U.S. CHAMBER OF COMMERCE FOUNDATION

FTC PrivacyCon: Recent Research for Consideration

The emergence of the Internet of Things (IoT) is rapidly changing the consumer landscape. To understand the impact new technologies and digital capabilities may have on consumer privacy and data security in the commercial sector, the FTC will host PrivacyCon, bringing together stakeholders to discuss the most recent research and trends.

The U.S. Chamber of Commerce Foundation recently released a collection of commissioned research on data-driven innovation and the IoT. This research was conducted and presented by some of the world's most authoritative academics, information security experts, business leaders, and data scientists. Research was conducted in 2015, and the resulting analysis is collectively some of the most up-to-date findings available on privacy, security and the IoT.

This research addresses numerous issues surrounding the IoT, including: implications for health monitoring and healthcare delivery; data privacy and security; consumer protection and benefit from connected devices; Big Data and its impact on all sectors of society; and necessary policy considerations for cultivating a dynamic, growth-oriented private sector. More specifically, the collected research presented here contains the following:

- The Director for the Center for Data Innovation Daniel Castro writes about "data poverty" and creating equal access to the IoT in "Addressing Inequality and the 'Data Divide.'"
- President of Entropy Economics Bret Swanson writes about how the IoT is changing healthcare delivery in "The App-ification of Medicine – Four Facets of the Information Revolution in Health." Swanson also presents research findings on how public policy challenges arise in the continuing growth of the IoT in "The Immersive Internet – Public Policy in a Hundred-Billion Device World."
- Made By Many Managing Partner Leslie Bradshaw writes about how data-driven innovation can help retailers better serve their customers while also growing their business in "Data-Driven Innovation in Retail."
- Executive Director for the Intelligent Car Coalition Catherine McCullough assesses the consumer benefits (particularly safety) from autonomous vehicles in "Driving into a Connected Future – How Data is Changing the Auto Industry."
- The Future of Privacy Forum's Executive Director Jules Polonetsky and Policy Counsel Joseph Jerome present considerations on consumer privacy in "Ethics and Privacy in the Data-Driven World."
- Sherrie Petersen, the Director of LivingWell@Home (an initiative from the Evangelical Lutheran Good Samaritan Society), describes how new connected health technologies are helping doctors shift from treating symptoms to preventing illness in "In Healthcare, Living Well Through Data."
- Phoenix Center for Advanced Legal and Economic Public Policy Studies' Chief Economist George S. Ford and President Lawrence J. Spiwak write about creating a cohesive, industry-wide privacy policy framework that can quickly adapt to a dynamic industry in "Information, Investment and the Internet of Everything."

- Founder and Executive Director of the Data Transparency Coalition Hudson Hollister presents research on how open data will impact government and business in the future in "Open Data – Policy Reforms Drive Innovation and Opportunity."
- U.S. Chamber of Commerce Foundation Scholar John Raidt writes about the new jobs and demand for skills being created by the IoT in "The Prescription & The Forecast – A look at the Skills Needed and End Results."
- President and CEO for the Center for Democracy and Technology Nuala O'Connor writes about the need to ensure consumer privacy while pursuing benefits from data-driven innovation in "Ushering in Digital Corporate Social Responsibility."
- Dr. Frank J. Cilluffo and Sharon Cardash of the Center for Cyber and Homeland Security at The George Washington University assess the security threats present in an increasingly connected world in "Vulnerability and Resilience in the Internet of Everything."
- Diane Coyle a Professor of Economics at the University of Manchester and author of *GDP: A Brief But Affectionate History*, writes about the need for a better economic measurements when considering data benefits in "Why the GDP Statistics Are Failing Us."
- Susan E. Dudley, the Director of The George Washington University Regulatory Studies Center and a Distinguished Professor of Practice at the Trachtenberg School of Public Policy & Public Administration presents research on why the United States needs a thoughtful, flexible regulatory framework for the data-driven world in "With Data, Will Regulators Show Humility or Hubris?"

The U.S. Chamber of Commerce Foundation is pleased to submit this research for consideration for inclusion in the FTC's PrivacyCon event. We appreciate the opportunity to contribute to the important national conversation on data, consumer protection and the IoT.

Addressing Inequality and the 'Data Divide'

By Daniel Castro, Director, Center for Data Innovation

In the coming years, communities across the nation will increasingly rely on data to improve quality of life for their residents, such as by improving educational outcomes, reducing healthcare costs, and increasing access to financial services. However, these opportunities require that individuals have access to high-quality data about themselves and their communities. Should certain individuals or communities not routinely have data about them collected, distributed, or used, they may suffer social and economic consequences. Just as the digital divide has held back many communities from reaping the benefits of the modern digital era, a looming "data divide" threatens to stall the benefits of data-driven innovation for a wide swathe of America. Given this risk, policymakers should make a concerted effort to combat data poverty.

Data already plays a crucial role in guiding decision making, and it will only become more important over time. In the private sector, businesses use data for everything from predicting inventory demand to responding to customer feedback to determining where to open new stores. For example, an emerging group of financial service providers use non-traditional data sources, such as an individual's social network, to assess credit risk and make lending decisions. And health insurers and pharmacies are offering discounts to customers who use fitness trackers to monitor and share data about their health. In the public sector, data is at the heart of important efforts like improving patient safety, cutting government waste, and helping children succeed in school. For example, public health officials in states like Indiana and Maryland have turned to data science in an effort to reduce infant mortality rates.

Many of these exciting advancements are made possible by a new generation of technologies that make it easier to collect, share, and disseminate data. In particular, the Internet of Everything is creating a plethora of always-on devices that record and transmit a wealth of information about our world and the people and objects in it. Individuals are using social media to create a rich tapestry of interactions tied to particular times and places. In addition, government investments in critical data systems, such as statewide databases to track healthcare spending and student performance over time, are integral to efforts to harness data for social good.

Unfortunately, while many communities have adopted these technologies, others have not. With the emergence of smart cities, there is a risk that areas of the country lacking high-quality data will become "data deserts" by comparison and their inhabitants will suffer accordingly. It is quite possible that rather than being the new oil, data is in fact the new oxygen, and without access to it, communities cannot thrive. Moreover, data deserts may by tied to certain demographics, rather than just geographic locations. Already a lack of health data about certain

minorities, such as the LGBT community, has contributed to unequal advances in healthcare outcomes.

There is no simple solution to this problem, but there are some short-term remedies. First, government-led data collection efforts should strive to obtain data about underrepresented and hard-to-reach populations to ensure all communities are represented in important datasets. In addition, when government agencies publish datasets, they should disclose any known shortcomings about the representativeness of the sample. Second, policymakers should insist that smart city projects are launched among diverse communities. One way to ensure this happens is for grant-making institutions to engage with local civic leaders so they understand how to integrate data-driven solutions into grant proposals. Finally, researchers need to identify where the data divide is a problem and evaluate the effectiveness of different interventions. While combating data poverty will not end inequality in America, building data-rich communities is an important step towards reducing these disparities.

The App-ification of Medicine: Four Facets of the Information Revolution in Health

By Bret Swanso, President, Entropy Economics

Introduction

Several months ago, I went to an orthopedic surgeon to check out my sore right shoulder. He had asked me to get X-rays of the shoulder at an affiliated medical imaging clinic before my appointment with him. After pushing and pulling on my arms and back for a few minutes, he decided to pull up the X-rays on his expensive computer system. When the pictures of my shoulder popped up on the screen, however, the doctor just shook his head.

"Who took these pictures?" he asked. "They look like film negatives."

My bones were black, and the background was white, the opposite of what he expected. He called for the information technology (IT) staff to see whether the problem was with the digital X-ray files or his computer system. As the IT staffer was searching for a solution, I pulled out my iPhone and opened my photo library.

"Would these photos help?" I asked. "I downloaded the X-rays from the disk the clinic gave me."

"Let me see those," the surgeon replied, taking the phone and zooming in with his fingers. He could see from the X-rays on my smartphone that there was no structural damage. He prescribed two months of physical therapy, which worked like a charm, and my shoulder still feels great.

Who knows what the problem was with those X-ray files. The story, however insignificant on its own, is just one of millions demonstrating both the problems with today's healthcare system and the vast potential of IT to improve, transform, and transcend the entire industry.

Computers and the Internet are on the cusp of making healthcare more personal, consumer oriented, cost effective, innovative, agile, and entrepreneurial. IT will empower both consumers and medical practitioners. We will have better knowledge of our bodies, and so will our doctors. We will communicate with our physicians more easily, and doctors will move down the cutting edge of treatment more quickly. Often the entire process will become automated, and the ubiquitous doctor visit will be saved for rare occasions. Researchers and entrepreneurs will make use of the new information to deliver better treatments and cures, and patients themselves will get in on the act. They already are.

Smartphones and software apps are an important component of this transformation. They are, however, just one facet of a much broader and deeper information revolution in health. This revolution will proceed down multiple paths of technology, medicine, research, and business, and each will build on and feed the others.

The Problem – Too Little Information

These opportunities come not a moment too soon for a health industry in various stages of crisis, as well as for patients desperate for more cost-effective care. The healthcare market is vast and deep, but many of its details are invisible and its scale impenetrable. It floats along, growing in bulk but too rarely in sophistication, even as health insurance rates continue to soar.

Healthcare employment is growing fast as well, but that's part of the problem. Between 1990 and 2010, while the rest of the American economy enjoyed annual productivity gains of around 2%, American healthcare productivity actually declined 0.6% per year. Over 20 years, that's a productivity differential of around 60%. If we could raise the productivity of healthcare, which is about one-sixth of GDP, we could substantially improve the nation's economic health.

Gene therapy, stem cells, organ transplants, robotic surgery, and robotic limbs—these are examples of the best of American technology. They seem almost miraculous in their sci-fi sophistication and healing power. Our highly trained doctors and nurses are the world's best. Yet, the inefficient structure of American healthcare is a heavy burden. We know the central problems: (1) lack of competition and innovation due to regulation and (2) a third-party payment system (Medicare, Medicaid, and nominally private insurance) that obscures price, choice, and value. This system saps our time and weighs on our individual and governmental budgets. According to the Centers for Medicare and Medicaid Services (CMS), today's health expenditures in the United States (around $3 trillion) will grow to more than $5.4 trillion by 2024. Healthcare's portion of the national economy is thus expected to grow to nearly 20% from an already-high 17%. This dead weight isn't just breaking our finances; it threatens to deaden our innovative capacity.

Government attempts to inject IT into the health system from the top down, via electronic health records for example, are well-meaning. The top-down mandates, however, ignore the fundamental reason healthcare had failed to deploy IT as effectively as nearly every other industry: perverse incentives that reward inefficiency and penalize innovation and thrift.[1]

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[1] A 2013 RAND study, shows that the nearly $50 billion in public and private EHR investments associated with the Affordable Care Ace are, so far at least, not paying off. See, Arthur L. Kellermann and Spencer S. Jones, "What it will take to achieve the as-yet-unfulfilled promises of health information technology," Health Affairs 32, no. 1 (2013): 63-68.

As deliriously frustrating as the paper-based medical record system is, the information revolution in health is, fortunately, far broader and more potent. Electronic medical records are just the beginning, and their deployment is likely to be successful only when bottom-up incentives to deploy in such technologies become a reality.

The Solution — More Information

The proliferation and democratization of computer and communications power will drive the real revolution from the bottom up. Consider that in 1971, Intel's first microprocessor, the 4004, contained 2,300 transistors, the tiny digital switches that are the chief building blocks of the information age. Between 1971 and 1986, Intel sold around one million 4004 chips. Today, an Apple A8 chip, the brains of the iPhone 6 and iPad, contains two billion transistors. In just the last three months of 2014, Apple sold 96 million iPhones and iPads. In all, in the fourth quarter of 2014, Apple alone put around 30 quintillion (30,000,000,000,000,000,000) transistors into the hands of people around the world. Individuals now enjoy more computing power, via smartphones and the Internet cloud, than entire hospitals and insurance companies had just a decade ago.

Much of the rest of the economy is riding this Moore's law wave. Today's bloated healthcare world, however, resembles a 1950s mainframe computer—big, bulky, slow, unconnected, and expensive. Despite terribly misguided policy, information is about to intrude on the healthcare world and break this mainframe into millions of pieces. Although the Affordable Care Act (ACA) pretends to be the main driver of changes to our health system, the real action will in fact occur in entrepreneurial realms, specifically in four areas of innovation:

- Smartphones and Personal Technology – Supercomputers in billions of individuals' pockets (and on their wrists and in their brains and intestines) all connected via broadband networks, will enable cheap, anywhere, all-the-time diagnostic tools and communication and data collection capabilities.

- Big Data, Social Data – With the collection, coordination, sharing, and analysis of unimaginably large troves of specific data on patients, treatments, physicians, and facilities, researchers and patients themselves will dig deeper and make more connections than ever before.

- The Code of Life – The truly radical new understanding of biological information networks, including genomics and proteomics, will yield personalized molecular medicine. Cracking this "code of life" is the most fundamental information technology at the heart of the health information revolution…and it is happening.

- The App-ification of Healthcare – A smartphone is a platform that empowers millions of diverse apps, products, and services created by other people and firms, targeting the needs of individual consumers. Healthcare, however, is too often a closed and stagnant system. For all of the new information technologies to truly flourish, the healthcare economic model must change. Instead of a centralized, opaque, top-down system of big hospitals, big insurance, and big government, we need an entrepreneurial model of numerous firms and technologies (healthcare "apps") delivering better care at lower prices to patient-consumers. The potential is enormous, but it will only succeed to the extent better policy allows.

Smartphones and Personal Technology

Several years ago, when my four children were much younger, we spent a lot of time at the doctor's office. We would detect an ear infection coming on, make an appointment with the pediatrician, bundle up, drive to the appointment, and then wait 45 minutes for the doctor to perform a three-minute exam. On perhaps a dozen occasions, the doctor told us the ears were fine—only for us to return, bundled, locked, and loaded two days later with an unhappy child with an obviously full-blown infection.

The healthcare system didn't reward our intuition. Tomorrow's parents and children, however, may not have to endure two days, two visits, and two sleepless nights before getting treatment. They will have help from, among other things, their smartphones. Plug a scope into your phone, peer into your child's ear, and let your phone's camera and an app analyze what it sees and senses. Amoxicillin to the rescue, without leaving the house.

Smartphones, tablets, and an array of wearable computers can catalyze a healthcare productivity revolution. They are connected, personal, and broadband-connected general purpose computers, limited in their capabilities mostly by the reach of our imagination. Today, 2.6 billion people around the world use smartphones, according to Ericsson, the wireless infrastructure provider. By 2020, Ericsson expects 6.1 billion smartphone users. Including other connected devices like tablets, wearables, and machine-to-machine wireless connections, total mobile subscriptions could reach 9.1 billion. In the seven years since Apple's App Store first opened in 2008, consumers have downloaded several hundred billion iOS and Android apps. The diversity of the new software tools is astonishing. It's all powered, moreover, by broadband wireless connectivity and the near-infinite computing and storage capacity of the Internet cloud.

Consider CellScope's smartphone otoscope and dermascope attachments—one looks into ears, the other at skin lesions, taking photos, keeping records, and forwarding pictures to your physician. A firm called Smart Vision Labs invented a small iPhone attachment that can replace a 30-pound, $30,000 piece of optometric equipment for less than $4,000, enabling cheap and mobile eye exams. Mobile electrocardiograms are already in widespread use. Eric Topol, a

cardiologist and author of the book *The Patient Will See You Now*, says he has already used his smartphone ECG to diagnose three fellow airplane passengers—one was having a heart attack, another a panic attack, and the third merely a "transient very slow heart rhythm."[2]

"The first time I had an ECG e-mailed to me by a patient with the subject line 'I'm in atrial fib, now what do I do?' I knew the world had changed," Topol writes. "The patient's phone hadn't just recorded the data—it had interpreted it."

Topol insists that although he is a cardiologist, these tools will allow anyone, such as flight attendants, to perform the same tests and relay the crucial information.

Dr. Peter Fitzgerald, a cardiologist and engineer at Stanford's Center for Cardiovascular Technology, estimates that one-third of cardiac clinic visits are unnecessary. Remote technology can do more than replace office visits and cut costs, he said. It can empower patients, individualize their care, and ultimately reduce morbidity and mortality.[3]

The wireless chip maker Qualcomm has partnered with the XPRIZE Foundation to challenge inventors and entrepreneurs to make what was once science fiction a true hand-held reality. To win the prize, this real-world Star Trek-inspired "Tricorder" must be able to make "negative assessments" of (or rule out) 13 core conditions, including anemia, lower urinary infection, Type 2 diabetes, atrial fibrillation, stroke, sleep apnea, tuberculosis, chronic obstructive pulmonary disease (COPD), pneumonia, leukocytosis, hepatitis A, and, last but not least, the dreaded otitis (ear infection). The device must also assess three elective conditions, such as hypertension, melanoma, cholesterol, HIV, and osteoporosis. Last, the device must measure the five vital signs: blood pressure, heart rate, temperature, respiratory rate, and oxygen saturation. Seven finalists have emerged, and the winners will be crowned in January 2016.

Other miniaturized medical breakthroughs will make the Tricorder pursuit look quaint. New research suggests a number of conditions can be diagnosed by looking at the inner eye or, separately, through chemical analysis of human breath. It is easy to see, once these technologies are perfected, how they might be integrated into mobile devices.

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[2] Eric Topol, *The Patient Will See You Now* (New York: Basic Books, 2015).

[3] Telemedicine services are growing rapidly in number, sophistication, agility, and cost-effectiveness. Large firms like CVS and smaller firms like Healthcare Magic, Dr. on Demand, ReelDX, and many more are experimenting with a number of business models and technologies. Physician groups, meanwhile, are beginning to develop policy guidelines for this new arena. See, for example, Hilary Daniel and Lois Snyder Sulmasy, "Policy Recommendations to Guide the Use of Telemedicine in Primary Care Settings: An American College of Physicians Position Paper," Annals of Internal Medicine, September 8, 2015.

Meanwhile, two researchers at Caltech have found a way to put a terahertz scanner on a chip. Like X-ray machines, these scanners see through objects, but they aren't as powerful and don't damage human tissue. No doubt you've seen big terahertz machines at airport security checkpoints. Now consider putting one of those in your phone and you've got a personal X-ray machine ready to go.

A host of wearable devices, such as FitBit wristbands and Apple Watches, will accompany this smartphone phenomenon. In just a few years, most watches of any kind will have health monitoring capabilities. Implantable and ingestible devices will also proliferate. Ingestible wireless cameras that perform nonintrusive colonoscopies have already been around for a decade, and the number and type of these devices will only multiply. We are already 3D printing replacement body parts, prosthetics, and pills. And someday, we may have billions of nanoparticles floating inside our bodies that wirelessly connect our brains to computers.

Big Data, Social Data

As all these devices collect information on lifestyle habits (such as diet, exercise, and sleep), biochemistry, and medicines (and our responses to them), we will compile vast troves of medical data that can fuel new research, as well as treatment. Smart devices will thus help bring the power of Big Data to healthcare. We will collate this real-time data with our genomic profiles and family histories. Then our physicians and thousands of researchers and computer programs will compare our data and profiles with millions of others.

Apple's HealthKit and ResearchKit platforms aim to feed exabytes of data into the global health matrix. HealthKit supports consumer apps that work with watches, wristbands, and other devices, while ResearchKit supports physicians and research teams looking for new ways to gather data and perform studies. Imagine, for example, recruiting and signing up study subjects around the world via smartphones rather than running radio ads and asking a local population to fill out paper forms.

Google's new Life Sciences project, organized under its Alphabet umbrella organization, is using data to target diabetes. The condition, which afflicts some 30 million Americans and is surging around the world, is among the most costly diseases, totaling some $245 billion a year in the United States. It requires a lifetime of blood sugar monitoring, insulin injections, and treatments for its many symptoms. Google hopes a new contact lens that measures blood sugar might eliminate the need to lance one's finger five times a day. It thinks huge databases of information on diet, exercise, insulin, and far more granular information on blood sugar and other biochemistry will, with its partners Sanofi, Novartis, and Dexcom, help it develop far more individualized treatment regimens.

IBM thinks Watson, its artificial intelligence engine, will play a major role in the medical cloud. Today, its Medical Sieve project has radiologists training Watson to get even better at analyzing X-rays and MRI scans. Several health systems are using Watson to help make diagnoses across a range of diseases, and IBM thinks Watson can help design targeted treatments for cancer. Dr. Lukas Wartman of the University of Washington in St. Louis tells the story of his own leukemia treatment, which used a novel genetic therapy originally designed for another type of cancer. He thinks, however, that Big Data can help design custom therapies much more quickly.

