve to make solar perform better. Hence while the amount of units supplied by solar are currently relatively small, their share of the 'value' is considerably higher.

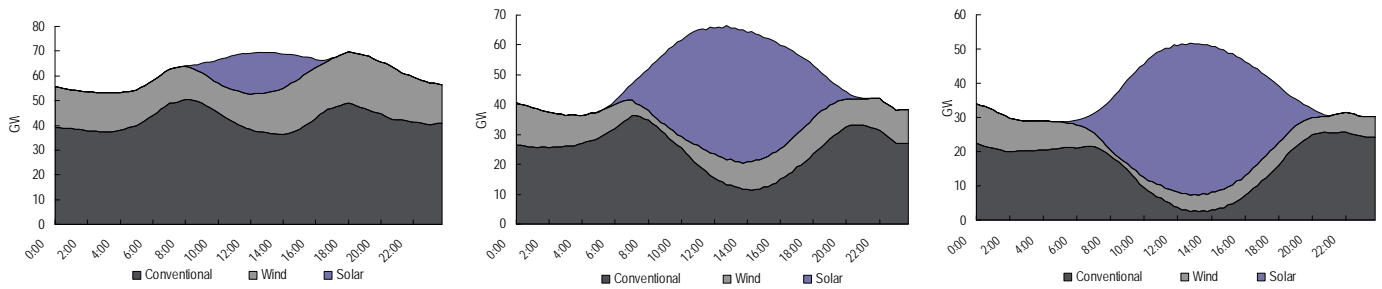
Figure 58. Solar has grabbed the peak of the electricity demand curve when prices are highest, displacing gas fired capacity. German electricity market, L to R, winter workday (1/2/12), sunny workday (25/4/12) and sunny weekend (26/5/12)



Source: Citi Research, EEX

This peak effect has resulted in some gas plants in Germany running in 2012 for no more than a handful of days, with resulting profit warnings from associated utilities. The economics of conventional generation dictate that nuclear and coal tend to run almost continuously (nuclear 90%+, coal ~80%), whereas the flexibility of gas (20-60%) lends itself to peak generation, and hence it has been the first to suffer. Where the situation becomes really worrying for conventional generators is if we project these penetration levels forward.

Figure 59. The same German load curves with (simulated) double the penetration of wind and solar, showing the disruption to baseload



Source: Citi Research

Figure 59 shows the impact on the German generation mix assuming double the penetration of wind and solar. Whereas in the previous examples it was gas that suffered as a peaking plant, these figures show renewables eating into baseload. Given the economics of baseload generation (i.e. it runs all the time) this has a massive impact on the utilities operating this plant, given that lower load factors will lead to this plant being uneconomic. Ultimately we believe that markets such as Germany must move to a capacity payment mechanism, whereby the owners of this plant are compensated (via consumer bills) for keeping this plant open, so that it is available for when it is needed (i.e. in the winter, Figures 5 and 8). We believe that this eating into baseload will actually drive demand for more gas fired plants to operate at times when renewables are not generating, given its flexibility.

Distributed nature of solar means lower utilization for networks

There are other serious connotations to this shift in the energy mix. Much of this solar is distributed generation, and hence does not flow through the grid or distribution networks, leading to lower revenues for network operators (again requiring higher per unit charges). Ironically this upward impact on bills is, in our view only likely to make consumers more likely to put panels on their roofs.

Solar has already led to negative power prices in Germany at times

The other alternative is that baseload keeps running, but the power is exported. This situation has already arisen in Germany in 2012 with negative electricity prices i.e. giving free power along with cash simply to balance the grid. This has even resulted in power being ‘dumped’ across national borders, which then starts to impact other markets. Clearly as more markets take on a greater proportion of renewables the ability to ‘dump’ power becomes less, and hence grid stability becomes a greater issue. Storage is the answer, but only serves to make solar more competitive as it removes the main hindrance of renewables – intermittency.