"Thanks to gene sequencing and analytics," Wartman writes, "we have the potential of doing a better job of treating the causes of the tumors. The problem is that we can't easily comb through masses of genetic data to spot the patterns and correlations that matter. But, with Watson's help, we might be able to cut weeks of analysis down to mere minutes."

While large tech firms like Apple, Google, and IBM aim to transform health with IT, so do thousands of smaller firms both inside and outside medicine. A new firm called Helix, a partnership among Illumina, LabCorp of America, the Mayo Clinic, and others, is an effort to build a high-quality repository of genomic information and platform for third-party genomic apps. These platforms, like the smartphone, will be a key to unleashing entrepreneurial ventures focused on both mundane and cheap new service and radical breakthroughs.

The power of information sharing and analysis, however, extends beyond pharmaceutical firms and Silicon Valley. Individuals with no medical background are using the Internet to make significant breakthroughs in their own health and that of others. Most doctors have funny stories about patients who think they know more than they do because they read something on the Internet. And yet the growing stores of knowledge available do allow the truly diligent patient-consumer to become something like experts in a relatively short period. Patients used to be ignorant and helpless. Doctors, moreover, faced with a rare condition, may have little recourse, and there is little chance such a patient would know anyone with the same affliction. Today, a patient with a rare condition (or even symptoms of an undiagnosed condition) can find similar people around the world. In some cases, these laypeople have even helped make medical breakthroughs because they made previously unknown connections via Facebook.[4] Thus, the impersonal correlations of Big Data will be supplemented by the genius and persistence of humans using social media.

In either case, if the problem is too little information, the solution is more information.

[4] See Topol, Chapter 1.

The Code of Life

If smartphones and Big Data are the IT we can see—the information on the outside—then molecular bioscience is the information inside.

Watson and Crick's discovery of deoxyribonucleic acid (DNA) in 1953 and the sequencing of the genome in 2000 were great scientific achievements. They are the foundation of the modern information age in medicine. Yet, in the first decade after the National Institutes of Health (NIH) and Craig Venter's team at Celera announced the decoded genome, it's fair to say most casual observers were underwhelmed by the apparent practical progress. Today, genomic medicine is in full flight, and the next several decades will be nothing short of astounding.

Vaccines and antibiotics brought us out of the Dark Ages and boosted human longevity. Yet, the information content of those important public health revolutions was relatively slim. Vaccines were based on the very diseases they were fighting, and antibiotics were an accidental discovery. Although early public health experts, researchers, and the Food and Drug Administration (FDA) over the last century used systematic information in crude ways, medicine until recently was mostly a trial-and-error, hit-and-hope world.[5]

Understanding the codes of the genome, proteome, epigenome, and metabolome, however, will unleash molecular medicine. Combining our new understanding of these biological information networks with traditional IT hardware and software will yield stunning breakthroughs. In 2001, the cost to sequence one genome was $100 million, but today the cost is just $5,000 and is rapidly headed toward $1,000.

"The vital core of medicine," writes Peter Huber in *The Cure in the Code*, "is now on the same plummeting-cost trajectory as chips and software."[6]

Just as the macrocosm of vacuum tubes gave way to the microcosm of silicon chips, we are moving from the goopy world of petri dishes to the biocosm of DNA and protein codes, biomarkers and pathways, the information networks of molecular metabolics. The new knowledge and tools will yield therapies customized not merely to symptoms or broad disease

[5] Early public health experts did use data about the spread of disease over various populations and geographies to pinpoint the causes of conditions such as cholera. And pharmaceutical firms and regulatory agencies have of course used trials and statistics to evaluate the safety and effectiveness of treatments. The new era, however, is characterized by a deep (although still very incomplete) understanding of the information networks among cells and even molecules. Yes, happy accidents still occur, but to a far greater degree than ever before, the new medicine is based on design.

[6] Peter W. Huber, *The Cure in the Code* (New York: Basic Books, 2013).

categories but to the individual person. Information-based medicine will provide for diagnostic "sniffers"—molecular sleuths meandering through our bodies on the lookout for anomalous cells and intruding microbes. We will *design* therapies to repair some cells and kill others, to open these pathways and block those.

Immuno-oncology (IO), for example, is perhaps the most promising breakthrough in cancer therapy. Traditional therapies burn (radiation), poison (chemotherapy), or excise (surgery) cancer cells, and with only varying degrees of precision and success. IO, on the other hand, uses the body's own immune system to target cancer cells directly and often dynamically: some IO therapies can adapt as the cancer tries to avoid pursuit. IO covers a variety of strategies, but some examples of early therapies are Provenge for prostate cancer and Avastin and Erbitux, which are used against many different cancers.

DNA editing is another new information tool that could change everything. Ever since the discovery that the foundation of biological information is digital, we have wondered whether it was possible to "program" life. The possibility is looking more likely every day. In the last five years, a technology known as CRISPR/Cas9 has emerged as a powerful tool to "cut and paste" DNA with great precision. It could be used to excise specific genes known to cause disease or merely to replace less favorable genes with better ones. The new technique is thought to be so powerful that some scientists have called for a moratorium on the use of CRISPR on human cells until we know more about its implications for safety and ethics. Nevertheless, DNA editing is an exemplary tool of the new science of bio information, and it is difficult to see how such a genie will be kept in the bottle. The big question will thus be whether and how the scientific and public policy communities can practically steer away from the most destructive possibilities while leaving the door open to beneficial advances.

Molecular medicine will challenge the prevailing model of the FDA. Supervising billion-dollar clinical trials run by big pharmaceutical firms is very different from supervising millions of people who are taking health into their own hands. In a world where individuals know their own genomes, teenagers are discovering causes of rare diseases, and patients and doctors collaborate by surveying all the accumulating data to develop exotic cocktail treatments to suit each individual, the FDA's current model breaks down.[7] Closely monitoring this world of exploding individualized information will be impossible, and if we try to do it, the benefits of the new innovations will be lost.

Designing a new system will not be easy. Just as apps and the Internet demanded (and depended upon) a more flexible regulatory environment than did broadcast TV and radio, so

[7] See Topol's description of 16-year old Elena Simon, who helped find the genetic cause of her rare liver disease.

too individualized healthcare in a world of exploding information requires a new and far more flexible model of medical oversight.

The App-ification of Healthcare

The information revolution in health science and technology will unfold, but we do not know at what speed. Policies to encourage scientific discovery and technological experimentation will help. To fully unleash the forces described in the preceding three sections and truly consummate the app-ification of medicine, however, will require a thorough transformation of the *business* of healthcare. Why? Because the business of healthcare is broken.

We spend way too much on lots of things and too little on others. Customers don't know the price of most health products—and neither do many producers. Consumers and producers, moreover, don't talk to each other about the prices they don't know. Market entry into services and therapies is artificially constrained by, for example, insurance and pharmaceutical regulation.

The more we spend on a dysfunctional system, the less we have to invest in future innovation. This opaque and bloated system is the opposite of our market for software apps in which anyone can build an app and individuals choose which apps offer value. Only a dramatic rationalization of the economics of healthcare, from physicians to insurers to consumers, can contain runaway health budgets while at the same time boosting investment in technology and unleashing innovation.

Transforming the business of health might, at first glance, seem easier than genetic engineering or robotic prosthetics. The new medical science often seems miraculous, after all. And yet, because of the obstacles we humans have built, a transformation of the business of health is more speculative and uncertain than the most radical new scientific discoveries.

We must therefore describe an alternative vision to today's health economy, one that is both far more sensitive to the needs and pocketbooks of patient-consumers and promises far more innovation and value from providers. Then policymakers will have to shed the rules that lock in today's frustrations and unleash tomorrow's possibilities.

In today's world, an ever-more diverse population must submit to a shrinking number of health providers and financial products. The results are high prices and less choice. Both providers and consumers are frustrated, however, because each must deal with a web of administrative bureaucracies that obscure information and suck value out of the system. Robert Graboyes, a researcher at George Mason University's Mercatus Center, calls today's healthcare system the "Fortress" for its immovable inertia and lack of innovation.

On the demand side of the equation, the tax treatment of health insurance and the structure and size of Medicare and Medicaid encourages most of our health dollars to be spent through the insurance channel, rather than directly. This "third-party payer" problem boosts prices and ensures overconsumption of many health services, although it probably leads to under-consumption of services not favored by private or government insurers.

The supply side of the equation is similarly distorted by rules (such as "certificate of need" laws) and payment methods that discourage innovation. Medicare and Medicaid also mold the structure for most of the provider world because they are such a large part of most providers' businesses. A few large payers—Medicare, Medicaid, and large private insurers—will tend to lead to a small number of large providers that can best navigate the payment and regulatory complexity of the administrative apparatus. Unfortunately, the ACA only makes most of these demand and supply side problems worse.[8]

There is a much better way. In the new world of health, a large number of competitive firms would offer a wide range of health and financial products to match the endless variety of consumers, patients, and their individual needs. Consumers would choose which doctors, services, clinics, and insurance products best fit their life circumstances. Graboyes calls this the healthcare "Frontier" for its forward-looking sense of possibility.

As the University of Chicago economist John Cochrane writes:

> *"We need to permit the Southwest Airlines, Wal-Mart, Amazon, and Apples of the world to bring to healthcare the same dramatic improvements in price, quality, variety, technology and efficiency that they brought to air travel, retail and electronics. We'll know we are there when prices are on hospital websites, cash customers get discounts, and new hospitals and insurers swamp your inbox with attractive offers and great service."*

David Goldhill, the author of *Catastrophic Care*, concurs. He writes:

> *"What consumer-driven industries do is give us a massive range of choices to match the complexity of our individual preferences and resources. All a consumer has to do is*

[8] See, for example, Scott Gottlieb, "The State of Competition in the Health care Marketplace – The Patient Protection and Affordable Care Act's Impact on Competition," Testimony, U.S. House Committee on the Judiciary, Subcommittee on Regulatory Reform, Commercial and Antitrust Law, September 10, 2015.

choose, because in a consumer-driven economy the producers and sellers chase consumers, not the other way around."[9]

Some argue that healthcare cannot be like other industries in which entrepreneurs supply diverse and innovative products and consumers pick and choose which are a good value. A typical objection to a more consumer-driven market is to ask whether grandma really has the time or wherewithal to shop around and pick a heart surgeon on the way to the operating room for an emergency bypass. This fundamentally misunderstands the way most industries work. In almost every product or service, the consumer does not need to deeply understand every intricacy of the technology, business model, and personnel of the service provider. The firms in most industries compete relentlessly to serve consumers, delivering to them the best products at the lowest prices. Markets develop so that consumers can "magically" find what they need on demand.

In a world of growing health information, the vast majority of healthcare will be non-emergency diagnostics, monitoring, and treatment. Health advances in smartphones, Big Data, and molecular medicine are only pushing further in this direction of choice, early diagnosis, and preventive and long-term care. We can both continue to account for emergency care and major surgeries and shift healthcare toward a consumer model. Let insurance cover truly surprising and serious health events, as insurance should, and move the rest of health supply and demand out of the insurance orbit.

Hospital system executives know this is the direction medicine must take, and they are planning for it. In a 2015 survey of 19 major health system executives, Deloitte found respondents believe that value-based care (VBC) and consumerism "will reshape the future of medicine." While large health systems will make important contributions to consumer-centric health, however, no industry can truly innovate without entrepreneurial firms experimenting with new products and services. Inertia is too powerful, especially in healthcare.

Several ironies and dilemmas prevail. Inpatient services are declining and outpatient services are rising, for example, and yet hospitals, clinics, and physician practices are consolidating into huge health systems and becoming a larger portion of the health landscape. The Deloitte survey found that "the biggest challenge noted by interviewed CEOs when preparing for 2025 is that they believe they must invest in VBC [value based care] capabilities even as much of their existing business is still oriented towards traditional FFS [fee for service] payment models and incentives."

[9] David Goldhill, *Catastrophic Care* (New York: Vintage Books, 2013).

This is the classic innovator's dilemma. How does a firm invest energy and money in speculative, inexpensive products that could end up supplanting today's expensive, best-selling items?

Big is not necessarily bad. Every industry has its economies of scope and scale, and firms should pursue the efficiencies offered by size. Large hospital systems and even insurers will be important parts of the future health landscape. Yet, any industry in which small, independent, competitive upstarts are either prohibited or discouraged will not be an innovative realm. Today's public policies dramatically favor consolidation and obstruct entrepreneurial health ventures. The app-ification of medicine demands a much freer environment in which physicians, researchers, and businesspeople of many backgrounds can approach health solutions in varied ways.

Policy for the Information Age of Health

Greater productivity in healthcare does not mean we need to "cut" healthcare quality or even, necessarily, spending. Healthcare is a superior good—when we have satisfied our other basic needs, it makes sense to spend to feel better, longer. As much as possible, however, individuals should make these decisions.

Productivity comes from matching real technology with real knowledge and real prices to produce real value. This is why medical procedures paid for with cash, such as Lasik eye surgery, have achieved dramatic technical success while driving down costs. The links between patient, doctor, technology, and price are real.

An ideal health system would combine several things:

1. Patients can and should be empowered by technology;
2. Insurance should actually be insurance against unforeseen illness, not a government-guided Rube Goldberg third-party payment infrastructure;
3. Doctors, clinics, technologists, and hospitals should be operating in a more dynamic environment with far more entrepreneurial business models than exist today; and
4. Regulatory bodies, including the FDA, should embrace the new world of personal devices, exploding information, and molecular medicine.

In the end, healthcare decisions should be personal and flexible, like a smartphone. Unfortunately, regulations under the ACA push in just the opposite direction, limiting diversity and choice in the insurance market, constraining individualized consumer-doctor decisions, and forcing industry consolidation when more health experimentation is needed.

A costly, bloated system will, at some point, degrade our ability to fund high-end research and pay for high-end services. We need technology at the low end of the spectrum—on and inside our bodies, with the patient as consumer of the doctor's services—to foster ever-more technology at the high end: pharmaceuticals, diagnostics, and surgery. With sound public policy, the information revolution in health can cure not only our medical conditions but possibly our economic ills as well.

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Portions of this report were adapted from the author's previous article "The App-ification of Medicine" in the Winter 2013 edition of the Business Horizon Quarterly.

U.S. CHAMBER OF COMMERCE FOUNDATION

Data Driven Innovation in Retail

By Leslie Bradshaw, Managing Partner, Made By Many

No one would disagree that data allows retailers to flexibly and quickly convert and retain consumers. Nor would the same audience disagree that there are powerful benefits for the consumer like highly personalized recommendations and tailored deals for the right products at the right moments in their lives. But the practicality of enabling data-driven innovation (DDI) is much harder than it looks.

Smart partnerships, more open systems, and leveraging not just the tech trends *du jour*, but the right tech trends for your business and your customers are critical for data-driven innovation to help realize a retailer's full potential of better serving their customers and increasing their revenues.

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Introduction

"We may look like the Jetsons on the outside,
but we are running like the Flintstones on the inside."
(Told to me by a former Nike brand manager in 2012)

The future of retail is using data to inform, connect, optimize, and continually innovate the way an organization services its customers. It's as simple and as complicated as that.

The simplicity lies in this equation: retailers who create, maintain, and evolve the connective tissue between their consumer, their site, and their physical stores will win big. These same winning retailers know how to gather and leverage the input from their consumer, their site, and their physical stores to offer better products, produced in smarter ways, at more competitive prices. This in turn leads to more customer satisfaction, lower acquisition and retention costs, and ultimately increased revenues. Nothing a retailer wouldn't want. Nothing we haven't all read before. And nothing controversial.

However, the hard part lies in what it takes to evolve the systems—from mindset to methodology to actual technological systems—that make these relationships, insights, and feedback loops possible. Even if CEOs at every major retailer said to their teams, "I want us to drive more innovation through data," there is inertia and status quo holding the organization hostage. At the same time, the steps that move an organization from Traditionalist, to Venturer, to Pilgrim, to (finally) Data-Driven Organization are linear and build on one another. This puts a slowed pace to the otherwise "future now" ambitions of the organization.

To complicate things further, while a growing number of data-driven startups are taking on some of the top issues in retail—from the software that runs the machines at the checkout, to the systems that help maintain an accurate picture of each customer's history and preferences, to the systems that connect how, what, when, and where we buy—these upstarts are either seen as or in reality are: (1) not stable enough to provide reliability at scale; (2) too modern to integrate into legacy code bases; and/or (3) threaten the investments made to date into large IT buildouts.

We can host events and write papers *ad infinitum* about the *Minority Report*'ization of retail, but until we solve the conundrum of "we want a more data-driven future now but are stuck with the technology equivalent of Stone Age tools," we will not fully realize the potential of data-driven innovation. Said another way: the near future of retail is less about innovating the interfaces through which consumers experience commerce and more about the radical innovation the underlying systems to these consumer experiences desperately need.

So what would it look like to put the right tools and methods in place to achieve uber-personalized and highly efficient outcomes for retailers and their customers? And how can we get there not just theoretically but practically? And what about all of the roadblocks and hurdles long-standing retailers are facing? They aren't going away anytime soon; the investments are too large and the inertia too heavy.

The answers to all of these questions will be the result of combining three activities: (1) knowing when, how, and with whom to partner—and then doing it consistently and well; (2) creating secure "doors" in and out of your systems where data can flow and external technologies can plug-in their capabilities so you aren't a closed, isolated system; and (3) leveraging the right macro technology trends that make sense for your business and your customers.

A Retail Innovator's Dilemma

Context: This is a real-world case study from a Fortune 500 business. It highlights the difficulties retailers face when they try to better serve their customers through data-driven innovations, like personalization and recommendation algorithms. In my 10 years of working in digital innovation, I have found that every business leader faces these challenges in one form or another and will continue to do so until their methods and tools are upgraded.

Consider a story from Priyanka,[10] one retail company's digital leader. Priyanka explained that her company's systems weren't able to sync up data from a customer's in-store credit card purchase history and data from that same customer's online purchase and browsing history. She also lamented that the in-store experience was poorly tracked and understood, leaving the company "blind and dumb" because it only provided insights if a credit card was used and if camera data was analyzed (which it wasn't). How many people came into the store, why they came, why they did or didn't buy something after they tried it on, and if they paid with any method other than credit card are all data points that were never collected.

And that says nothing of what the consumer wants and needs out of the situation. When asked, Priyanka's core customers wanted three things: less lines, better deals, and a heads up when something they would *truly* like has just been released (or went on sale). I emphasize the *truly* because I've also worked with clients on algorithms that were more about featuring "bumper crop" inventory than serving up what the end customer *truly* would like.

To make matters worse, despite the fact that Priyanka's company collected millions of e-mail addresses from its customers over the years, they weren't able to match it with any on- or offline purchase history or preferences. This further hindered her ability to meaningfully

[10] Name changed to protect the confidentiality of the employee, company, and project.

segment her company's customers in a way that allowed her to deliver personalized messaging and offers—not to mention learn about things like product trends that could influence "fast fashion" decisions at the production level.

Let's take stock for a moment of the data and tools Priyanka had—and didn't have—at her disposal:

- Insufficient collection tools
    - Unable to collect in-store behavior data

- Insufficient connection tools
    - Unable to map meaningful relationships between in-store, online, and e-mail
    - Unable to create personalized, omnichannel experiences for consumers

- Sufficient collection tools
    - Able to collect in-store credit card purchase data
    - Able to collect online purchase history data
    - Able to collect online browsing history data – on-domain
    - Able to collect online browsing history data - cookie'd

- Sufficient connection tools
    - Able to map meaningful relationships between various online behavior data (e.g., purchase history, on-domain browsing history, off-domain browsing history)

With this as a starting point, Priyanka pursued a variety of initiatives, including building and implementing a loyalty app where she and her team had hoped to put data to work in the name of customer service, inventory management, and yes, of course, revenue goals. However, in addition to the challenges already enumerated, Priyanka had no way of dynamically accessing the organization's vast catalog of product shots she envisioned serving up to these same customers in customized ways through a yet-to-be-developed loyalty app. And if she couldn't match any pre-existing insights with registrants of the app (which knowing what we know from the above, she couldn't), at least she could track preferences once a customer created a login…right? Wrong.

As for said loyalty app, while Priyanka spent six months iteratively learning from customers, testing low-fidelity prototypes, and validating value propositions with a "side projects" team, when it came time to build, she found that working with deeply ingrained systems was like working with an curmudgeon board at City Hall: you can't fight it as an upstart and win without

more air cover and more capital. This introduced an additional set of collection and connection insufficiencies into the mix.

- Sufficient innovation tools
    - Able to identify, prototype, and validate value-driving propositions

- Insufficient implementation tools
    - Unable to port catalog content through an API
    - Unable to integrate innovative digital products into proprietary IT

The outcome of the project? The loyalty app was never created. A deeper relationship with customers was not established. These same customers never received the kind of geolocation, temporal, or product preference information they were asking for—and getting from tangential brands like Netflix, Amazon, and Rent the Runway.

Instead, a few additional features were bolted onto an existing mobile optimized website but done so in such way that they were not easy to find. To paraphrase the old adage: if a new feature is added into an experience and no one knows about it, is it even useful? This move also violated the *sine qua non* of software development: good user experience is not about more features; it is about more focused features. Users don't want all the things to sort of do some things well. They want a few killer things to perfectly solve their one or two main problems. Furthermore, the point of sale system is slated to be upgraded in the next two years and integrated with CRM data. But unlike the personalization promise heralded by clickbait headlines, the Holy Grail of data-driven innovation remains elusive for this retailer. And thousands more like them.

A Retail Innovator's 3-Pronged Solution

Priyanka's unfortunate tale is more the rule than the exception. For anyone who has faced similar challenges, here are three achievable solutions to consider.

1) <u>The future belongs to those who partner best</u>

The world has reached a point of complexity that without a war chest like Apple's, doing everything in-house is near impossible (and even that technology behemoth depends on a cadre of external partners to design and produce their wares). What's more, there are also upstarts and boutiques who have made it their sole focus to be the best in the world at one thing, which, let's face it, you can never match as long as you have dozens of priorities. With these two bookends in mind, partnering has never been more important and more possible than in this moment

Let's look at a few examples of successful pairings that are advancing a retailer's ability to drive innovation and deliver better, faster, and stronger for their customers.

One way Macy's is infusing innovation into their organization is through their quarterly request for proposal (RFP) process. The RFPs pose a new retail-related challenge every three months to relevant startups. From social shopping to in-store behavior tracking, they've been able to learn from external partners while also providing real-world scale and scenarios for startups that are still trying to crack their product market fit. How might you take the biggest challenges you are facing and turn them into open-ended briefs for startups to respond to, present on, and possibly even execute against?

Another way to bring innovation into the fold is to buy the upstarts doing it better than you are. For example, retail giant Bed, Bath & Beyond (BB&B) recently announced their acquisition of indie darling Of a Kind, a beloved brand that "sells the pieces and tells the stories of emerging fashion, home, and jewelry designers." Market research informed BB&B that the next generation of shoppers isn't looking for cookie-cutter items that all match but rather is interested in the back stories, ethics, and exclusivity of what it buys—and Of a Kind delivers this model in spades.

Finally, an unexpected partner to bring in earlier and at a deeper level is "Big IT." Too often, innovation projects are developed in isolation and without consideration of what's possible not just on current IT systems but what they could be in the future. Major IT providers like SAP and Oracle are working hard to innovate, and the more real-world requests they get from important clients, the more likely they are to prioritize the right feature upgrades and systems revamps.

2) Build for and with Application Programming Interfaces (APIs)

Historically, retail systems have at best been connected by proprietary protocols—and at worst remained unconnected and in siloes.

To overcome these challenges, more progressive technologists and software companies are turning to open systems that allow for others to leverage and share tools, data, and protocols. The entry points to these systems are called application programming interfaces (APIs) and act just as the name implies: they allow for an interface from which (and to which) programming and building applications can occur. In turn, innovation cycles are sped up and the work is distributed across thousands—and even sometimes millions—of other minds, computers, and talent types.

Consider again the example of Priyanka's company. One of the most effective things her organization could do is build APIs and algorithms for each dataset that enable logic-based requests to recall and relate information. In addition to having APIs and algorithms for things

like customer size preferences and purchase history, they are great tools for visual content-heavy product catalogs and corresponding pricing, sizing, and availability data.

APIs are also essential for accurate inventory availability data and competition. Highly expectant consumers who shop in a hyper-competitive retail environment expect the items they want are in stock—and if they are not, then they have no problem going to another site or possibly even voiding the purchase altogether. In light of these needs, consider again the limitations of siloed systems. With data stuck in separate "vessels," it is hard to reconcile duplicative data (e.g., the same e-mail address being tied to multiple purchase mediums like online, through partner retailers online, and in-store at multiple locations). With siloed systems, it is also hard to deduce any patterns or make any connections because you don't have all the data combined in one holistic picture (e.g., similarities between *when* and *where* certain customers buy *which* type of products). This is why APIs are so critical. They marry data, they flag and clean up duplicates, and they ultimately give you a 360-degree view of your data and your customer.

A related concept to building APIs within your own systems is building APIs into which outside developers can tap. At first glance, this might feel like creating a security nightmare, but when done properly, a well-documented API actually encourages innovation from external sources. It is one of the single biggest reasons why the early Twitter ecosystem exploded: their open, well-documented API allowed developers to collect and analyze data, mash its data up with other sources, and build applications that displayed data in interesting ways. APIs also accelerate the ability of partner systems (such as inventory and fulfillment) to gain visibility into purchasing patterns and supply chain demands.

3) <u>Understand and leverage macro trends in technology</u>

One of the greatest things a retailer can do to innovate actually has little to do with invention and everything to do with overlaying a comparative advantage with the right macro technology trend. These trends are being driven by advances in technology, advances in devices, evolution in design techniques, and new interface experiences.

Customers are expecting to have transparency in time and distance, while also having full control making requests and contacting a real person to aid them. This is something seen in the fast-growing business, Uber. If this is what consumers are coming to expect when it comes to travel, what is the Uber equivalent for the retail business model? Is it about tracking an order beyond just the delivery point and instead seeing its actual position on a map? Or is it about the customer having a more direct route to the delivery truck or store that has their item in their site—not just some call center thousands of miles away? Or some of all of the above?

What about the Netflix-i-zation of content? Their model has evolved from DVD subscriptions to streaming content subscriptions—and now they are even in the original content game. They've not only set the bar for all other media companies—which they have—but they are also able to make smart original content investments based on the massive dataset they've collected on user preferences, behaviors, and trends. What is the Netflix equivalent for the retailer? Is it about vertically integrating and cutting out distributors? Or is it about powerful recommendation engines? Or some of all of the above?

Top 6 Tech Trends for Data-Driven Retail

To further stir your thinking, here are six macro technology trends, examples of top players leveraging the trend, and a snapshot of the role innovation and data are playing with each.

1 - Enabling physical retail stores to simultaneously serve as warehouses and store fronts

- **Why**: Net shipping costs are outpacing shipping fees for many online-only retailers, chief among them the powerhouse of all powerhouses, Amazon. In 2014, they charged $3.1B in shipping fees and spent $6.6B in transportation costs to deliver. Macy's doesn't have Amazon's transportation cost problem. In addition to having smartly invested $2B on technology and e-commerce, their physical stores are acting as "ship to store" and "online in-store pickup" locations while still serving as good-old-fashioned storefronts, earning revenue-per-square foot, too. To decrease their transportation costs, Amazon needs to make a brick and mortar acquisition. NYU Professor and L2 Digital founder Scott Galloway suggests RadioShack, a gas station chain, or the U.S. Post Office.
- **Who**: Any retailer who has only click, only brick, or click and brick models.
- **Data's role**: Understanding the final mile of shipping is *sine qua non* in retail fulfilment. There are so many data points tracked here from utilization, to routes, to pounds of inventory, to what's selling best and where.

2 - The rise of subscription and bundled services

- **Why**: Sign up once and get what you need at the frequency you need it. It also helps company's project and plan for fixed revenues, increase the lifetime value of a customer, and cut down on friction and transaction costs for both the buyer and the seller.
- **Who**: Amazon Prime, Jet.com, Walmart Subscription, Trunk Club, Birchbox, Sephora, Blue Apron
- **Data's role**: For consumer product good (CPG) companies, data reveals which purchases are made with some regularity and what that timeframe looks like. For example, women buying mascara know the "safe zone" is getting a new one every 90 days to avoid diseases like pink eye. Recognizing this, Lancome offers a 15% discount to sign up for its subscription service. What do you offer that needs

to be regularly replenished? You have an opportunity to track habits, purchasing patterns, and external factors (like weather) to determine what can be offered in a bundle and/or as a subscription—from highly disposable items like food to staple items in our wardrobe that wear over time.

3 - Groceries, content, and chores delivered immediately and at scale through an app

- **Why**: These are the ultimate enablers of acting on impulses, having near-instant convenience (Zeel will send a masseuse to you within two hours!) and saving the time-and-hassle normally associated with securing things like groceries, a movie rental, or even disrobing outside of your home for a massage.
- **Who**: Freshdirect, Netflix, Zeel, HelloAlfred.com, Seamless
- **Data's role**: While these companies may seem like they are simply providing a good (like Freshdirect does for groceries) or a service (like in-home concierge service Alfred[11] does for busy professionals)—they are all actually data companies. They are collecting every possible bit of information about your demographics and what people like you want, when you want it, and how often you want it. The more data they have, the better they can target and recommend options to you, which as we know lowers cost of acquisition of a customer thanks to referrals, retention, and lower churn rates. It creates deeper loyalty to the brand, and as a result, the retailer enjoys a higher lifetime value per customer.

4 - The rise of niche and aggregate marketplaces

- **Why**: Googling something is no longer enough—the sheer amount of information online is overwhelming. Niche sites are bringing order to this chaos by surfacing deals, aggregating luxury items, and offering unique items in one place. It is also providing an unprecedented opportunity for independent artists, namely through sites like Of a Kind and Etsy, to produce in small volume and still make a living.
- **Who**: Etsy, 1stdibs, Shoply, Bib & Tuck, ArtFire, Zibbet, Beauty.com, Overstock, One Kings Lane, Gilt Groupe
- **Data's role**: Never before have retargeting and recommendations been more powerful. Smart retailers in this space are using data to determine what people are searching for and posting in social media—and then targeting them with the right item and right deal at the right time. Data is also being used to understand and optimize for the right keywords and content placement for high-ranking results in search engines (namely Google). This is allowing smaller niche sites and larger aggregate marketplaces *that are not Amazon* to become known for being

[11] Disclosure: Alfred is a client of my company, Made by Many. I am also a subscriber.

the "ultimate destination" for a particular good (e.g., the way Overstock has done with furniture).

5 - The rise of social shopping and data-driven fashion production

- **What**: Peers and role models have always played a role in determining what's hot (or not) each season. And brands are perpetually playing catch up with design and production cycles that lag behind the latest trends. This phenomenon is now on steroids thanks to technology and data. Technology-enabled platforms like Instagram and Tumblr are decentralizing the power of advertising, as these outlets are *the* place for models, cool hunters, and tastemakers to share their of-the-moment styles. In turn, magazines, editorial columns, and out-of-home ad buys have less and less pull. They are still a part of the media mix that influence a purchase, but they are now one of a dozen touchpoints—not the only one.
- **Why**: There is more interest in following and buying what models, celebrities and social icons are promoting than there is with traditional mediums like fashion magazines and ads. Much like the rise of blogs decentralized and disrupted news, Instagram and Pinterest have decentralized and disrupted the fashion industry—and by proxy, the retailers who market their wares.
- **Who**: Instagram, Pinterest, Tumblr, "hover states" within reputable editorial sources
- **Data's role**: There are two important roles data is playing—one at the initial "which styles to produce phase" and one at the post-production "how to market, drive preference, and purchase" phase.
    - Regarding the production phase, retailers like Adidas are making investments in major fashion hubs like Brooklyn to embed their teams with *the* teenagers driving new looks. Not only does osmosis come into effect, but they are able to study adjacent purchasing behaviors and related data to help them determine what they should be producing. Zara has traditionally done a phenomenal job of shortening the cycle from street trend to production—also known as "fast fashion"—by closely monitoring trends with the help of outside companies.
    - As for the marketing phase, a dream scenario is unfolding for retailers in which a customer's organic passions for certain items, colors, and styles can instantly be satisfied with digital clicking and one-touch impulse buying online and through their phones. Love what you are pinning on Pinterest, don't just know where to go to buy it, have a hover state that allows for immediate conversion. This is what the second screen experience has been trying to

achieve between tablet, phone and TV but has yet to cut down on the steps between see it, love it, buy it.

6 - Enabling short-term consumption and one-off ownership

- **Why**: There are a few interesting drivers of this trend. Some relate to technology advances, such as more advanced geo-positioning systems, ability to make micro-payments, lower cost and higher quality cellular bandwidth technology, and the ubiquity of free Wi-Fi. Other drivers have more to do with shifts in mindset; for example, studies show that millennials have a new definition of success that values experience over possession—and other generations are starting to make the shifts, too. Whether it is because the technology is now available or because of human factors like the financial crisis of 2008 turning us off the idea of going into debt to own a lot of stuff, the fact remains: there will only be more and more instances of this type of consumption. I know I am personally looking forward to the day that I can rent an entire season's worth of on-trend clothing—and return it three months later.
- **Who**: Rent the Runway, Bag Borrow or Steal, iTunes, Uber, Lumoid, Hulu, Audiobooks
- **Data's role**: In addition to basic human psychology driving a preference for experiencing over owning, the Internet age has produced accessibility, impermanence, and rapid change like no other moment in time. Valuing experiences means we don't want just one thing; we want a little bit of everything. Businesses launching or adapting to this are smart to do so. And there is plenty of data to help light the way.

Conclusion: Time to Turn it Into Action

Let's do a quick back of the napkin exercise to start bringing these concepts together. Go ahead and take out a pen and draw three separate circles, filling them in with these contents:

- One should be labeled **underserved customer need** and under that label list at least 2 to 3 customer insights you've gathered from the front lines of talking with customers (and not just having them passively fill out surveys). Is waiting in line an issue? Special sizing a problem? Too many choices and not enough guidance on what to buy? Dig in, shop along, and record.
- The next circle should read **our comparative advantage**, under which you list off the 3 to 5 things you are known for and/or have special systems in place that others don't. Perhaps it's about your loyalty program or your supply chain or maybe your partnerships and endorsements. Think: what do you have that would be extremely hard for a startup in a garage in Silicon Valley to replicate in less than a year.

- And the last one should say **macro technology trend**, which is where you examine the six items listed above and pick 1 or 2 that *really* fit your business. The best way to determine this is to look at the best in class "Who" examples and try to find a similar company to yours—even one of your competitors.

Now that you have these three circles, it's time to make a Venn diagram. There will be a point in the middle where all three overlap—what customers need but don't yet (fully) have; what you uniquely provide and/or have access to; and the larger trends in technology that are driving customer behaviors. This is where you explore deeper with your team and your partners.

And as we've learned, it's one thing to have grand ideas about how to use data and technology to better serve the end customers, and it's quite another to actually implement these innovations. That's why you are going to write down the 3 to 5 most important people at your company who have authority in the areas of IT, digital/mobile/social, and customer relationship management (CRM). Get to know them, the technologies they use and are exploring, and find ways to build social capital and excitement with them before you have a big data-driven innovation ask.

Next, it's time to look at who the right external partners might be. You will hopefully begin to populate a list from the meetings you take with your tech colleagues and to it, add companies from Angel.co and Crunchbase.com that are in and around the space you occupy. Also keep your eye on non-establishment trend-watching retail blogs like Refinery29.com and Racked.com. They are great at calling attention to killer apps and upstart retail companies that would make for great partners or even acquisition targets.

Finally, if you already haven't de-siloed your data, the time has come to put APIs in place that will enable innovation from the inside out and the outside in. The human relationships you forge with internal partners will ideally pave the way for this to be a reality, and the relationships you forge with external startups will provide you with "beta" partners who can leverage your data in interesting, value-driving ways. It won't be easy, but it will be worth it. Winning the future of retail requires the right partnerships, the right systems, the right data, and the right methods. Let's replace those "Flintstone" tools with the "Jetsons" ones we know we need to get there.

And above all, let's remember why we are doing this in the first place: better knowing and serving the end customer. Their lives are increasingly complex, and they are turning to technology to make sense of it. The smart companies are the ones shifting their offerings and modalities to meet the underserved needs of the modern consumer. And the less smart companies are hoping that if they close their eyes and double down on their existing

infrastructure, it will all be over soon like some sort of bad dream. Because in the end, what's good for the customer has more times than not proven to be good for the business, too.

Driving into a Connected Future – How Data is Changing the Auto Industry

By Catherine McCullough, Executive Director, Intelligent Car Coalition

What if every American had access to a machine that could save people's lives?

What if this machine could stop a traffic accident, preventing tragedy from ever occurring?

What if that machine could help save the environment, create jobs, bring thousands of new products to the market, and lead the way to a consumer-centric marketplace where buyers become the overwhelming force for change and innovation?

Technology like this hypothetical machine is not a quixotic or imaginary proposal. Most of us will have access to this machine very soon, if we don't already. It's called a connected car, and it stands on the precipice of igniting a renaissance in U.S. industry. Some estimate that 75% of the world's vehicles will be connected to the Internet by 2020.[12] Thanks to the power of wireless connectivity, combined with both new auto and data technology innovations, the connected car has the potential to save lives, fuel, money, time, and the environment.

We have seen the impact that data-driven digital technologies have had on other industries. In the past two decades, technologies that use wireless connectivity and the Internet to share information have made their marks on established businesses–such as media, music, and telecommunications–and fundamentally transformed those industries and the way consumers interact with them. When digital technologies touched these industries, new products and business models were invented. New consumer expectations were created, and hundreds of thousands of new jobs were generated.

Building upon innovative technologies from the automotive and telecommunications industries and data-driven technology, the connected car has the potential to transform our society. That's because the underlying platform–the car itself–is unique. While modern cars are indeed individualized mobile platforms–attributes they share with smartphones–they are foremost modes of transportation designed to safely carry individuals and families over long distances.

On a practical level, the fundamental physical aspects of cars include the capabilities to gather more data and more types of data. And because the automobile's performance is the result of both behavioral and environmental factors, this data is more valuable than that generated by other consumer products. Here are a few ways marrying the attributes of cars with wireless connectivity and data technologies are already bringing changes to industry and providing benefits to both individuals and society.

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[12] Eric Chang, "75% of the World's Cars Will Be Connected by 2020, Reports TrendForce," TrendForce, April 8, 2015.

Connected cars and data put consumers at the center of the value chain

Taking an automobile from the design board to production requires a longer lead time than other consumer products, normally around 5 to 7 years. This is largely due to the complexity of the systems involved and the durability requirements for motor vehicles.

Next to a home, a motor vehicle is typically the largest consumer purchase an individual will make in a lifetime. A new car today typically costs in excess of $30,000 and is expected to last 20 to 30 years. There may be several different owners in the lifespan of a vehicle, and the product itself must be durable throughout that lifespan. The average age of a motor vehicle on the road today is 11 years.[13]

Automakers employ a multi-faceted approach to design and build safe, durable, and secure vehicles. This approach includes: robust process standards for product development, extensive testing and validation, diagnostics, provision of fail-safe mechanisms, controlled network gateways, and controlled fleet tests on public roadways. Each auto maker designs its vehicles and their features to meet customer demands for attributes such as comfort, style, fuel economy, safety, and reliability. All product design and development decisions are also influenced by anticipated product development, manufacturing, warranty costs, and by the need to comply with federal emissions, fuel economy, and safety standards.

However, as auto technology has evolved and consumer demand has changed, more software has been integrated into the design process and greater connectivity is being added to the motor vehicle. This does not just mean that better cars are produced faster, but it also means that in the near future, it may be possible to systematically repair and upgrade entire vehicle fleets using connectivity systems. This digitally hastened timeline is one way auto companies are able to invest in safety, security, and clean technologies that meet and exceed consumer demand and expectations.

The increasingly software-based nature of today's vehicles is also important when it comes to leveraging data. Vehicles that are able to send information back to owners, dealers, and Original Equipment Manufacturers (OEMs) about component performance can help diagnose problems and enable parts to be repaired more quickly. The data feedback loop—which is leveraged to provide both safety improvements and better design and production of vehicle parts—is continually shortening. Combined with a more efficient vehicle design pipeline, consumers will increasingly see their driving experience improve at much faster paces.

In addition, consumers are finding creative ways to benefit from the data generated and collected by their car. The vectors by which data is fed into and out of the car are increasing as consumers bring more devices into vehicles, and these vectors are increasingly controlled by

[13] "Average Age of Automobiles and Trucks in Operation in the United States," Office of the Assistant Secretary for Research and Technology, Bureau of Transportation Statistics, U.S. Department of Transportation, 2015.

consumers. For example, aftermarket dongles made by insurance companies can be plugged into cars' on-board diagnostics ports to extract driver performance information and earn drivers discounts on coverage. The decision to plug in an aftermarket device is completely in the hands of the consumer.