The Drawbacks

Intermittency is the largest drawback, which storage should ultimately solve

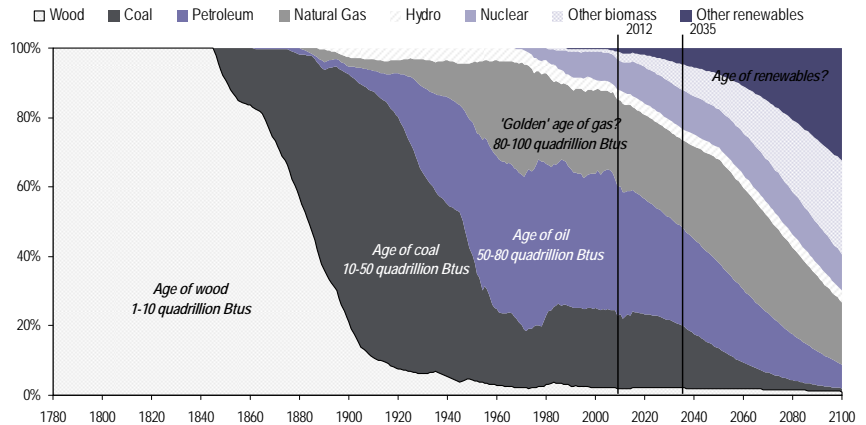
Intermittency is the key drawback to solar, in that the level of generation is to some extent weather dependent, as well as seasonally variable. However, as the cost of both solar and storage reduce, this problem will be reduced. The other ‘timing’ issue is that while solar might be at ‘socket parity’ already, unless the electricity is used in the day, homeowners are only likely to receive a lower feed-in tariff for their generation, rather than the equivalent price of the grid electricity which they are offsetting. Storage is the associated Holy Grail, and in the much longer term could have an even more dramatic impact on electricity markets. Solar works well as a distributed generation which when combined with local storage (potentially from electric vehicles), could in the much longer term see the utility industry split into centralized back-up rate-of-return generation (much as it was throughout the world pre-privatization), with much smaller local companies managing local supply and demand, potentially even on a ‘multi-street’ basis. Whether those companies are traditional utilities, metering/technology companies, or branded ‘customer service’ companies is also open to question. This is crystal ball gazing, but the point is that the utility market could look dramatically different.

Solar is parasitic and substitutional, making it truly parasitic

The Scope of the Opportunity

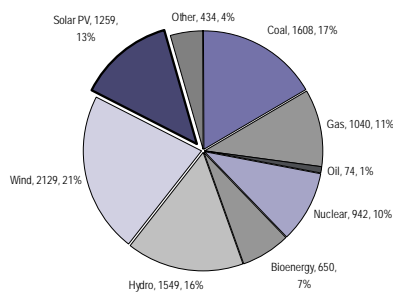
As a previous Saudi oil minister once noted, “the stone age didn’t end for a lack of stones...”, and this substitutional process can be well demonstrated looking at the US energy mix over the longer term (Figure 60).

Figure 60. Share of U.S. primary energy demand — 1780-2100



Source: Citi Research, IEA, EIA

Figure 61. Forecast investment in power generation, 2012-2035



Source: Citi Research, World Energy Outlook 2012 OECD/IEA

In summary, solar represents a truly disruptive technology now and for the future

It is this process of substitution which is particularly pertinent to this theme of disruptive technologies; solar is not just a ‘choice’ when considering new generation requirements for growing energy demand, but it is also substitutional in that it is being installed for purely commercial reasons, thereby removing demand from conventional generation sources, especially in developed markets. The scale of the opportunity is enormous. As Figure 61 shows, the IEA under their base case are forecasting that solar will receive \$1.3 trillion of investment in new capacity between 2012-35, representing 13% of the total global investment in power generation, ahead of gas, and only marginally behind coal. This scenario forecasts a total installation in that period of 662GW, out of total additions to capacity (all technologies) of 5891GW, representing 11.2% of all new installed capacity. However, we view these figures as being highly conservative, given that this equates to just 28GW of installations per year, versus our forecast even for 2013 of 35GW. Indeed we forecast an incremental 473GW to be installed between 2012 and 2020, i.e. more than 70% of the IEA’s estimate in less than half the time. Clearly this would have a dramatic effect on solar’s share of both the generation mix and spend if our more aggressive forecasts prove to be correct.

Solar is already competitive, is already outstripping conventional generation installations in developed markets, and is causing utilities to profit warn. Its nature means that the technology keeps getting cheaper, while alternatives gradually become more expensive, and so the ‘problem’ only becomes exacerbated. Moreover, solar is a parasitic technology which not only takes share of new demand, but eats into existing demand, and most importantly takes the most valuable part of the demand at times of peak load. Accordingly, solar represents in our view a truly disruptive technology now and for the future. While benefiting certain solar companies, it will have in our view material impacts in coming years on utilities, as well as potentially oil & gas companies, particularly where long-dated assets at the top of the cost curve are concerned.