Connected cars marry innovative mechanical R&D and innovative digital R&D, producing the opportunity for exponential innovation

Many companies see the vehicle as the ultimate mobile consumer platform—a product that a consumer has invested considerable money into choosing and individualizing and a place where drivers spend a great deal of time. These attributes have attracted new and enthusiastic companies eager to service the vehicle platform.

Today's marketplace is an expanded ecosystem in which OEMs, traditional auto suppliers, non-traditional auto suppliers (such as app developers and cybersecurity firms) are partnering on some projects and competing on others.[14] Data technologies are driving this innovation by providing important and anonymous feedback to automakers based on consumer actions and needs. Subsequently, consumers are demanding more in-vehicle connectivity.

Consumers aren't the only ones benefitting from changes OEMs are making. For instance, some automakers are shifting how they deal with their suppliers to give those businesses more input into the design process. The increased flexibility and efficiency created by the shortened pipeline rewards companies for being more responsive to consumers, resulting in better products through a more competitive market.

This "expanded ecosystem" model, with the consumer in the center, was first noticed in the telecommunications industry with the introduction of the smart phone. As consumers saw more of their demands being met, they in turn demanded even more innovative products, and the market responded by creating products that ran on—and delivered—improved data. The market for smartphones took off and spawned an entirely new mobile application economy that created hundreds of thousands of jobs.[15]

As in the telecommunications industry, this expanded ecosystem and hyper-competition has turned the traditional model of product regulation on its head. For instance, as OEMs compete to add more safety features to vehicles to keep up with consumer demand, the need for new government mandates has been surpassed by the auto industry's rapid development and introduction of new technology to further enhance vehicle safety.

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[14] Joseph Szczesny, "Changes in Auto Tech Attract New Companies," *Oakland Press*, Aug. 7, 2015.

[15] Jonathan Sallet, "The Creation of Value: The Broadband Value Circle and Evolving Market Structures," April 4, 2011.

Such innovative safety improvements include driver assist technologies,[16] which use real-time data from sensors to apply the brakes in emergency situations. Many new cars already include this feature. Other crash avoidance technology tells drivers if there is someone in their blind spot. Still other technology helps drivers keep their eyes on the road by offering "heads-up" displays that give vital data to drivers (such as speed) without glancing away from the road.

As cars gain access to more data about their environments from information fed to them via vehicles' sensors and cameras, the Internet, global positioning satellite systems, and other systems, they will be able to become more autonomous—including the capability to take partial or complete control of the driving task. Automated cars have numerous safety and environmental benefits. The U.S. National Highway Safety Traffic Administration (NHTSA) estimates that around 94% of crashes are caused by driver error.[17] The more autonomous capability hits the road, the more that crash rate is expected to go down.

Automated vehicles have other advantages as well. As NHTSA outlined in its Preliminary Statement of Policy Concerning Automated Vehicles in 2013, "Vehicle control systems that automatically accelerate and brake with the flow of traffic can conserve fuel more efficiently than the average driver. By eliminating a large number of vehicle crashes, highly effective crash avoidance technologies can reduce fuel consumption by also eliminating the traffic congestion that crashes cause every day on our roads. Reductions in fuel consumption, of course, yield corresponding reductions in greenhouse gas emissions."[18]

Connected cars benefit society as well as individuals

There are so many amazing ways connected car data can help individual drivers. A car that has been in an accident can automatically call for help. A driver can find a lost car in a parking lot. We can choose to share information with our insurers to reduce rates.

But when we share connected car data, we can also help more than just ourselves. Sharing traffic congestion data can help motorists plan ahead to avoid congestion and cut emissions, ultimately reducing our carbon footprint. This extends to other areas that impact safety and congestion, such as the ability to warn other drivers of dangerous road conditions.

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[16] "Testimony of Mitch Bainwol, President and CEO of the Alliance of Automobile Manufacturers before the U.S. House of Representatives Judiciary Committee, Subcommittee on the Courts, Intellectual Property and the Internet," Internet of Things, July 29, 2015.

[17] "Traffic Safety Facts: Critical Reasons for Crashes Investigated in the National Motor Vehicle Crash Causation Survey," National Highway Traffic Safety Administration, U.S. Department of Transportation, February 2015.; "Traffic Safety Facts 2013: A Compilation of Motor Vehicle Crash Data from the Fatality Analysis Reporting System and the General Estimates System," U.S. Department of Transportation, National Highway Traffic Safety Administration.

[18] "U.S. Department of Transportation Releases Policy on Automated Vehicle Development," Press Release, NHTSA, May 30, 2013.

Some suggest that future vehicle fleets may include sensors that will feed hyper-accurate local weather data to forecasters, enabling more accurate weather predictions. In addition, once fully implemented, "vehicle-to-vehicle" (V2V) technology will allow cars to share their proximity to one another to avoid crashes by using radio waves and in-vehicle technology. This technology and the use of spectrum will allow cars to talk with other cars, helping to eliminate up to 80% of non-impaired accidents.[19]

There are other ways sharing anonymized data can help society. As previously discussed, feedback on auto parts can help pinpoint products that may not be functioning correctly and allow OEMs and dealerships to identify problems and fix them across product lines. The part that is fixed may help save money for other drivers, reduce emissions over the lifetime of the vehicle, or even save lives.

Most importantly, by fulfilling its purpose as an even safer mode of transportation, leveraging its ability to sense dynamic environmental variables, while using data feeds to inform design and development, the connected car has the potential to spread its benefits to all of society.

Intentional Restraint in Regulation

Automakers and their partners in the connected car ecosystem know that the potential is as real as it is vast. But if consumers find this market to be unsafe, insecure, intrusive, or unaffordable, it will never achieve its potential. Building this trust is up to the producers. However, if consumers are removed from the primary decision-making process, the connected car's continued development may stall.

The primary way to encourage adoption of connected vehicles is to allow for their natural development. This is the method the government made for another major innovative technology years ago: the Internet.

In a now-famous speech, the former Chairman of the Federal Communications Commission under President Clinton, William Kennard, said, "The best decision government ever made with respect to the Internet was the decision that the FCC made…*not* to impose regulation on it. This was not a dodge; it was a decision *not* to act. It was intentional restraint born of humility."[20]

Traditional regulation, born in a mechanical (rather than digital) age does not always allow regulators to move quickly enough to keep up with technologies that outpace law, nor does it

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[19] "Our latest research estimates that V2V has the potential to help drivers avoid or mitigate 70 to 80 percent of vehicle crashes involving unimpaired drivers, and that could help prevent many thousands of deaths and injuries on our roads every year." See, David Freidman, "V2V: Cars Communicating to Prevent Crashes, Deaths, Injuries," *Fastlane Blog*, Feb. 3, 2014.

[20] William E. Kennard, "The Road Not Taken: Building a Broadband Future for America," Remarks before the National Cable Television Association, June 15, 1999.

always encourage innovations that will bring more consumer- and society-friendly technologies to market. The FCC's decision, and government policies designed to incentivize the private sector to invest the billions of dollars needed, helped to expedite the Internet's development.[21]

This policy of intentional restraint is even more appropriate for the connected car industry. Just as the government helped to encourage investments in Internet infrastructure through forgoing the instinct to overregulate, it should likewise encourage the consumer-centric connected car economy by choosing to wield caution rather than regulatory sticks.

Fully realized, connected cars have nearly endless capabilities. Ultimately, the potential for improving our society with the connected vehicle market can be achieved through the power of purchase—with the consumer at the wheel.

[21] Telecommunications carriers invested $32.1 billion in capital expenditures in 2014 alone. See, "Annual Wireless Industry Survey," CTIA-The Wireless Association, June 2015. AT&T ranked #1 out of all U.S. companies in capital expenditure investment in 2014, and Verizon ranked #2. See, Diana Carew and Michael Mandel, "U.S. Investment Heroes of 2014: Investing at Home in a Connected World," Progressive Policy Institute, September 2014. Automakers are also among the biggest investors in technology and innovation. *Fortune* named two auto companies among the top ten companies investing in research and development, including #1, Volkswagen. See, Michael Casey and Robert Hackett, "The Ten Biggest R&D Spenders Worldwide," *Fortune*, Nov. 17, 2014. Together, auto companies spend nearly $100 billion annually on R&D. See, "2014 Innovation Report: How Automakers are Driving Innovation," Alliance of Automobile Manufacturers, 2015.

Ethics and Privacy in the Data-Driven World

By Jules Polonetsky, Executive Director and Joseph Jerome, Policy Counsel, Future of Privacy Forum

Each year, billions of new devices become newly connected, generating exabytes of data. As one former European consumer protection commissioner put it, personal information has become not just "the new oil of the Internet" but also "the new currency of the digital world." However, this explosion of personal information raises new privacy issues that responsible companies need to confront head-on.

Longstanding Fair Information Practice Principles, which have governed how organizations handle personal information for decades, are increasingly becoming strained. Principles that focus on minimizing data collection and specifying exactly how information can be used are challenged by a world awash in data. More problematic, giving consumers adequate notice and choice has largely devolved into endless privacy policies that no one reads or understands. In a world of drones, smart lighting, and wearables, traditional notices are less and less practical. The path forward will require a flexible approach, and companies will need to be more creative about how they communicate with consumers and involve them in the new data economy.

Make no mistake: in sector after sector, society is seeing how the use of data provides real value to consumers and to society. Location information can be used to improve traffic flows, reduce wait times in store lines, help the blind navigate airports, and provide essential navigation information. Wearable devices can give us more granular information about ourselves than anyone could have imagined, and the spread of low-cost sensors is making everything from our living rooms to our cities "smart."

Yet, with all of these new data-driven innovations, we will see a backlash if companies do not make a better case that all this information is being used in ways that helps consumers and society and that personal data is being adequately secured and protected. Critics worry that the same beneficial information could also be used for unfair profiling, new forms of discrimination, and an Orwellian future. These concerns need to be addressed.

One important tool will be to rely on de-identification. Although researchers have been able to re-identify information from supposedly anonymized datasets in some cases, it would be a mistake to conclude that it is always easy to re-identify data or that de-identification is not a useful, privacy-protective practice. Data that is sufficiently aggregated or scrubbed of direct and indirect identifiers decreases the risks that personally identifiable information will be used for unauthorized, malicious, or otherwise harmful purposes. However, there remains little consensus on the science or law of de-identification, and many companies rely on detailed datasets that critics consider personal. Progress and consensus on effective de-identification will be critical to the success of the Internet of Everything.

Increasingly, having some sort of data ethics policy will be essential. In many cases, the collection and use of personal information is perfectly legal, but product improvements and valuable research may involve testing and experimenting on consumers. In recent years, we have seen flaps about A/B testing, leading the founder of dating-service OkCupid to declare, “We experiment on human beings!” In response, academics have called for companies to learn from the biomedical and behavioral sciences and establish ethical review processes to monitor and approve new and surprising uses of personal information.

Formalizing an ethical review process will give companies an outlet to weigh the benefits of data use against a larger array of risks. It provides a mechanism to formalize data stewardship and move away from a world where companies are largely forced to rely on the “gut instinct” of marketers or the C-Suite. By establishing an ethics policy, one can also capture issues that go beyond privacy issues and data protection, and ensure that the benefits of a future of smart devices outweigh any risks.

The Immersive Internet: Public Policy In A Hundred-Billion Device World

By Bret Swanson, President, Entropy Economics

The next act in the Internet saga is upon us. Some call it the Internet of Things, or the Industrial Internet, or the Internet of Everything (IoE). Whatever its name, it will create immense new value for consumers and firms, but it also presents an array of public policy challenges. As the number and diversity of Internet connections grows—from billions to perhaps hundreds of billions—the number and diversity of policy questions concerning privacy, wireless spectrum, and cybersecurity, to name just a few, will also grow.

The IoE will unfurl over decades, but it has already begun to emerge. The wireless chip maker Qualcomm, for example, reported 2014 IoE revenues of $1 billion. AT&T has reached the $1 billion mark in IoE service revenue, and Intel expects IoE sales of $2 billion in 2015.

Thomas Edison himself thought power generation would happen at numerous, small power plants and be distributed to factories in nearby neighborhoods. By 1930, however, 80 percent of the nation's electricity was supplied by large, centralized power companies. The spreading web of electricity through regional and then national grids, then through ubiquitous use of batteries that made electricity mobile, and finally through the combination of the two — the charging of billions of mobile devices — has created an immersive electrified world.[22] Over the last century, it served as the foundation of modernity.

Like Edison's original model for electricity, the Internet began by connecting terminals to one another, most often in the form of desktop PCs. In the last decade, the evolution of the Internet again paralleled the evolution of the electrical model, which saw more centralization of some functions and more decentralization of others. Today, data warehouses and cloud computing have centralized many computing and storage functions, but they have also ignited an explosion of new connected devices.

The Internet may already seem to be all around us. As recently as in 2000, the United States had a mere five million broadband connected homes. Just 15 years later, however, the residential market is nearly saturated: more than 90 million American homes have broadband.[23] Mobile has enjoyed an even faster rise: the U.S. now has more mobile

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[22] For much more on the fascinating history of Edison, Westinghouse, Tesla and electrification, see, Jill Jonnes, *Empires of Light* (New York: Random House, 2003).

[23] See, for example, Leichtman Research, "About 360,000 added broadband in 2Q 2015," August 18, 2015.

subscriptions — some 355 million — than inhabitants.[24] And yet, we are still in the early stages of Internet immersion.

The idea that most people on Earth now have mobile phones is staggering. These billions of mobile computers far outnumber the connected devices of the earlier Internet era (i.e., PCs). As the world becomes saturated with 7 billion or so mobile phones, however, the immersive Internet will multiply that total several times over. In the next decade, we might connect *50 billion* or so devices to the Internet — every car, watch, boat, shoe, package, shipping container, medical device, vending machine, traffic light, household and industrial appliance, camera, drone, sensor, tracker, meter, 3D printer, implantable gadget—you name it.[25]

The physicality of the IoE — linking the digital world to the real world, the word to flesh — will have similarly large effects but is a slightly different animal. In the beginning, electricity was an obviously better way to power factories but few envisioned ubiquitous air conditioning, let alone electric toothbrushes or battery-powered aerial drones. The IoE will be full of surprises. Because of its immersive nature, the IoE will not just push and pull existing information. It will, like a digital vacuum, relentlessly collect information about the real and virtual worlds all around us.

Connecting tens of billions of additional devices to the Internet will change mundane industries, enhance productivity, generate unimaginably large troves of data, and improve our understanding of the world. Connectivity, however, cuts both ways. The benefits of so much information will at times be accompanied by discomfort and uncertainty.

Electrons Vs. Bits

While the arcs of electrification and the Internet paralleled each other in some ways, the two technological platforms differ in other important facets. Electrons are, in general, clones. Bits—the basic units of information—are individual. Electrons are commodities, while bits are distinct. Bits are created by manipulating and giving order to previously indistinguishable electrons. Bits are smart electrons, both more powerful and more fragile. These differences will manifest themselves in a number of ways, perhaps most importantly in the world of public policy.

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[24] See the CTIA "Annual Wireless Industry Survey." Note that subscriber devices can exceed the number of subscribers because subscribers can have more than one device (e.g., two cell phones, a tablet, multiple SIM cards, etc.)

[25] See, for example, Cisco's estimate of the number of connected devices in "The Internet of Everything Economy."

While electrification was accomplished largely through utilities, the Internet has spread via private investment in numerous competitive (and thus risky) platforms—telecom, cable, mobile, Internet backbone, satellite, and cloud, to name a few. Electricity had implications for safety and interoperability. But bits are more subtle. Bits contain information about the world around us and thus pose challenges for privacy and security. Bits can interfere with one another, and we must distinguish among them, so the management of wireless spectrum (or radio waves) is crucial. As the number of bit-sensing, bit-storing, and bit-transmitting devices grows toward 50 billion, and beyond, potential sources of conflict will likewise multiply.

Automating the Automobile

A new General Motors ad campaign boasts of Chevrolet's wireless broadband connectivity and Buick's in-car Wi-Fi. Nowhere do the ads mention horsepower, fuel economy, or the other traditional metrics of automobile marketing. Today, there are some 16 million connected cars in the United States and 25 million around the world. The vast majority of new car sales will be network capable, and that number will grow quickly. In just five years, most of the vehicles on U.S. roads will have Internet connectivity, in-car Wi-Fi, and a host of cloud-enabled entertainment and navigation features. Our cars will integrate with our personal cloud profiles and our home networks. Different types of firms will provide these new software and connectivity platforms: the automobile companies themselves, of course, but also firms like AT&T with its Connected Car, and Apple, whose CarPlay system, after several years of development, is finally rolling out preinstalled in Chevys and BMWs.

Connecting cars to the Internet, however, will not just extend today's familiar Web content into the passenger and driver seats. It will change cars themselves, the ways we (or computers) drive them, and the ways vehicles interact with each other. Development of self-driving cars, or autonomous vehicles, has progressed swiftly over the last decade. DARPA, the Pentagon technology research agency, helped launch the idea of "robo cars" into the popular imagination with its 2004 Grand Challenge, a 150-mile trek by autonomous vehicles (AVs) through the Mojave Desert. None of the entrants that first year made it even to the eight-mile mark. Yet, by the next year, five entrants completed the entire 150-mile journey.

Google has since picked up the mantle and made heroic progress. When Google initiated its self-driving project in 2009, many thought it was science fair vanity or a hobby. Yet, by May of 2015, when Google reported detailed results from the first several years of robo-car testing, the project had become very real.[26] Google's autonomous cars, according to its July 2015 update, have driven more than 1.1 million miles with excellent results, and it has never caused an

[26] "Google Self-Driving Car Project Monthly Report — May 2015."

accident. Along the way, Google has learned a lot about *human* driving behavior and the real sources of traffic accidents. It believes AVs will save many lives.

This is an important facet of IoE automation. As connected vehicles, devices, and sensors proliferate, the data we collect will create feedback loops of learning and better performance. As we try to emulate human tasks in hardware and software, we necessarily have to learn at a much deeper level how humans operate and interact with the world around them. Taking the human element out of tasks, it turns out, sometimes gives us a much better understanding of humans. It will also help us create new systems in which each element has better information about the others, enabling, for example, new smart traffic management.

Dan Ricci, head of automotive analytics at IBM, summed up the possibilities:

> "Vehicle telematics collect a wealth of data in motion such as sensors for assisted driving, vehicle speed, braking, transmission control systems, air bags, tire pressure and wiper speed, as well as geospatial and environmental conditions. Last year, an estimated 26 million connected cars collected more than 480 terabytes of data. That number is expected to increase to 11.1 petabytes by 2020…Information will deliver a new level of value to automakers, partners and suppliers and to cities looking to operate increasingly efficient transportation systems."[27]

Over the next few years, increasing numbers of cars will begin incorporating robo-features step by step—first lane avoidance, then assisted parking, then semi-autonomous highway driving. The Boston Consulting Group estimates that fully autonomous vehicles will be on the roads—urban, highways, and anywhere in between—in 2025.[28] Tesla Motors founder Elon Musk believes self-driving cars will be the norm 20 years from now. Some believe long-haul trucking will be the first big application for autonomous vehicles, and Daimler has already broken new ground this year in this area, revealing its 18-wheel Freightliner, "Inspiration Truck." Most transportation analysts assume that Uber and Lyft will look to robo-cars instead of human drivers for their personal taxi services in the coming years.

Some treatments of autonomous cars underestimate the complexity of the task and oversell the successes to date.[29] Google's cars, for example, have so far relied heavily on highly detailed maps of well-worn territory—specifically, inch-by-inch surveys of the neighboring streets of

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[27] Dan Ricci, "How vehicle telematics is changing the auto industry," IBM, April 20, 2015.

[28] Boston Consulting Group, "Revolution in the Driver's Seat," April 2015.

[29] See, for example, this profile in *The New Yorker*, which explains the real challenges and limitations Google has encountered. Burkhard Bilger, "Auto Correct," The New Yorker, November 25, 2013.

Mountain View, CA. Google could not today comfortably drop one of its autonomous vehicles in unfamiliar territory and assume flawless, or perhaps even adequate, performance. In addition to ever-more detailed mapping technologies, future iterations will rely more heavily than today's versions on real-time sensing of the environment and interaction via the Internet. The foundations of connected and autonomous cars are, nevertheless, growing more robust every day.

Healthcare is still in the beginning stages of a multi-faceted information revolution.[30] New devices, networks, and apps are sensing, generating, transmitting, and analyzing far more information about our bodies, environments, and treatments than ever imagined. Many of the most popular apps for smartphones are health-related. Fitness trackers have become the most popular early wearable devices, and young physicians and nurses are leveraging information technologies to transform their professions. Yet, these are still early days.