Appendix – Author Bios



Naveed Sultan is Global Head of the Treasury and Trade Solutions Group within Citi's Institutional Clients Group. With over 25 years of institutional banking experience, Mr. Sultan has been at Citi for over 18 years, and in his current role, is responsible for Treasury and Trade Solutions globally. Treasury and Trade Solutions is one of the largest global businesses and encompasses multiple integrated solutions including: Trade & Supply Chain, Export Agency Finance, Liquidity & Investments, Cash Management, Wholesale Card Service, Information Services and Receivables serving public sector clients, corporates and financial institutions, a client base that includes 97% of the top 300 companies in the world in over 120 countries. Prior to being appointment to his current role in June 2011, Mr. Sultan was the Transaction Services Region Head for Europe, Middle East and Africa (EMEA), the largest region for Citi Transaction Services, with a presence in over 50 markets and a multi-billion dollar revenue base. Mr. Sultan serves as a Director on the board of Citibank Europe plc, Citibank A.S (Turkey) and LCH.Clearnet, and is also a member of the Management Committees for Citi's EMEA Operating Committee, Institutional Clients Group and Citi Transaction Services. He is also a member of Citi's Innovation Council and chairs the CTS Global Innovation Council. Mr. Sultan holds an M.S. in Management from M.I.T's Sloan School of Management as well as an M.B.A. from the Institute of Business Administration, Lahore.



Vivien Azer is Citi Research's U.S. Tobacco and Alcoholic Beverage Analyst and was ranked Runner-Up in Tobacco in the 2012 Institutional Investor survey, after having been named Best Up-and-Comer in the 2011 survey. Vivien joined Citi in 2004 as an Associate on the Technical Research team. Subsequently, she moved to Fundamental Research and served as the Senior Associate for both the Home & Personal Care and Beverage industries. Vivien received her MBA degree from NYU's Stern School of Business, and her BA degree from the College of William and Mary.



Jason B Bazinet is a Citi Research Analyst covering the Cable and Satellite industries. Before joining Citi in 2005, Mr. Bazinet worked for three years as an equity analyst at JP Morgan, where he followed the Telecom, Cable, and Satellite industries. Prior to that, he was for three years an engagement manager at McKinsey & Company. Mr. Bazinet received a BS degree in mechanical engineering from Vanderbilt University and an MBA degree from The Kellogg School at Northwestern University.



Amit Bhalla is a Director at Citi Research, covering the Life Sciences Tools and Medical Technology Industries. Prior to joining the firm in 2006, Amit worked for Morgan Stanley as a Vice President for five years covering the Medical Technology and Specialty Pharmaceuticals sectors. Prior to that, he worked at Johnson & Johnson's Ortho-McNeil unit, rotating through several departments including Research & Development, Quality Control, and Manufacturing. Amit holds a Bachelor of Science degree in biology from Cornell University and an MBA degree from Carnegie Mellon's Tepper School of Business.



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.



Kevin J Dennean, CFA is an Analyst with Citi Research covering the Data Networking and Telecom Equipment sectors. He has been with Citi since May 2007, and was an Associate on the Wireless Equipment team through October 2009. Kevin was previously with Nationwide SA LLC, a subsidiary of Nationwide Financial, where he was a Technology Sector Analyst focused on Hardware, Semiconductors & Semi Cap Equipment, and Communications Equipment for seven years. Kevin is a CFA charterholder and has a BS degree in Accounting from St. John's University.



Ryan W Kauppila is an Equity Research Analyst covering European Oil Services. Previously, he has worked for Oil & Gas teams ranked #1 by Institutional Investor at Lehman Brothers and Nomura. Before equity research, Ryan spent five years in New York as an equities trader for Morgan Stanley and Burlington Capital. Ryan has BA and MBA degrees from Harvard University.



Seth Kleinman joined Citi as Head of Energy Strategy on the commodities side. He covers all aspects of global oil and gas markets. Seth has spent the last 15 years in the energy markets as an analyst, trader and researcher. He started in market analysis at PFC Energy in Washington DC, moved into physical and prop trading at Hess Energy Trading Company in New York. He moved to Morgan Stanley to write oil research, before moving to London with Glencore to head up its global oil analysis team there.



Graeme McDonald is an 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 Vice President at Citi Research covering the U.S. Autos & Auto Parts sector. 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.



Marie Miyashiro, CFA is an Analyst with primary coverage for the Australian Utilities and Infrastructure sectors. Prior to joining Citi Research in 2006, Marie worked for AMP Capital and Credit Suisse. Marie is a CFA Charterholder.