Within four years, the number of "wearable devices" will approach 600 million.[31] Most of these will be connected watches and health fitness trackers, such as the Apple Watch or FitBit. Smartphones with diagnostic tools will allow patients to self-diagnose, or at least pass along vital information to their doctors, without visits to the clinic or hospital.[32] Smartphones and other wearable and implantable devices will vacuum up huge amounts of data on our health and our responses to therapies, nutrition, and the environment.

Doctors and nurses will, in conjunction with all these remote monitoring capabilities, conduct increasing portions of their care via telemedicine. The Good Samaritan Society's LivingWell@Home program is one successful example of monitoring and treating patients with chronic conditions. The service reminds patients to take medication and helps monitor vital signs, sleep patterns, and responses to treatments, among other remote capabilities. Pooling and then analyzing data from millions of subjects' FitBits, Apple Watches, and telehealth connections will yield new insights and paths of research.

As the price of sequencing a genome continues to fall (currently less than $1,000), the number of people who get a full DNA workup will explode. Already firms like 23andMe provide basic

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[30] See our related report, "The App-ification of Medicine." XX-Link to other article-XX

[31] Cisco, "Visual Networking Index: Global Mobile Data Forecast Update 2014-2019 White Paper," February 3, 2015.

[32] The Qualcomm Tricorder XPRIZE, for example, aims to turn the science fiction of Star Trek into reality. Seven finalists, who have developed small devices that can take human vital signs and diagnose 15 different diseases and conditions, are now vying for the $10 million prize.

genealogical information for less than $100. A new firm called Helix aims to be the central repository and "app platform" for much of the world's genetic information.

Google has similar ambitions.[33] Alphabet, the new parent company of Google, is collecting and organizing 10,000 anonymous genomes in an attempt to understand what a "baseline" healthy human looks like. Project Baseline, as it is known, will then be used as a reference for researchers looking into genetic disorders and abnormalities, or merely to better understand the variety of life.

Implantable and ingestible devices will relay information from our bodies to doctors, technicians, and databases and will provide both real-time diagnostic tools and also supply the data to analyze long-term trends. Massachusetts Institute of Technology researchers, for example, have found a way to monitor tumors with tiny sensors that track biomarkers and relay data wirelessly to physicians, eliminating the need for additional MRI scans or biopsies.[34]

These devices, however, are not just passive data collectors. They will also be used to administer therapies inside us. In the future, we may even be able to connect the brain and computers wirelessly. Early research with magnetoelectric nanoparticles (MENs) suggests one possible brain-machine interface.[35] MIT researcher Polina Anikeeva told the *New Scientist,* "All of a sudden we can have subjects that look entirely natural, no wires, no connectors no implants, and yet they will be equipped with the ability to receive a stimulus…We're dealing with something very small, injectable, more like a drug than a device. I think it's really exciting."

All this genetic, clinical, and real-time information will feed into repositories that can then be analyzed by medical researchers and entrepreneurs seeking new treatments that will be increasingly customized. Peter Huber writes in *The Cure in the Code that* "the vital core of medicine is now on the same plummeting-cost trajectory as chips and software."[36]

Just as the macrocosm of vacuum tubes gave way to the microcosm of silicon chips, we are moving from the goopy world of petri dishes to the biocosm of DNA and protein codes, the information networks of molecular metabolics. The new knowledge and tools will yield therapies customized not to symptoms or broad disease categories but to the individual person. And information-based medicine will also provide for diagnostic "sniffers"—molecular

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[33] Davey Alba, "Google Won the Internet. Now It Wants to Cure Diseases," Wired, August 2015.

[34] Jessica Barltett, "MIT's tiny sensor can wirelessly track tumors," Boston Business Journal, August 9, 2015.

[35] "20 Billion Nanoparticles Talk to the Brain with Electricity," New Scientist, June 8, 2015.

[36] Peter W. Huber, *The Cure in the Code* (New York: Basic Books, 2013).

sleuths meandering through our bodies and smartphone apps gauging chemicals in our breath and ominous signals in our retinas.

Allowing information-based medicine and healthcare to impart its most powerful economic benefits will require a rethink of policy, research, and the hospital-based delivery system. As Robert Graboyes writes, we need to replace the "fortress" mentality that governs today's industry and regulatory apparatus with a "frontier" ethos of entrepreneurial business models and scientific discovery.[37]

The Policy Challenge

The massive scale of these new stocks and flows of information will yield correspondingly large benefits—often estimated in the tens of trillions of dollars. An immersive Internet, however, will also spur a number of crucial public policy debates.

Among the list of challenges we can foresee today:

- Is there enough commercially available wireless spectrum—both licensed and unlicensed—to allow all these devices to communicate effectively?
- How will voters and policymakers react to an explosion of information that was once considered "private?" How will we balance the benefits of information abundance versus concerns over privacy and government surveillance?
- With smart devices everywhere, who gets access to the information? Will governments demand "open access" to various forms of public health and transportation data? And who assumes liability for information leaks, drone incidents, or 3D printing mishaps?
- Can we agree on interoperability standards when needed? And can we agree to disagree when competing standards vie for supremacy?
- Will we tolerate individuals altering their bodies (and minds) through wearable and implantable technologies?
- Can we secure these devices and networks against increasingly sophisticated hackers, whether hobbyists, mercenaries, or sovereign states?

Perhaps the biggest challenge is whether society can rationally assess these concerns, address them prudently, and embrace an ethos of innovation, so we might enjoy the benefits of an immersive Internet to its fullest extent. Technology policy analyst Adam Thierer warns us

[37] Robert Graboyes, "Why We Need to Liberate America's Health Care," *PBS NewsH*our, January 9, 2015.

against "threat inflation." Yes, new technologies are commonly lauded, but he has shown that they are also often accompanied by "techno panics"—or widespread fears of the unknown that can inhibit technological innovation.[38] The best way to avoid these harmful backlashes, perhaps, is to acknowledge the challenges head on and develop common sense ways to mitigate ill effects.

The Urgent Need for More Wireless Spectrum

From connected cars to telemedicine and beyond, tens of billions of new connected devices demand the availability of far more wireless spectrum (i.e., the radio waves that carry information through the air).

According to Cisco, North American mobile data traffic in 2014 was 31 times the total of just 5 years ago, in 2009.[39] Cisco projects additional mobile data growth of 57% *annually* over the next five years. This growth is straining existing spectrum allocations, and not enough new spectrum is in the pipeline to ensure new devices and services will have the space to experiment and expand.

The immersive Internet requires both licensed and unlicensed spectrum. Licensed spectrum is owned by individual firms and is exclusive. It is used to provide mobile phone or satellite services, for example. Unlicensed spectrum is open for all to use, under power limitations that reduce interference. Examples are Wi-Fi and Bluetooth. Licensed and unlicensed spectrum each have strengths (and weaknesses), and we need more of both.

The most recent U.S. spectrum auction demonstrated the huge demand for spectrum. In the auction known as AWS-3 in early 2015, firms bid a record $41 billion for the slice of airwaves, more than double what experts had predicted. In 2016, the FCC will hold an important "incentive auction" that will, in effect, allow TV broadcasters to sell their underused airwaves to mobile service providers. Yet, even if this auction goes well, the pipeline of spectrum is not sufficient to support future demand and innovation.

Today, the U.S. government owns between 60% and 70% of the best remaining spectrum. Much of this government-controlled spectrum, however, is either unused or underused, and efforts to pry the spectrum from agency hands have seen limited success. The National Telecommunications and Information Administration (NTIA), the agency that manages spectrum, in conjunction with the Pentagon, has recently begun a pilot program of "spectrum

[38] Adam Theirer, "Technopanics, Threat Inflation, and the Danger of an Information Technology Precautionary Principle," Minnesota Journal of Law, Science, and Technology, Winter 2013.

[39] Cisco, "Visual Networking Index."

sharing." Under the project, the Navy (in this case) will allow commercial service providers to use its airwaves in limited ways at limited times. It is a good start but is only an experimental baby step, will take years to roll out, and won't come close to filling the pipeline. Policymakers should thus continue to find novel ways to incentivize government agencies to transfer these highly valuable underused assets into the commercial sphere.[40]

Another important step is Wi-Fi. It extends our broadband networks to our smartphones and tablets and to all kinds of new mobile devices. Because of its success, however, the existing Wi-Fi bands are crowded with users and traffic. We need more unlicensed spectrum to truly unleash the immersive Internet.[41]

Making spectrum available for commercial use takes time. From the time spectrum is identified to the time it goes into service, a dozen years may have passed. Priming the future spectrum pipeline must therefore happen today if we want to encourage innovation tomorrow.

Privacy and Security

More information means less privacy. More devices mean more targets to hack. That, at least, would seem to be the common wisdom. On some levels, it is true, and for the immersive Internet to flourish, commercial and civil institutions will have to develop strategies and techniques to combat these modern challenges. We should also remember, however, that technology itself can offer solutions. So can our unique human ability to adapt.

We have long sought to protect health information, through laws such the Health Information Portability and Accountability Act (HIPAA), which contains a number of regulations protecting patient privacy. Yet, the new environment creates new complexity. The amount of health information about to explode and the ways in which we'd like to collect, store, transmit, and use it will change profoundly. No longer is our health information contained in a paper file in a doctor's office. Now, our health information will be flowing over networks in real time, all the time. We will want it too, for the many benefits it will provide. This will mean laws like HIPAA

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[40] One idea is to implement "overlay licenses," as suggested by Brent Skorup. See, Skorup, "Sweeten the Deal," Mercatus Center, August 2015.

[41] Wi-Fi operates in both the 2.4 GHz and 5 GHz bands. In the fall of 2014, the FCC eased restrictions on 100 MHz of spectrum in the 5 GHz band. It was a good first step. To truly empower the immersive Internet, however, the FCC should take the next step — approving an additional 195 MHz within the 5 GHz band to enable the next generation of Wi-Fi. This new band will help reduce interference among our rapidly proliferating devices and could reach capacity of more than one gigabit per second, or 10 times faster than today's version.

may in some ways be too constrictive but will also mean we need to find new ways to protect ourselves.

Or consider the geolocation data that will attend connected cars. The constructive use of such data will help us navigate the roads more efficiently and will provide immensely useful data for car makers, city planners, and even economists. Some, however, will be sensitive to this new form of personal information.

In the last few years, hackers have breached a number of high profile targets in both the commercial and government worlds: Target and Home Depot, for example, and, perhaps most spectacularly, the theft of some 21 million employment files from the Federal government's Office of Personnel Management.

In the summer of 2015, two hackers demonstrated that they could remotely hack into a Jeep vehicle and commandeer it while driving on the road. The group publicized the event to demonstrate the vulnerability and encourage better security practices. In response, Jeep issued a nationwide recall of more than 1.4 million vehicles to patch the security hole. The event startled many: *even my car can be hacked!?*

Indeed, for all their benefits, connected devices are in some ways more vulnerable precisely because of their connectivity. In other ways, more decentralized connectivity will help mitigate intrusions. Security will thus prove a constant challenge as we race to stay one step ahead of our adversaries.

A long list of government agencies are interested in these privacy and security topics: the Federal Trade Commission, the Federal Communications Commission, the Food and Drug Administration, the Federal Aviation Administration, the National Highway Transportation Safety Administration, to name a few. State and local regulators are also jumping into the fray.

Privacy encompasses both "reputation"—what my neighbors or co-workers know, for instance—and also "discrimination"—what my health insurer or employer knows. There is no sure-fire way to fully enjoy the benefits of sharing more information with those we prefer to know and also completely quarantine it from those we don't. Security is likewise a balancing act. To make use of information, we must store and transmit it, which inevitably opens the possibility of breaches.

Mercatus's Thierer counsels that patience and organic adaptation is the wisest path.[42] Fears and concerns are real. Yet, we are remarkably well suited to overcome these fears and thrive

[42] Adam Thierer, "The Internet of Things and Wearable Technology: Unlocking the Next Wave of Data-Driven Innovation," Slide presentation, AEI-FCC Conference, September 11, 2014.

with modernity. To ameliorate the unsavory side-effects of new technologies, we often develop or deploy *additional technologies*. Just so with privacy and security. In addition, we adopt new social arrangements and customs to deal with the cultural discomforts of the information explosion.

Consider the case of the hacked and commandeered Jeep. At first glance, it is a scary incident. Yet, more than a hundred years after the car was invented, some 50,000 people die on American roads each year. If someone told us a century ago that cars would kill millions of people over the next hundred years, would we have allowed automobile technologies to proceed? Autonomous car enthusiasts counter that robo-cars may save the lives of thousands of people by reducing basic human errors, distractions from mobile phones, and drunk driving. In this context, the hacking of the Jeep might thus seem less frightening.[43]

Thierer shows that fears of rapidly changing technologies often follow the same path: first, resistance; then, gradual adaption; and finally, widespread assimilation. This is not to say no new laws and rules will be needed. Concepts of liability and tort law may have to evolve. In some cases, moreover, we may need to find novel ways to increase the costs of hacking by foreign governments.

Because of the interconnected and thus complex nature of this ecosystem, diverse firms and industry associations, meanwhile, will have to work together to agree on new standards and share best privacy and security practices. On this front, there is reason for optimism. As CTIA - The Wireless Association reports, government agencies such as the National Institute of Standards and Technology (NIST), the National Highway Traffic Safety Administration (NHTSA), and the North American Electric Reliability Council (NERC) are actively engaged in standards and information-sharing, as are non-government sector groups like the Institute for Electrical and Electronic Engineers (IEEE), Broadband Forum, and Telecommunications Industry Association (TIA), among many others.[44]

The vital concern, however, is that we continue to prefer open innovation and resist the temptation to preemptively block paths of experimentation.

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[43] Or as Michael Hendrix put it in a pithy Tweet: "1.23 million = annual road deaths caused by human drivers. 0 = annual road deaths caused by computer hackers."

[44] See "Mobile Cybersecurity and the Internet of Things," CTIA.

Conclusion

In August of 1998, the cover of *Wired* magazine pictured computer scientist Bill Joy.[45] The first Internet wave was very much based on PCs and websites, but Joy had a vision of connecting everything. He even had a new language—Jini—that he thought could be the common link among billions of connected things. The vision was compelling, even if the details have not played out as he surmised. The future will continue to surprise us, usually in pleasant ways—if we let it.

Before long, this emerging Internet of Everything will be so commonplace that the term will drift out of usage. (We do not refer to the "Electrification of Things.") The Internet will be a foundation of not just Web content but of most industries. It will operate in the background, like electricity. It's possible we will integrate the IoE with the blockchain to provide a running record of information across the globe and provide a financial underpinning of so many nanoscale transactions.[46]

Just as the old dial-tone of dial-up Internet access gave way to "always on" broadband, we will take for granted that most future devices and platforms will be connected to one another and the cloud. The positive impact, nevertheless, will cascade for many years to come.

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[45] See the cover story by Kevin Kelly and Spencer Reiss, "One Huge Computer," Wired, August 1998; and in the same issue, an interview: Kevin Kelly and Spencer Reiss, "Joy Shtick."

[46] See, for example, IBM's ADEPT project, a blockchain for the IoE.One of Thomas Edison's chief inventions was the meter that kept track of electricity usage, measured and regulated peak versus average loads, and thus enabled pricing of the fixed and variable service.

In Healthcare, Living Well Through Data

By Sherrie Petersen ,Director of LivingWell@Home, Evangelical Lutheran Good Samaritan Society

Looking after the health of those we care about, especially our senior citizens and other vulnerable population members, is always a priority for family and friends. Unfortunately, because of time or distance, we often can't monitor their health and wellbeing as much as we would like. With the advent of greater data access, improved connectivity and other technologies, the wellness of those we care about is having a new and more promising day. LivingWell@Home is a service of The Evangelical Lutheran Good Samaritan Society that's designed to help people stay in control of their health by identifying potential health concerns earlier.

LivingWell@Home uses sensor and telehealth technology to spot changes in day-to-day living so caregivers can identify developing conditions before they become a problem. Sensor technology uses small devices sensitive to movement that are placed in a person's home to measure sleep and activity patterns. Telehealth is a tool that tracks vital health information, such as blood pressure, pulse, weight, oxygen saturation, and glucose levels.

The data from the sensors and telehealth technology are measured over time and reviewed by the LivingWell Center, the Society's own centralized team of registered nurses and data specialists. If any of the data is outside the ranges set by a primary care giver, a LivingWell Center staff member follows up with the client.

This is what sets us apart from all the other technology providers—the LivingWell Center staff members personally connect people and their caregivers to the data. The health information is provided to them with the objective of early detection on potential healthcare changes leading to early interventions that reduce or prevent a negative healthcare change.

That is an important distinction as LivingWell@Home is a trending service, not an emergency service. It is proactive, versus reactive. The data it receives can lead to early intervention and detection of conditions, such as congestive heart failure, chronic obstructive pulmonary disease, pneumonia, dementia, diabetes, depression, medication adherence, and medication reactions.

The population that LivingWell@Home is serving often has multiple chronic conditions, multiple contributing factors, and are frequent users of the healthcare system. As a result of this new innovative approach to wellness, LivingWell@Home has minimized emergency room visits, unnecessary hospitalizations and enhanced the knowledge base of primary care providers on

how their patients are really doing. One clinic partner stated, "We knew our patients were sick, but until we began using LivingWell@Home, we didn't know how sick they were."

In the United States today, 11.7% of our population lives with more than three chronic health conditions. Individuals with more than three chronic conditions, who are more than 65 years old, contribute to 90.6% of all hospital stays. On average, this results in 2.25 hospital stays per year for these individuals.

Recently, LivingWell@Home reviewed data from one of our clinic partners. The data showed that from December 2014 to August 2015, LivingWell@Home prevented 70.1 % of expected hospitalizations for 31 patients. Furthermore, clinic care coordinators identified 30 instances in which LivingWell@Home prevented an adverse event.

The difference is in utilization. According to the 2014 National State of Industry Report from Fazzi Associates, of agencies reporting that they have a telehealth program, less than 25 % of their units are in use on any given day. In contrast, the average daily utilization of the LivingWell@Home service and telehealth equipment is greater than 93%.

LivingWell@Home is a powerful example of how technology can be leveraged to meet the needs of an exploding population attempting to manage chronic health conditions. As a result, LivingWell@Home clients are realizing the many benefits of the service, including:

- Data to support baseline assessments
- Wellness coaching with goal setting
- Proactive identification of health and safety concerns
- Reduced readmissions and emergency department visits
- Patient engagement enhancement
- Dual eligible beneficiary community costs lessened
- Increased patient satisfaction
- Improved health and wellbeing of population

Most of all, LivingWell@Home has offered peace of mind, not only for its users but also their caregivers, be they local or far away. The data, technologies, and services that come together help people live as independently and healthfully as possible and according to everyone's individual needs. That extends wellness and comfort to clients, their families, and healthcare service providers—something we all enjoy sharing.

Information, Investment and the Internet of Everything

By George S. Ford, Chief Economist, Phoenix Center for Advanced Legal and Economic Public Policy Studies, and Lawrence J. Spiwak, President, Phoenix Center for Advanced Legal and Economic Public Policy Studies

The emerging Internet of Everything (IoE) is rapidly changing the way we live, work and communicate. According to estimates by Cisco, a whopping 50 billion devices could be interconnected by 2020.[47] This massive growth in the IoE economy will greatly benefit consumers, whether directly from the services they consume or indirectly from the industry incentives to invest in new and better technologies. Such investments will drive both innovation and sectoral employment. That is, of course, if policymakers permit the rising IoE tide to lift all boats.

As a simplistic way to visualize the IoE, picture both an "edge" and a "core." The "edge" is made up of the device-makers and app developers (e.g., Google, Facebook, Amazon and Apple), while the "core" consists of the Broadband Service Providers (BSPs) who invest in and manage the networks that connect these billions of devices and applications. For both the edge and the core, however, the common currency of the IoE is *information*—that is, the ability to collect, track and ultimately monetize a plethora of information to provide enhanced online experiences for consumers. Moreover, it is the ability to monetize information successfully that will encourage, at least in part, the investments by both the edge and core to support the IoE.

That said, the high value of information also brings risks. Protecting consumer privacy, for instance, is extremely important, so developing a cohesive industry-wide privacy policy framework that can quickly adapt to a dynamic industry—without eliminating a core source of value of the IoE—should be a priority. Unfortunately, that is currently not the case. Despite the fact that both edge and core companies collect functionally similar information about consumers, federal regulations are not focused on an industry-wide approach. Instead, policymakers appear predominantly focused on regulating behavior of the companies at the core in a manner inconsistent with how edge companies are treated. This asymmetrical regulatory treatment between the edge and the core not only leaves consumers more vulnerable to bad behavior but also disincents aggressive investment in the networks required to make the IoE function.