Shahriar (Shar) Poureza, CFA is a Vice President and Senior Analyst for the North America Alternative Energy sector. He joined Citi in 2009 as a Senior Associate on the Electric Utilities team. He has more than ten years of experience in equity markets (sell- and buy-side) with a primary focus on energy/commodities. Shar's career started at Merrill Lynch Asset Management in 1999. In the early years, his focus was mainly on global equities and EAFE (Europe, Asia, Far East). His career on the buy-side concluded at GE Asset Management. Shar joined Credit Agricole in 2007, helping to cover the energy space. Shar is a CFA Charterholder and is an active member of the New York Society of Security Analysts and CFA Institute. He holds a BS degree from the University of Scranton in Business and Operations Management Science.



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.



Ashwin Shirvaikar, CFA has been at Citi Research since early 2000 and has worked in or written about the Services sector (both Computer Services & Business Services) since 1991. Before joining Citi, Ashwin worked at AlliedSignal for three years, within its defense/aerospace M&A group, and was responsible for the P&L at the New Ventures group. Ashwin also has over 6 years of consulting and account management experience working with several blue chip clients. Ashwin earned an MBA degree from Cornell University in 1997. In addition, he holds a Master's degree in Mechanical Engineering from the University of Cincinnati. He is also a CFA Charterholder.



Robin Shoemaker joined Citi Research in 2008 as an Oil Service and Equipment analyst. Prior to joining Citi, Robin was with Bear Stearns as Oil Service analyst from 1999 to 2008. He was a runner-up in Oilfield Services on Institutional Investor's All-America Research Team in 2007. From 1996 to 1999, Robin worked in the emerging markets area at Lehman Brothers as an oil analyst and head of Asian equity research (based in Hong Kong) and, subsequently, head of Latin American research (based in New York). He was Lehman Brothers' domestic oil analyst from 1987 to 1996. His analytic work encompassed US integrated oil companies and refining and marketing companies. He was a runner-up on Institutional Investor's All-America Research Team in 1990, 1991, and 1992. He was listed in the Wall Street Journal's 1993, 1996, and 2001 surveys of all-star analysts. Robin's oil industry research skills were developed in Houston, where he worked as a financial and market analyst for two oil service companies. He was with Dresser Industries from 1979-81 and with Global Marine Inc. from 1981-86.



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.



Adam Spielman is a Managing Director at Citi Research, covering the European Tobacco & Beverage sectors. Between 2007 and 2010 Adam was consistently ranked the No. 1 tobacco analyst in Europe in both Extel and II. He was also the No. 4 ranked tobacco analyst in the 2010 US II survey. Adam joined Citi in 1997, having earned an MBA degree from Harvard, where he graduated as a Baker Scholar. He began his career as an analyst at Gemini Consulting in 1989. Adam has an MA degree in engineering and philosophy from Cambridge University.



Philip Stiller, CFA covers Specialty Payment Processors as part of the Computer Services & IT Consulting team at Citi Research. Philip previously covered the Business & Professional Services sector as part of the same team. Prior to joining Citi in 2007, Philip spent three years in equity research at Renaissance Capital as a Lead Analyst covering a variety of industries. He received his B.S.E. in Biomedical & Electrical Engineering from Duke University. Philip is a CFA charterholder.



Simon Weeden is a Managing Director and Head of European Telecoms Research. He has been a sell-side equity research analyst covering Telecommunication Services since 1998. Mr. Weeden's personal coverage has at one time or another included all of the largest companies in the sector in Europe which has required him to have a view of developments globally in the sector. Prior to his time as an equity analyst he spent five years in the telecoms industry at Cable & Wireless in a variety of roles including regulation, strategy, product management and marketing. Prior to that he spent two years at LEK Consulting, a management consultancy, and two years in military service. He has a degree in Mathematics from Oxford University

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Key Insights regarding the future of Disruptive Innovation



INNOVATION

To date, many innovations have been the result of random market “hits and misses” due to an absence of a standard innovation process at most organizations. / Fast and effective innovation involves the implementation of efficient processes and approaches, collaborative cross-disciplinary efforts and robust client engagement which is used to drive unique value. This leads to outcomes that tend to be highly predictable and accompanied by superior financial performance and market expansive offerings.



TECHNOLOGY

Although there are always improvements being made through technology, major changes to how we do things are a rare occurrence. / With an increased focus on the process around innovation, disruptive innovation in technology is increasing and changing the way that consumers interact with everyday goods and services. From how a consumer accesses content on their television to paying for goods and services, accessing data and even smoking a cigarette, innovation will force a change in consumer behavior.



SUSTAINABILITY

The widespread adoption of renewable energy solutions in processes from electricity generation to transport and been hampered partly by the high cost of harnessing renewable energy sources. / Innovation in the fields of solar photovoltaics, electric vehicles, and compressed natural gas engines is quickly lowering costs associated with these more sustainable energy sources.