The root of this bifurcated regulatory approach can be traced to the Federal Communications Commission's (FCC) decision in March 2015 to reclassify broadband Internet access as a Title II

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[47] Dave Evans, "The Internet of Things: How the Next Evolution of the Internet Is Changing Everything," Cisco, April 2011.

common carrier "telecommunications" service in its controversial *Open Internet Order*.[48] The Commission's *Order* has two significant legal consequences germane to the privacy debate.

First, all BSPs—whether wireline, cable or wireless—are now subject to the Customer Proprietary Network Information (CPNI) statutory framework contained in Section 222 of the Communications Act—rules that were designed for pre-Internet services offered by the handful of telephone companies in existence at the time.[49] Second, with reclassification, the Federal Trade Commission (FTC)—which traditionally has jurisdiction over digital privacy concerns for the entire IoE ecosystem—may be statutorily prohibited from bringing enforcement actions against firms who provide a "common carrier" service.[50]

Accordingly, rather than have a harmonized IoE-wide regulatory approach to digital privacy, we now have two discrete asymmetrical regulatory regimes: an *ex ante* regime *specifically for BSPs* (and no one else in the IoE ecosystem) with rules enforced at the FCC, and an *ex post* case-by-case regime enforced by the FTC for everybody else.[51] This regulatory asymmetry imposed on BSPs can have profound, negative consequences, only a few of which are mentioned here.

Given the dynamic nature of the IoE, stakeholders need the ability to adopt best practices that can quickly respond to technical and market developments to allow consumers to manage their level of data sharing. If, however, policymakers erect barriers to those privacy protection solutions that are developed through standardization, best practice activities and public-private partnerships, then consumers' options are foreclosed.[52] But this is precisely what the FCC has done: voluntary, industry-wide solutions for consumers must now proceed under constraint of *ex ante* asymmetrical regulation of BSPs at the FCC.[53] As a result, the current bifurcated, asymmetrical regulatory approach to privacy affords consumers *less* protection from harmful behavior.

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48 *Protecting and Promoting the Open Internet*, Report and Order on Remand, Declaratory Ruling, and Order, FCC 15-24, 30 FCC Rcd 5601, 80 Fed. Reg. 19738 (rel. Mar. 12, 2015).

49 47 U.S.C. § 222.

50 *See* 15 U.S.C. § 45(a)(2).

51 *C.f.*, Michael O'Rielly and Maureen Ohlhausen, "The Consequences of a Washington Power Grab," *Wall Street Journal*, August 6, 2015.

52 *See* Telecommunications Industry Association, "Realizing the Potential of the Internet of Things: Recommendations to Policymakers," Whitepaper, 2015.

53 The FCC is expected to write aggressive new CPNI rules in the fall of 2015. *See*, Brian Fung, "The Messy Battle to Protect Your Data from Your Own Internet Provider," *Washington Post*, August 20, 2015. Until these rules are finalized, the FCC's Enforcement Bureau stated that it would "focus on whether broadband providers are taking reasonable, good-faith steps to comply with Section 222, rather than focusing on technical details." While the Enforcement Bureau provided no clear definition of "good faith," it stated that "[a]lthough no broadband provider is in any way required to consult with the Enforcement Bureau, the existence of such a request for guidance will tend to show that the broadband provider is acting in good faith." "Public Notice - Open Internet Privacy Standard, Enforcement Bureau Guidance: Broadband Providers Should Take Reasonable, Good Faith Steps To Protect Consumer Privacy," DA 15-603, Enforcement Advisory No. 2015-03, May 20, 2015.

Another effect of asymmetrical privacy regulation is the disincentive it creates for investment in broadband infrastructure.[54] Each year, BSPs invest billions of dollars into their networks, with nearly $0.20 of every dollar of revenue going to network investment.[55] However, as we at the Phoenix Center have repeatedly pointed out,[56] and was just again recently recognized by University of Pennsylvania Professor Matt Blaze at the FCC's April 2015 Privacy Workshop,[57] broadband is increasingly becoming "commoditized." This commoditization results, in part, from economic forces, but it is also driven by government interventions, like net neutrality.[58]

What is crucial to understand is that *as commoditization of broadband becomes more prevalent, the incentive to invest in network infrastructure goes down*.[59] To stem this tide, Professor Blaze testified that BSPs are going to "look for ways to monetize [consumer] data" to support the needed network investments.[60] Monetizing data injects income into the ecosystem's core, providing a sound financial environment for the IoE to evolve and flourish. Asymmetrical regulatory intervention on one (albeit extremely crucial) segment of the IoE ecosystem, which is mostly politically motivated and whimsical at this point, directs this evolution on a less healthy and innovative path by effectively transferring profits from the core to the edge.[61]

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54 Such disincentive runs contrary to the Commission's statutory mandate to "encourage the deployment on a reasonable and timely basis of advanced telecommunications capability to all Americans" under Section 706 of the Telecommunications Act (47 U.S.C. § 1302).

55 Indeed, according to the Progressive Policy Institute, telecom and cable companies invested approximately $46 billion in 2014, compared to the Internet and technology segment which invested $23 billion, a 2:1 ratio. *See*, Diana Carew and Michael Mandel, "U.S. Investment Heroes of 2014: Investing at Home in a Connected World," Progressive Policy Institute, September 2014.

56 *See, e.g.*, T. Randolph Beard et al., "Network Neutrality and Industry Structure," *Hastings Communications & Entertainment Law Journal* 29 (2007): 149; T. Randolph Beard et al., "Shocks to the Broadband Ecosystem: Implications for Competition and Market Structure," *Phoenix Center Policy Bulletin No. 30* (September 2011).

57 Matt Blaze, "FCC Public Workshop on Broadband Consumer Privacy," Slide presentation, April 28, 2015: 6.

58 *Supra* n. 10.

59 George Ford, Thomas Koutsky, and Lawrence Spiwak, "Competition After Unbundling: Entry, Industry Structure and Convergence," *Federal Communications Law Journal* 59 (2007): 331; George Ford, "Bait-and-Switch—Or Why the FCC's 'Virtuous Circle' Theory is Nonsense," *Bloomberg BNA*, May 18, 2015. Significantly, the Federal Communications Commission has also recognized (but not always adhered to) this basic maxim. *See* "Connecting America: The National Broadband Plan," FCC, March 16, 2010: 136. (When "service providers in these areas cannot earn enough revenue to cover the costs of deploying and operating broadband networks, including expected returns on capital, there is no business case to offer broadband services…"); *see also*, "The Broadband Availability Gap," *FCC Omnibus Broadband Initiative (OBI) Technical Paper No. 1* (2010): 1 ("Private capital will only be available to fund investments in broadband networks where it is possible to earn returns in excess of the cost of capital. In short, only profitable networks will attract the investment required.")

60 Blaze, *supra* n. 11.

61 For much of the Open Internet debate, there is great disagreement over whether reclassification will or will not decrease investment. On that question, the pattern of aggregate investment levels is frequently used as evidence. Such patterns do not reflect, however, the influence of public policy. The correct question to ask is how much more would BSP have invested "but for" the regulation? To answer this question, actual investment must be compared to a counterfactual level of investment (or,

In sum, as the IoE evolves, there will be a lot of trial and error as both edge and core providers seek to innovate and build alternative business plans around the new economics of the IoE. The distribution of new value across the IoE ecosystem will determine its evolutionary path, and this progress should be left, to a large extent, to efficiency rather than political dictates. That said, an eye must be kept on privacy concerns, but the best way to manage privacy is also yet to be determined. Who is best to manage access to data? Who will shield customers from prying eyes? Who do customers ultimately want to deal with for protection? Not knowing the answers to these questions requires a policy of maximum flexibility. Yet, the government has already begun to place serious constraints on how the core of the IoE can respond to the rapidly evolving marketplace.[62] As the policy choices we enact today will shape the IoE of tomorrow, it doesn't appear that we are off to a particularly auspicious start.

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investment absent the policy). *See, e.g.*, George Ford, "Finding the Bottom: A Review of Free Press's Analysis of Network Neutrality and Investment," *Phoenix Center Policy Perspective No. 09-04* (October 29, 2009).

62 *C.f.* Maureen Ohlhausen, "The FCC's Knowledge Problem: How to Protect Consumers Online," 67 *Federal Communications Law Journal* 67 (2015): 203 ("the regulator's knowledge problem is most acute when regulating in a fast-changing factual environment—when guesses about the future are more likely to be incorrect. In such a situation, the collected knowledge quickly becomes stale. Indeed, if the regulator collects knowledge more slowly than the environment changes, even continuous information gathering cannot stop the regulator's knowledge from growing obsolete over time.")

Open Data: Policy Reforms Drive Innovation and Opportunity

By Hudson Hollister, founder and Executive Director, Data Transparency Coalition

Open data—machine-readable information published online by governments and others—is a resource for innovative businesses and an engine of economic growth. As the Center for Data Enterprise's Joel Gurin explained in 2014, "A growing number of companies … are using [open] data to deliver entirely new products and services."

Open data business models cluster in three areas: republication, analytics, and automation. When government information is expressed as open data, it can be cost-effectively *republished* on platforms that enable citizens, researchers, journalists, and others to interact with it in new ways. Open data empowers *analytics* because the shift from disconnected documents to standardized, searchable formats dramatically reduces extraction costs. And just as the IRS and state tax agencies made TurboTax possible by adopting a standardized electronic format for tax returns in the 1990s, open data enables a whole range of compliance tasks to be *automated*.

The global open data movement was first motivated by the need to empower people to interact with their governments—a goal well-served by the many new republication platforms our companies are building. But the business models harnessing analytics and automation reach far beyond government to society *outside* government. Shifting from disconnected documents to searchable formats also permits data-driven management *within* government and cheaper reporting *to* government.

The open data industry's growth is only just beginning. The limiting factor is not technology but outdated policies. Existing laws and practices frequently assume—and in some cases explicitly provide—that government information must be reported, stored, and disseminated as disconnected documents, not as machine-readable, searchable data. As a result, the very domains of government information that could prove most valuable to future business models are not yet fully available as open data.

Government management: Information about government spending and performance is economically valuable because America's public sector represented more than 40% of GDP last year. There is enormous demand for solutions that republish spending and performance data *outside* government, analyze it *within* government, or automate the reports that grantees and contractors must submit *to* government.

The federal government took a giant step toward transforming its own management information into open data when Congress unanimously passed, and President Obama signed, the DATA Act of 2014, mandating a government-wide data format for spending. The DATA Act will take years to implement, but with the right leadership, it will turn federal spending

information—previously segregated in purpose-built systems and disconnected documents—into freely available, machine-readable data.

Further reforms are in the works to connect performance to spending and to open up state-level management data.

Markets and Economy: Information submitted from the private sector to government regulators is valuable to investors, competitors, and researchers. Some federal and state regulators have started to adopt machine-readable formats for the information they collect. This in turn enables regulated companies' to seamlessly republish, analyze, and automate their data, all of which reduces their compliance costs.

Standardization projects in Australia and the Netherlands show the potential of automated reporting in particular. In those countries, different regulators are working together to adopt consistent data formats across their regimes, allowing companies to integrate reporting software and dramatically reducing compliance costs.

Bipartisan legislation was introduced in the House of Representatives in May to require U.S. financial regulators to use open data, consistently formatted, for the information they collect. That proposal has a long road ahead.

Laws and Regulations: In the future, the substance of laws and regulations will be expressed as open data rather than as documents. Legislative and administrative proposals will automatically track changes to the previous policies that they amend; members of Congress and legislators' jobs will be simplified; and business software will automatically respond to legal changes. By making legislative text available to be downloaded, Congress, and several state legislatures, have taken first steps toward this open data transformation. But the larger challenge of creating laws and regulations that are born as data is still some years away.

As governments embrace the notion that their information should be published as machine-readable data, the new open data industry will meet an increasing demand for republication, analytics, and automation. Its fast-growing companies will serve society while creating new value.

U.S. CHAMBER OF COMMERCE FOUNDATION

The Prescription & The Forecast – A look at the Skills Needed and End Results

By John Raidt, Scholar, U.S. Chamber of Commerce Foundation

The enormous amount of data generated today is driving the creation of new jobs, new companies and new possibilities. Just a decade ago, the world's sharpest data experts were only beginning to forecast a coming Internet of Everything (IoE), vast cloud computing and storage, and mobile devices that outnumber human beings. Today, journalists from the national news to the local press write about the companies that are building these 21st century realities.

Whether we will bring to full blossom the metamorphic potential of these new realities remains in question. Done right, we can supercharge the country's innovation, growth and competitiveness. If not, we may well squander an opportunity to usher in what could be the most promising epochs of human prosperity and advancement.

The stark difference between the two alternative futures imparts great urgency on a national "to-do" list—a campaign requiring America's signature energy and focus to accomplish. The stakes are enormous. A recent McKinsey report estimates that improved use of open data alone could generate $3 trillion in additional value each year in seven industries. Of this, $1.3 trillion per year would benefit the United States. In a report titled "the Next Great Growth Cycle," The American Enterprise Institute says, "Big Data analytics and services, nonexistent just a few years ago, is already a $3 billion industry and will be $20 billion in a half-decade. Cloud-centric services will drive productivity, and thus, collaterally, job growth across all sectors."

Seizing this monumental opportunity will help secure America's competitiveness and leadership for many decades to come. If we are to succeed, the data tell us we better get busy setting the table. Here are the requirements for unsealing the promise and potential of the data revolution.

Greater Public Awareness and Advocacy

Preparing for the competitive demands of a global, data-driven economy will require galvanizing the energy of our people, polity, and institutions. We need a vigorous public dialogue about the historic opportunities that data-driven innovation presents, not just the obstacles and potential downsides. Widely publicizing the competitive stakes—and the opportunities quantified by McKinsey and countless other experts—would set a foundation of support for the action needed to succeed. Such a campaign could begin with the enlistment of a National Data-Driven Innovation (DDI) Council composed of prominent leaders drawn from government, business, academia, and NGOs. Such a body could galvanize the national dialogue and marshal the strategic effort recommended next.

Bona Fide National DDI Strategy

As Sun Tzu noted, "Tactics without strategy is the noise before defeat." The United States lacks a bona fide strategy to prepare our systems (economic, social, educational, financial, commercial, and legal) for competing to win in a global data-driven economy. Neither government policymaking nor market dynamics alone will sufficiently pave the way. Preparing the nation's institutions and developing the holistic framework required to thrive demands a purposeful and coordinated whole-of-society effort. A disciplined strategy-setting process will force us to anticipate needs and take the actions, some long-lead, to meet them. Developing critical workforce skillsets, building mission-critical infrastructure, and establishing the proper legal frameworks and collaborative mechanisms—the list goes on—takes thought, strategy, and, above all, determined action.

A STEM-Excellent Workforce

Nothing is more important to the DDI enterprise than human intellectual capital in the form of a prepared workforce well-grounded in the disciplines of science, technology, engineering, and math (STEM). Our student body still lags behind international peers on standardized tests in technical skills. Too few high school graduates pursue higher education in STEM. The number of U.S. students seeking doctorates in these fields remains appallingly slim. It's time for an all-out campaign to motivate students to train in the technical disciplines. Making this transformation will take inspirational leadership at home, in the classroom, on the playground, behind the pulpit, and from the public dais. Without it, we can't hope to make the IoE, the data-driven economy, and our future all that it can be.

Proper Credentialing Systems

Technical professions and specialties we can only dream of now, and many we can't yet imagine, will proliferate across the DDI/IoE landscape. Qualified institutions will be needed to set proper professional competency standards for practitioners in many specialized niches. Getting our standards, certifications, and best practices right will put our firms and DDI/IoE system out ahead of competitors abroad where such competency-based credentialing may be lax or non-existent.

Effective Data Governance and Legal Structures

Market forces and free enterprise will do most of the heavy lifting in creating value in the data-driven economy; however, the success of our business system requires good governance and proper codes of conduct. Sensible rules can help stimulate competition and innovation. They are needed to foster market efficiency, assure responsible behavior, and de-conflict legitimate competing interests. In pursuing these objectives, however, public and private policymakers must draw lessons from regulatory failure today. Whether promulgated by government or industry, demanded by customers, regulators, or courts, standards and rules must be:

- Clear, to promote compliance;
- Consistent, to foster planning and investment;

- Properly scoped, to avoid unnecessary cost; and
- Performance-based rather than prescriptive, to achieve their intended objective.

These requirements apply whether policymaking on cybersecurity, privacy protection, the technical standards, or any of the many other aspects of a prosperous data-driven economy. Prerequisite for success is social license, which means that all stakeholders must have a seat at the policy table where their interests and needs are respected and transparently factored into decision making.

Preventing Databuse

In today's enterprises, everyone holds a key stake in preventing "databuse"—defined by the Brookings Institution's Benjamin Wittes and Wells C. Bennett as the "use of a person's data in a fashion adverse to that person's interests and in the absence of that person's knowing consent."

Wittes and Bennett argue that databuse is a more definitive, substantive, and actionable concept than privacy, which they find amorphous and poorly defined. They proffer a set of principles to prevent databuse, which can be boiled down to five main areas:

- *Integrity* in the use of data
- *Transparency* in how it is used
- *Security* in how it is handled
- *Sovereignty* of consumers in making decisions that apply to them
- *Reliability* in fulfilling commitments made to those whose personal data one holds

At its core, the transfer and custody of personal data is a transaction based on trust. When this trust is broken, consumers and enterprises are injured. At scale, such injuries will constipate the flow of data undermining DDI and shorting its benefits.

In structuring measures and policies to prevent databuse, society would do well to observe the principles Wittes and Bennett carefully describe. In applying them we must remain keenly vigilant of the costs, benefits, and net effects of the protections prescribed. Failing to tease out the second- and third-order effects—or consider unintended consequences—of well-meaning action could harm the very people that laws, regulations, and standards aim to protect. That would be the case if excessive, unbalanced, and poorly structured means of databuse prevention unduly constricts the data flows necessary to unlock great mysteries that yield life-improving innovations and advance the human condition.

Preventing databuse, including the breach of personal information, is mandatory for DDI to thrive. It is also a major commercial opportunity. As the data revolution gathers steam

worldwide, the demand for databuse prevention solutions will grow exponentially. The United States should be the global thought leader and solution supplier in this domain, as it entails two skills at which America shines: protecting rights and meeting market demand.

Cybersecurity

The data-driven economy can't flourish if the data supply chain is vulnerable and unreliable. The United States continues to lag many competitors in protecting critical cyber systems. America's cybersecurity framework remains balkanized and undeveloped. The Department of Homeland Security is responsible for protecting the .gov component. The Department of Defense is responsible for security of .mil. Protection of the .com world is the responsibility of the private sector. Yet, these different domains are integrated circuits of a comprehensive system. Vulnerability in any of these artificially compartmentalized components places the whole at risk.

The need to stay ahead of the hackers, e-thieves, and cyber spies is a shared one. There is no one-size-fits-all cybersecurity solution, but many best practices and standards of care are universal. We need stronger mechanisms for vigorous private and public sector coordination to drive best practices and fill jurisdictional gaps. The process of strengthening U.S. cybersecurity law, regulation, and best practice must be agile and evolutionary to protect the flow of data supply chains and the innovation they spawn.

Coherent Data Property Rights and Intellectual Property Doctrine

Who owns data? What rights do data holders have in relation to those from whom the data was derived, knowingly or unknowingly? What are the intellectual property rights associated with those who cull, process, algorithm-ize data? How are these various rights to be established and protected?

Vesting individuals with compensable rights to the data they help create seems fair and reasonable. It can incentivize data generation and sharing. But if the system for assigning and securing these rights becomes too complex, burdensome, or snarled in litigation, it could also become an enormous impediment to data flow. Likewise, conferring intellectual property (IP) rights on innovators who turn data into useful insight will incentivize progress. But if IP rights are excessively scoped or patents and copyrights protection become a legal tangle, then innovation will be the victim.

The cost and benefits of chosen legal and commercial doctrine on data ownership and IP rights must be carefully weighed and balanced. Rather than passively letting ad hoc events and a patchwork of court decisions shape policy based on 20th century legal doctrines and structures, the country would be better off defining rights and addressing the attendant policy challenges purposefully and strategically with an eye to the future.

DDI Critical Infrastructure

Like the intricate supply chain responsible for moving goods from field and factory to the consumer, the data supply chain is also a complex network. It starts with billions of electronic production points. The digital goods are stored in container packets and whisked across wired and wireless transportation routes to storage and processing facilities, from where value-added data products move to consumers. This symphony, like its agricultural and industrial analogues, requires an elaborate network of critical infrastructure to perform.

A country intending to lead the global data-driven economy requires world-class infrastructure to keep the DDI system strong and ahead of the competition. Last century, the United States could never have become a great industrial power without the interstate highway system and a world-leading transportation network to efficiently move our goods across the value chain and to the market.

In this century, we can't remain a great data power without the fastest, most capable digital transportation network in the world. This presents the mission-critical challenge of increasing the accessibility, speed and capacity of America's Internet pipelines and wireless broadband systems. It requires greater ingenuity in managing the electromagnetic spectrum (EMS)— the indispensable medium for mobile communication and the IoE. Spectrum is a finite resource, requiring that we use it wisely and efficiently. New tools and technologies must be devised to maximize its utility—an imperative requiring R&D investment and intense cross-sector collaboration.

These initiatives must be matched with efforts to modernize our aging and oversubscribed electric grid—a necessity to keep zeros and ones reliably on the move. Also needed is a larger complex of supercomputers to handle the skyrocketing demand for high-level analytical capacity. Significant private and public investments will be needed. In a time of budget constraints, making these investments isn't a simple proposition, but they are imperative for turning slow growth and fiscal constraint into prosperity and abundance.

Research, Development, and Deployment

The need to invest more generously in research and development (R&D) can't be overstated. As the Council on Competitiveness warns, America must "innovate or abdicate." The United States has the greatest innovation system known. Our national labs are the envy of the world. Our technology hubs and clusters are innovation dynamos that create prolific synergy between universities, federal research institutions, and private companies. But that top tier status is not guaranteed. Our international competitors are making their own massive investments to outpace us.

Empowering our research and development ecosystem to keep raising the bar on data excellence demands extraordinary energy and ingenuity. The federal government has created fruitful agencies that conduct advanced research in defense, energy, and intelligence. Perhaps it's time for a similar institution devoted to excellence in data analytics.

A big part of unlocking innovation is overhauling America's tax and regulatory policy to foster greater private investment in R&D and to encourage the formation of venture capital to fund start-ups. Without generous funding for R&D and muscular incentives to spawn start-up enterprises, the performance of our DDI system will falter. What's clear is that we must innovate to innovate, collaborate to lead, and compete to win.

Business Incubation

Public-private collaboration in research and development should be paralleled by strong teaming to help DDI businesses incubate and entrepreneurs develop core competencies. Businesspeople and investors will be the job creators of the data-driven economy. The more our systems can help incubate enterprises in new niches, establish novel business models, and share DDI skills with entrepreneurs and investors, the stronger our economy and better our future.

International Protocols

The trade-based global economy requires that America compete and collaborate across international borders. Frameworks to facilitate mutually beneficial trade are as critical for data as they are for any other good or service. In fact, as the Brookings Institute's Joshua Meltzer writes, "data flows are the fastest growing portion of world trade." The greater volume of data available, the faster innovation can move.

We must beware protectionism by those bent on slowing down the American data juggernaut. Vigorous trade in data must be established in major trade pacts that the United States and partners in Europe and Asia-Pacific are currently negotiating. Securing a robust global data flow requires coherent international norms on privacy protection, cybersecurity, and personal data property rights. Before we can compete at our best, we must collaborate at the highest level to eradicate international obstacles.

Fertile Business Environment

The business of data is no different than any other industry—enterprise requires a fertile business environment to flourish. The U.S. Chamber of Commerce Foundation has written extensively on the dynamics of a fertile business system and the mix of tax, regulatory, governance, security, and innovation policies that incentivize investment, productivity, and growth. Such reform is needed to catalyze DDI every bit as much as to expand the economy at

large. Perhaps data will play an important role in the case for how best to produce and sustain growth, helping turn truth into action.

Conclusion

The data-driven economy is rife with possibilities. Hopeful and exciting as it may be, the word "potential" is rather meaningless unless nurtured and brought to fruition. Bringing data-driven innovation to full blossom is a future-defining challenge that requires an American business system and government at their best.

Our competitive success and leadership is not self-fulfilling. It will be the product of visionary commitment, wise choices, coherent strategy, and ample investment. As one scholar recently noted, "The future is still in our hands— if we don't sit on them."

If the United States is able to achieve the requirements needed to realize the full potential of the data-driven future, one wonders what might journalists be writing about a decade from now. If we act purposefully and positively here and now, it might read something like this:

SUCCESS MAGAZINE

World's Most Successful Companies in 2025

AUSTIN, Texas—The champagne flutes have been put away, a New Year has been ushered in, and the annual tradition of ringing in the world's most successful companies has arrived. The 2025 roster of U.S. firms that capitalize on mankind's most abundant and fertile asset—digitized data—continues its dominance.

Whether it's a recent startup or old stalwart, practically every highly successful company possesses a core business line focused on developing and marketing data products and services. Many of the firms are long-standing enterprises with deep roots in traditional business sectors. Recognizing the enormous value of the information they generate or can access, the achievers are establishing dedicated business units to harness data-driven insight to improve operations, develop new profit centers, and push revenues higher.

No country's firms have done that better than the United States. America intelligently used its strong comparative advantage in information and communications technology (ITC) to seize supremacy in the data domain. It continues to out-innovate and out-collaborate the competition to win data business in tightly contested markets around the globe.

The American success story has not been written by the data innovators alone. Factoring heavily in the nation's enviable reign are the favorable business conditions established by long-awaited improvements in U.S. public policy. Over the past two Administrations and four Congresses, policymakers, bucking popular expectations, mustered the courage to take steps to unleash the country's business system for competitive success.

Leaders placed the country's broken national budget on a sure and steady glide path to balance. They reformed the tax code to foster investment, productivity, and job creation. New trade agreements were bought online enabling American goods and services to tap fast growing global markets. World-leading levels of cybersecurity and privacy protection assurance were achieved.

During his recent graduation speech to an audience of newly minted MDMs (Master of Data Management) from universities across the country, the U.S. Secretary of Data observed:

> *"Data is a digital cosmos containing limitless worlds of knowledge and insight that can improve every aspect of human life. In the data age, the job of business—your mission—is to extract insight, shape knowledge into life-improving products and services, and move these continuous innovations efficiently to the marketplace. For you, the sky is no longer the limit, but rather an expanding universe of life-changing possibilities. We can all be proud that American enterprise is leading the way."*

In the epic growth of data-driven businesses, three groups have benefitted most: American workers gaining access to a widening array of high-paying jobs; consumers enjoying a spectacular spectrum of affordable, new life-improving goods, services, and solutions; and shareholders reaping historically high returns, enabling many public and private pension funds to meet huge financial obligations to throngs of current retirees and millions more in the pipeline.

With that as backdrop, below we profile this year's top six companies harnessing data-driven innovation. Each enterprise either directly supports the data supply chain or harnesses data to deliver novel products or services. All have registered explosive growth and make their debut on this year's roster of most successful enterprises.

Datapeutics, Inc.: Growth has been breathtakingly fast and steep for this young company that developed a data-based technique for predicting and fighting epidemic disease outbreaks. The firm broke new ground by developing an algorithm that helps detect viral and bacterial mutations while calculating the probabilities of human infection and pandemic. Today, the company super-computes microbiological and pharmacological data to speed the development of antibiotics and anti-viral treatments. Datapeutics, partnering with national and international

public health institutions, drug companies, and hospitals, has lowered the cost and time taken to get new medicines and therapies to the market, helping mankind stay one step ahead of disease.

Integreatt: The company marries data from a consumer's virtual and physical worlds to create far deeper, more accurate profiles. Data on an individual's physical purchases is combined with online browsing, social networking, travel, and shopping patterns. This information is integrated with data about in-store behavior patterns derived from sensor systems in stores, malls, theaters, and other public places. The devices capture a broad set of bio-markers—sounds, gestures, and changes in body temperature, breathing, and electrical brain signaling—that indicate the scope and intensity of people's likes and dislikes to particular products, services, advertisements, sales interactions, entertainment, and communications. The company's unique analytical processes extract useful insight about consumer habits and reactions. As a result, communicators benefit by getting much better bang for their marketing buck. Product designers can produce more attractive and functional goods. Retailers are able to improve shop layout and lighting, product placement, and sales techniques. Above all, consumers have more efficient access to goods and services that better meet their needs and preferences.

All Street Data Exchange (ASDE): The five-year-old enterprise—with roots in the Chicago Board of Trade and Chicago Mercantile exchange—provides a Web-based platform for the commercial trading of data. Trading services include the execution of buy and sell contracts on data spot prices, forwards, futures, and options on futures. While more complex and diverse than agricultural commodities (like corn and soybeans), the zeros and ones of raw digital data can be bundled and sold in volumes the same way. The ASDE traded more than 50 million data contracts last year. That volume is expected to jump to more than 500 million contracts per year within the next five years. All Street's online platform enables worldwide electronic brokering transactions. Analysts credit the exchange with expanding the volume, range, and availability of data driving innovation in every sector of the economy. The exchange's founder recently said, "While open data platforms are an important component of the data-driven economy, so are mechanisms to bring buyers and sellers of data together efficiently for their mutual benefit."

Blueprint Mart: Homes and offices across the world use BM's downloadable 3D manufacturing blueprints for thousands of common household and workplace items. Blueprint Mart operates under license with hundreds of companies to sell the additive manufacturing software for producing their respective branded goods. The company also offers its own line of subscription 3D software blueprints for generic products**,** leases 3D printers and components, and sells materials for home and office-based additive manufacturing. In addition to its online offering, the company has opened a nationwide chain of 3D manufacturing retail outlets to print goods

on demand. Blueprint Mart's subscription offering enabling customers to conveniently and legally access the latest software has helped curtail pirating and intellectual property right violations inimical to the industry and innovation.

Fanterience: This company leases and sells its patented system called "the Pod"—a programmable bodysuit that manipulates all six senses and the body's central nervous system. The company has capitalized on major advances in the physical and life sciences to create a state-of-the-art system for providing full immersion virtual reality (VR) experiences. The company has set a new standard of authenticity making the experiential difference between actual and virtual reality barely detectable. The company has partnered with museums, galleries, and tourist sites around the world under license to add continuously to the menu of authentic VR experiences. Customers can download a menu of pre-created experiences or customize their own. Fanterience systems are used worldwide for professional training in a wide spectrum of disciplines. "The Pod" has become a common tool for helping children and adolescents practice how to handle peer pressure or respond appropriately in troublesome situations. The system is used in more than 3,000 senior care facilities where Baby Boomers who regularly use Fanterience report levels of happiness and contentment far higher than seniors who do not yet have access.

Viz: Viz has developed nano-scale radio frequency tags that can be microscopically imbedded in items such as car and airplane parts, high-performance factory equipment, and every manner of manufactured good. The tags transmit data on location and condition, as well as information on the item's origin, material composition, design, operating instructions, and other specifications to support the use, repair, and replacement of the article. In some applications, the tags transmit replication instructions directly to a 3D printer for instant manufacturing of replacement parts where precise duplication is mission-critical.

In addition, the company has patented technologies and processes that improve the interface between these sensors and humans, easing the process of harnessing real-time data to monitor risk, producing new operational efficiencies and achieving cost savings. Thousands of major manufacturing and retail companies are employing the system to improve inventory control and the operations and performance of their value and supply chains.

The company also operates a consumer division marketing systems that enable firms to offer supply chain transparency to their customers with Web-enabled service that allows a consumer to access detailed product supply chain information. As part of its Web-based consumer service, Viz uploads certifications, ratings, and assessments assigned to suppliers by government agencies, NGOs, and industry associations.

U.S. CHAMBER OF COMMERCE FOUNDATION

Synched In, an official sponsor of the World's Most Successful Companies, presents this sampling of employment opportunities in the data domain.

Synched In

September 1, 2025

MEGA-JOB CATEGORIES

Location: Nationwide
Industries: All
Enterprise size: Large, medium, and small
Compensation levels: Upper quartile
Opportunity Trends: Growth

Data Supply Chain

Wanted: Huge number of well-qualified professionals to fill a broad spectrum of data supply chain positions at enterprises across the economy. Successful candidates will possess a strong knowledge of the systems, processes, and best practices for capturing, organizing, storing, maintaining, and managing digital data. The vast majority of the high-paying positions require professional credentials or a technical degree to meet employer needs. Four types are in the spotlight:

Data trade specialist: Overseeing or implementing procedures providing for the import and export of data across international borders.

Data purchasing agent: Seeking and buying data to support the employer's business operations and value proposition.

Data broker: Independently intermediating the buying and selling of data.

Data inventory specialist: Curating the organization's data wealth. Overseeing the organized and useful flow of raw and processed data from internal and external points of origin to the company's business units.

Data-Driven Innovation

Wanted: The successful job seeker will possess the range of skills necessary for harnessing data to support the employer's innovation objectives. Most positions in this enormous field of employment opportunity require specialized training in technical disciplines such as algorithmic design, analytical software development, and applied data solutions. Each position has a network of specialty niches and support requirements that create an expanding network of employment opportunity. Four types are in the spotlight:

Virtual reality designer: Graphically displaying data and statistics to communicate the knowledge and insight extracted from them.

Innovation specialist: Translating data-driven insight into practical applications that improve the enterprise's internal operations or into marketable innovations.
Business Intelligence Officer: Turning data into business intelligence on enterprise operations, market dynamics, customers, vendors, and competitors.
Data liaison: Representing the organization's data component to find partnerships and synergies with datasets held by other organizations and enterprises to find mutually beneficial synergies and opportunity for marketable cooperation.

Sensors, Robotics, and Machine-to-Machine Communications

Wanted**:** Specialists in a multitude of professional fields related to the commercial deployment and utilization of sensors, robotics, and machine-to-machine communications. Highly technical field requiring experts certified in the broad span of specialties. Four types are in the spotlight:

Sensor engineer: Designing, operating, and managing data-streaming sensor and monitoring devices and systems used throughout the economy.
Machine-to-machine communications engineer: Designing and maintaining machine-to-machine communication systems used to enhance machine learning, operations management, and productivity, particularly in the manufacturing industry.
Robotics information management officer: Optimizing the data streams created by robotic systems to enhance productivity and create commercially useful datasets.
Brain-to-machine interface engineer: Designing, operating, and managing systems that provide interface between the human brain electrical signaling system and machine electronics to enhance robotics development and machine operations.

Ushering in Digital Corporate Social Responsibility

By Nuala O'Connor, President & CEO, Center for Democracy and Technology

Transparency, openness, and honesty are traits that have always served the business community well. In today's always-on, hyper-connected world, as companies have more and more data about their customers, these traits become even more important. As we continue to see the further emergence of the Internet of Everything, the companies that thrive will be the ones that both realize this responsibility and recognize that we are actually talking about personal information describing the lives of individuals.

Without question, technology empowered by rich data will continue to drive innovation and help us tackle society's major challenges. Yet, these clear benefits must not come at the cost of our privacy. Companies should view protecting their customers' personal information as their digital corporate social responsibility (CSR). As with all CSR efforts, this is good for society and good for business.

So what does digital CSR truly mean? It requires companies to respect consumers' digital dignity and to treat data as though it has a context—its customers' lives. Businesses should be fully aware of the physical environment, the human interface and—most importantly—the very society that is being created. They should make respectful choices about the data that is collected both directly and indirectly.

Especially when it comes to big companies with wide swaths of personal data, there is an impact on human life. Whether it is data on the employees and others who come into contact with the connected devices, or those whose activities are monitored by the devices, the data is personal and must be protected. The potential for misuse of data will always be there, especially as it becomes a more sought-after and valued commodity. Thoughtful leaders will ask not only, "Can we?" when it comes to technology and data, but also, "Should we?"

To that end, to practice digital CSR, businesses should first be forthright and transparent about the data they collect, how that data is used, and with which third parties it is shared. This is the foundation for trust in the digital age. Beyond transparency, companies should also be sure to delete data they don't need and refrain from collecting personal information that is not necessary to the bottom line. Finally, they should ensure that strong security measures are in place to protect data and their networks. These include simple methods, such as establishing firewalls, promoting encryption internally, and assisting employees with avoiding cybersecurity attacks, such as phishing.

When consumers clearly know the deal they are being offered and trust that a company will protect any personal information they share, we get much closer to a world that is enhanced by data. Without this level of trust or transparency, we run the risk of creating a data-driven world that respects neither our privacy nor our dignity. But both are still important in the digital age; our digital selves are extensions of our physical selves. This is both an opportunity and a

challenge for businesses in all sectors. By practicing good digital CSR, businesses can set a trend and shape a digital future that we all want to live in.

Vulnerability and Resilience in the Internet of Everything

By Dr. Frank J. Cilluffo and Sharon Cardash, Center for Cyber and Homeland Security (CCHS), George Washington University

By 2020, billions of devices will be connected online. The possibilities within this Internet of Everything are innovative, extensive, and valuable. Think driverless cars, "smart" houses and cities, and critical healthcare delivered virtually to remote locations. But these developments also have a dark side. With opportunity comes challenge, in the form of vulnerability.

The smarter the device, the more likely an adversary can do harm—to it, to the owner, and to third parties. The very connectivity that enables advances in so many domains and ways in turn provides an access point for attack and exploitation. This built-in weakness, which exponentially expands the surface for potential attack, is particularly problematic when it comes to critical infrastructure sectors like national defense, energy (electric, oil & gas), water, banking, and so on. Left under-protected and exposed to physical or cyberattack, these vital areas and services could be undermined and/or halted. The longer the disruption, the greater the potential for people to lose trust and confidence in the system as a whole. Recall the widespread concern generated by the shutdown of the New York Stock Exchange in July of this year. The apparent culprit there was just a technical "glitch." Imagine the damage and mayhem that an actor with malicious intent could cause.

How should we deal with the countless security vulnerabilities introduced by our unprecedented level of connectivity? One crucial way is to build security proactively into our devices and architectures, rather than trying to retrofit it after a breach or incident. At the same time, we need to change our culture and mindset as a nation. In part, this means educating and training the upcoming and existing workforce to appreciate the importance of security concerns in this context; and acting in a manner that reinforces our protective posture instead of undercutting it. Keep in mind that that posture is only as strong as the weakest link in the chain, so vendors, suppliers, contractors, and other third parties must all hew to the standard.

No system will be foolproof though, so resilience is an equally crucial aspect of the equation. The ability to bounce back and to do so quickly is perhaps the greatest deterrent to those who may wish to do us harm. Consider, for example, a scenario where the adversary combines physical and cyberattacks, using both means to target the electric grid and disable emergency response. Sound far-fetched? In fact, a variant of this has already happened: in 2013, a Pacific Gas & Electric Company substation in Silicon Valley was the subject of an armed attack in which phone cables were also cut. Farther afield, in Yemen, terrorists blacked out the entire country in June 2014.

The bottom line: networked critical infrastructure clearly presents a considerable security challenge. Yet, leadership and sustained effort within and between the public and private sectors could go a long way towards shoring up vital services and assets. With 80% of critical infrastructure privately owned and operated in the United States, collaboration between government and industry is crucial to protecting and preserving our national and economic security. Sharing threat-related information in real-time (or close to it), assessing and prioritizing risks, and allocating scarce resources accordingly are just a few of the things that we can do—or at least, do better.

Our adversaries are networked and varied, including nation-states, terrorist groups, and organized criminals. To be effective, the response must be equally networked and nimble. Moreover, responsibility extends all the way down to the level of the individual. The Internet of Everything means each and every one of us needs to own our security.

Why the GDP Statistics Are Failing Us

By Diane Coyle, Professor of Economics, University of Manchester, and author of GDP: A Brief But Affectionate History

The economy businesses and citizens are experiencing, increasingly driven by digital technology and measured by Big Data, is largely absent from the conventional measure of how the economy is performing, Gross Domestic Product. A new approach to the statistics is needed to paint an accurate picture of the economy for policymakers.

The 1885 Abstract of Statistics for the United Kingdom was published at the height of the Industrial Revolution, but you would never guess it from the information that was gathered about the economy. A dozen pages covered the factories, mines and railways. Ten times as many gave exhaustive detail on agricultural output and trade.

Statistics always lag behind what is actually happening in the economy. Not only does it take time to gather and collate the data, it can also take many years to understand how to think about the economy at a time of major structural change, whether in the late 19th century or today.

Gross Domestic Product (GDP) is the concept we use for understanding and measuring economic progress. It is discussed every day in the media, and for banks and businesses, as shorthand for how the economy is doing. Above all, it shapes the debate about economic policy. Increasingly, however, there is an awareness that GDP is not an entirely satisfactory measure, as it does not give policymakers an accurate picture of how the economy is changing. The economy that businesses and citizens are experiencing, driven by Big Data and "software eating the world," is largely absent from official statistics.

GDP is not a natural object but a concept, compiled in an extraordinarily complicated manner from thousands of data series from many sources. The U.S. Department of Commerce Bureau of Economic Analysis (BEA) described it as "one of the greatest inventions of the 20th century." It was devised during World War II, defined to best enable the efficient use of all available resources for the war effort. The concept of "the economy" as an entity was new, for questions of national wealth and progress had been debated in different ways during previous decades.

We are once again experiencing significant structural economic change, and above all are the changes to business organization, trade, and innovation arising from digital technologies and their consequences. The statistics are struggling to keep up. To give an idea of the scale of the measurement challenge, imagine that the GDP figure just omitted all of the investment in machinery and commercial buildings and factories by American businesses—about $1.5 trillion in 2014.

That is how much Federal Reserve economists estimated was left out by the failure to include in GDP business investment in "intangible" capital, such as software, brand equity, and R&D.

This situation is just starting to change, with new definitions introduced in 2013 adding 3% to the size of the American economy overnight.[63] But there is no doubt that official statistics still fail to capture much of the digital economy, as investment in "intangibles" now exceeds investment in physical capital equipment and structures. Including a complete assessment of the increasingly important components of the digital economy would have a profound impact on how we understand economic growth.

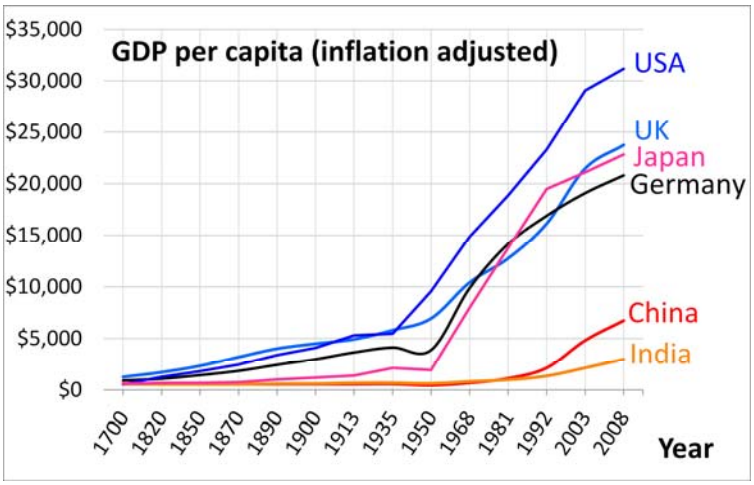
There are in fact four significant problems with GDP: how to measure innovation; the explosion of free online services; the shift away from mass production to customization and variety; and the increase in specialization and extended production chains, especially across national borders. None of these will be solved by a quick fix, but at least being aware of them will help us interpret today's economic statistics.

Innovation

A chart showing GDP per capita over a long period of time tells the essential story of dramatic increases in prosperity: very slow year-on-year growth gives way to an exponential increase in living standards in the "hockey stick of history." The restless dynamism of market capitalism manifests itself in the creation and growth of businesses delivering innovative products and services, creating jobs, and rewarding both workers and shareholders. The "free market innovation machine" is at the heart of economic growth.[64]

[63] The BEA included $690 billion of "intellectual property investment" in 2014's GDP figure.

[64] William Baumol, *The Free Market Innovation Machine: Analyzing the Growth Miracle of Capitalism* (Princeton University Press, 2002).



Source: The Maddison-Project, http://www.ggdc.net/maddison/maddison-project/home.htm, 2013 version

Yet, measured GDP underestimates the benefits of innovation. Some innovations represent incremental improvements to existing goods, although even these can be compelling to consumers. For example, DuPont sold 800,000 pairs of nylons on the first day they went on sale on May 15, 1940, and the company sold 64 million pairs in a year. Others innovations, however, bring about step changes in human wellbeing. The economic historian David Landes recounts how Nathan Mayer Rothschild died of an infected tooth abscess in 1836.[65] What might the richest man in the world at the time have paid for an antibiotic, if only they had been invented?

Economists call the gap between market price paid (which is used to calculate GDP statistics) and what someone would willingly have paid for a product *consumer surplus*. It is potentially high for new goods and services. By definition, consumer surplus is not included in GDP, which adds up output measured at market prices. At times of rapid innovation, there can potentially be a large amount of consumer benefit not being captured in the statistics.

Statisticians do aim to account for innovative goods by deflating dollar values with price indices adjusted for rapid improvements in quality or attributes; these are known as hedonic prices. The Boskin Commission in 1996 concluded U.S. real GDP growth had been underestimated by about 1.3 percentage points a year because of a failure to make this kind of adjustment for innovation in consumer electronic goods, notably computers.

Deflating nominal GDP to get real growth using hedonic price indices has become standard practice since then. Still, it is not likely that this kind of technique can ever fully capture the

[65] David Landes, *The Wealth and Poverty of Nations: Why Some Are So Rich and Some So Poor* (W.W. Norton, 1998).

impact of innovations that are radically new. When one estimate has the price of a unit of computer power (millions of instructions per second) declining at least 1.7 trillion-fold, no price index or real GDP measure will ever be able to incorporate it. It is a qualitative change. Nor can hedonic indices ever capture quality changes that are more a matter of judgement than definable and quantifiable characteristics, which includes not only many services but also intangible goods such as software or entertainment products.

Hal Varian, Google's chief economist, has specifically argued that GDP cannot measure some "sharing economy" innovations because of their character. The consumer benefit of a matching platform like Uber or Airbnb consists partly of standard gains (such as lower prices due to competition) and partly of pure efficiency gain (such as less waiting time or a better fit to individual requirements). GDP captures only some of the benefits.

Economists have always known that GDP does not measure innovation well and fails to incorporate consumer surplus. However, the problem can often be ignored as GDP growth will remain a useful indicator as long as the pace of innovation is roughly constant—but not at times when innovation is particularly rapid or radical.

There are economists who challenge the idea that there is at present particularly rapid innovation, prominent among them Professor Robert Gordon of Northwestern University.[66] Indeed, a worry about slowing innovation is one of the strands of the argument that the economy is suffering "secular stagnation."

This perspective is at odds with the experience of most people who work in high-technology sectors, whether that be digital or advanced materials and manufacturing or the frontier of medical research. One possible explanation is simply that it takes time for innovations to diffuse across the economy, so the statistics will show the effect when people are finally using the new products.[67] Although there is great variability between firms and between countries, however, the speed of diffusion is extremely rapid with many of the new digital technologies. The more likely explanation is that the sceptical economists are of course looking at GDP data. If GDP statistics do not capture the innovations, they will by definition not give a complete picture.

There is much debate at present about just how large consumer surplus due to innovations might be. At the optimistic end, one U.S. study estimated that free websites generated a

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[66] Robert Gordon, "The Demise of U.S. Economic Growth: Restatement, Rebuttal, and Reflections," NBER Working Paper 19895, February 2014.

[67] Historian Paul David set out this argument with regard to electrification in "*The Dynamo and the Computer: An Historical Perspective* on the Modern Productivity Paradox," The American Economic Review, 80, no. 2 (1990): 355-361.

consumer surplus for 2007-2011 equivalent to 0.75% of GDP a year, and a European study (using data up to 2011) estimated their benefit at 0.6% to 1% of GDP a year. Other economists challenge these large estimates, arguing that much of the digital economy is captured elsewhere in GDP, including in broadband subscriptions and the value of online advertising. While that is correct, it is not plausible that the statistics capture the step changes in quality of life brought about by all of the new technologies, any more than the price of an antibiotic captures the value of life.

The "Problem" of "Free"

This debate highlights a specific challenge the technology-driven changes in the economy pose for GDP statistics. That is the "problem" of "free." As GDP measures expenditure on goods and services at market prices, something with a zero price is not included. We are of course awash with free services online, all creating value for their users: Google, Wikipedia, open source software, news and entertainment sites without paywalls, blogs that compete with magazines or journals, music and films and podcasts (not all of it pirated), and so on.

In the case of free goods, the consumer surplus "wedge" in excess of GDP is obviously at a maximum. How could statisticians begin to measure something with no price and no sales revenue attached?

There is an important caveat—revenues might simply have been redistributed around the economy. People using free online services are paying their broadband or cell phone providers and paying for electricity. Advertisers are paying the online companies. These are earning revenues selling data about their users back to advertisers. Employment in traditional newspapers has declined but more people are working for smaller firms in the digital economy. It is not clear what the net effect on sales or on wages and employment has been.

In a 2012 report, Michael Mandel estimated that the "app economy" had created nearly 500,000 jobs in the American economy since 2007, largely below the radar due to the smaller scale of the firms involved. On the other hand, a recent study of the value of advertising-supported, free-to-consumers online entertainment estimated that incorporating this would raise real GDP growth only by a small fraction of 1% per year.[68] Nor do we know to what extent in some cases "free" is a temporary stage until business models evolve. Even so, the cornucopia of free online activities will remain, delivering some consumer value. Can this be reflected in GDP statistics?

[68] Leonard Nakamura and Rachel Soloveichik, "Valuing 'Free' Media across Countries in GDP," Federal Reserve Bank of Philadelphia Working Paper No. 15-25, July 2015.

There are already several categories in GDP for which statisticians have to devise prices because there is no market price. The obvious example is government expenditure, where often the wage paid to government employees is used, or the price of a similar private sector service. Some "informal economy" activities that are not marketed are also included, especially in developing countries where households often produce significant amounts of food and clothing for their own use (although notoriously everyday housework and caring for dependents is excluded). Finally, statisticians will "impute" prices to some services that are not paid for, notably the value of living in owner-occupied housing. Again, market rents provide the price measures used.

At present there is no momentum for official statisticians to try to incorporate the "free" digital economy into GDP statistics. This remains just one more question mark over what we actually learn from current GDP statistics.

Mass Production versus Customization

A third piece of the statistical puzzle is the huge variety of products and services available in the U.S. economy. Its origins in wartime planning and subsequent prime use for economic management mean GDP is not concerned with the mix of products or expenditure—just the total. In a mass production economy, this was not a big drawback. As long as the number of cars rolling off the lines could be counted accurately, what type they were was relatively unimportant. Yet, GDP puts the same value on three spoons as it does on a knife, fork and spoon; the same value on two left shoes as it does a matched pair of shoes. The greater the variety of products and services being purchased, the less well GDP reflects the consumer benefits.

There are no statistics available measuring variety, although there can be no doubt there has been a substantial increase. The only published estimates appear in the Dallas Federal Reserve Bank's 1998 Annual Report. It concluded:
"We might not see faster growth rates or surges in productivity, but mass customization will pay off for America. Resources are wasted guessing what customers want. When more products are customized, we won't squander money on clothing that sits in the closet…or compact discs with only one or two songs we really like."

Some social scientists argue that too much choice imposes a psychological cost on consumers. The "paradox of choice" finds that the wider the choice of items people are given, the less happy they are and the less likely they are to choose anything.[69] However, what might be true

[69] Barry Schwartz, *The Paradox of Choice: Why More is Less* (Harper Perennial, 2004).

at individual level does not carry over to aggregate measures, as people are all different. Even if I am better off when faced with a choice of only four types of jelly, not ten, there is no reason why you would want to select from the same four types as me. For the nation as a hole, the explosion of variety is a clear consumer benefit.

Digital technologies have already unbundled albums packaged by the recording industry. If anything, this will have reduced measured GDP because the recording industry has lost revenues, while the consumer gains are unrecorded. What will the scale of the uncounted value be as 3D printing or personalized medicine come to the mass market? This too will be a further wedge between GDP and the wellbeing or economic welfare of the population.

Globalization and Networks

A final area where conventional economic statistics struggle to keep track with profound changes in the economy is the significant changes in the structure of production during the past 25 years or so. Enabled by a combination of digital technologies and deregulation (including trade agreements), firms are increasingly links in long chains of specialized contributors to final products—and increasingly, services. These often are located in several countries, and this reorganization of production is one aspect of globalization. There are fewer large corporate hierarchies producing much of what they need to create the final product in-house, and more networks of firms are linked to each other in complicated relationships.

The reshaping of the global economy into increasingly specialized units has been the source of great leaps in efficiency, as well as the rapid economic growth in countries like China and Brazil. Indeed, research by Professors Ricardo Hausman and Cesar Hidalgo shows a strong link between the extent to which a country is part of the global production web and its prosperity.[70] Economic complexity—a measure of both the variety of products and services in the economy and the degree to which producers are linked to others—is highly correlated with output per head. The extent to which the economy is structured as a network of specialized producers is a key indicator of prosperity.

This does not mean GDP should include a measure of complexity, but again, this means that the statistic does not paint a full picture of what is happening in the economy. Globalization also makes standard trade statistics an incomplete measure of the economic reality because they do

[70] See, Cesar Hidalgo, *Why Information Grows: The Evolution of Order from Atoms to Economies* (Basic Books, 2015).

not net off the imported components used in manufacturing, although the new world input-output database does provide global trade statistics on this value added basis.[71]

The Purpose of GDP Statistics

These significant areas of difficulty with the GDP statistics do raise the question of what their purpose is now. The recent changes in the economy have in fact revived the 1930s debate that pre-dated the wartime creation of GDP. Simon Kuznets—often described as the father of GDP because he did so much of the preliminary statistical research—was strongly opposed to the measure that became GDP because it was a tool for tracking output but not economic welfare. He argued for an economic welfare measure but lost the debate because of the wartime imperatives and the later use of GDP for the macroeconomic policies of demand management.

The same dilemma has recurred, however, due to the growing wedges between GDP and economic welfare described above. They add to long-known gaps between GDP and economic wellbeing, above all the question of sustainability and impact of economic growth on environmental indicators. Indeed, a complete list of questions about the usefulness of GDP, if the aim is to measure economic welfare, would also include:

- Should we measure what is created outside the market, such as work in the home, voluntary activities, contributing to Wikipedia or open source software, writing free blogs, etc.?
- Should the distribution of income be a key statistic?
- How should the statistics account for the nation's balance sheet in terms of financial, physical, human, and natural capital?

These are ultimately questions about the purpose of GDP.[72] Is it a measure of economic welfare by which citizens can hold their policymakers to account? Is it simply a tool to help the Fed and the Treasury set macroeconomic policy? Is it an administrative device for benchmarking national performance (as in the EU's Maastricht criteria, which set budget deficit limits as ratios to GDP, or the World Bank's league tables of national performance)?

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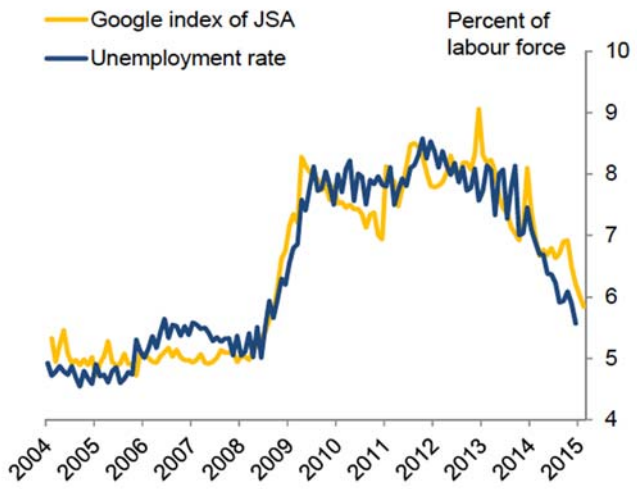
[71] See, Susan N. Houseman and Michael Mandel, eds., Measuring Globalization: Better Trade Statistics for Better Policy (Kalamazoo, MI: W.E. Upjohn Institute for Employment Research, 2015).

[72] Diane Coyle, "*Talking about the National Accounts: Statistics and the Democratic Conversation*," University of Manchester Economics Discussion Paper Series EDP-1506, May 2015.

If it is a welfare measure, it is doing a decreasingly effective job, but there has been too little research by economists into what ought to replace it. A number of "dashboard" alternatives exist—as recommended by an influential 2009 commission of experts—but these consist of eclectic lists of indicators reflecting the interests of their originators, and there is no consensus about what to include.

If it is simply a macroeconomic or policy tool, GDP has become far too complex. In central banks and treasuries around the world, there is unease about making decisions affecting businesses and households on the basis of such a highly judgemental and significantly revised statistic. It is alarming to consider that Greece's future hangs on the estimates of the ratio of its debt to its GDP, given how much uncertainty there is about this latter figure.

Some economists urge alternatives. One option is using nominal GDP only, without the difficulties of making adjustments for prices. Others are strong advocates of another series the BEA has recently started publishing each quarter: Gross Output. This adds intermediate products to final value added and so double counts activity. Yet, it is a useful indicator of the economy's supply side capacity and may be a better guide to the business cycle.[73] More radically still, the Bank of England has even looked into whether online data, easily and cheaply gathered, could replace complex and expensive statistics, although it has no current plans to do so.[74]



Source: Bank of England Quarterly Bulletin

[73] Mark Skousen, "At Last, a Better Economic Measure," Wall Street Journal, April 22, 2014.

[74] N. McLaren and R. Shanbhogue, "Using internet search data as economic indicators," *Bank of England Quarterly Bulletin*, 51, no. 2 (2011): 134-40.

The Promise and Challenge of Big Data

How much scope there is for innovation in the collection of statistics is an obvious question. To what extent can the data revolution simply make conventional GDP (and other) statistics redundant? Already there are projects (such as MIT's Billion Prices project) or commercial equivalents that scrape websites and/or gather user-generated information. Search engines, social media, and cell phone data will in time become more useful as a source of economic information. For many purposes, this will be a faster and simpler source of information about the economy. Official statisticians ought to be asking themselves about the extent to which they can go digital in their data gathering and construction.

However, Big Data also holds serious challenges. Statisticians are careful to ensure they collect data from a sample that matches the overall population; with Big Data, the sample is rarely considered and often self-selected (for example, depending on who uses a certain website or search engine). In some cases, the data generated will be biased by the structure of algorithms or because the context is commercial rather than in answer to an official survey.

One important consideration is the legal framework for making datasets available. Official statisticians already do not have access to most commercial databases (such as the scanning data from stores) or if they do, it must be purchased. In any democracy, it would be difficult to countenance having policy rely on statistics owned by commercial entities with no obligation to share their collection methods or statistical processes, and no right for government agencies to share the information with the public. There would need to be debate about the appropriate legal framework before Big Data generated by search engines or social media could be used for any official policy purposes. It is hard to imagine that economic statistics will be unaffected by the data revolution, but these kinds of issues could prove difficult to resolve.

Conclusion

Almost since its birth, GDP has had vocal critics. Some environmental campaigners were proposing alternatives as early as the 1970s. Yet, for the most part, it has served as an unchallenged headline measure of economic progress around the world for more than 70 years. This is changing, and the swelling chorus of criticism is sounding from different quarters.

The reason is without doubt the fact that the economy, nationally and internationally, has been changing so substantially that GDP is an increasingly ill-fitting measure, serving none of its purposes as well as it used to. We are at the uncomfortable point of recognizing its shortcomings without having any consensus among either users of GDP or economists and statisticians about what might replace it—or even whether there should be a single headline

measure of the economy, or a dashboard of measures, just as a well-run company would never rely on a single key performance indicator (KPI).

It is almost a century since the economic profession debated to any extent the question of economic measurement; economists simply download the latest GDP figures without thinking about them, rarely even checking their conclusions when the data are revised, as they always are. It is time for economists to think seriously about measurement again.

The creation of GDP, and its development as an international standard, was the work of a decade or more. It will take as long to create its successor. Careful study of the effects of new technologies will be a vital part of the work. But so too will be debate about the purpose of measuring the economy, and if what we want is a broad measure of economic welfare, what that means for a prosperous and innovative (but unequal and resource-intensive) economy like the United States.

With Data, Will Regulators Show Humility or Hubris?

By Susan E. Dudley, Director, the George Washington University Regulatory Studies Center, and Distinguished Professor of Practice, Trachtenberg School of Public Policy & Public Administration

Technological change, rapid data generation, and greater interconnectivity are transforming the way we live and work. Will these changes also transform how government agencies regulate private activities?

To consider this question, let's go back 70 years to the 1945 writings of Frederich von Hayek on the use of knowledge in society. Hayek was critical of social planners' attempts to regulate the economy because "the 'data' from which the economic calculus starts are never for the whole society 'given' to a single mind which could work out the implications and can never be so given."

In awarding Hayek the 1974 Nobel Prize in Economics for his work, the Swedish Academy noted his conclusion "that only by far-reaching decentralization in a market system with competition and free price-fixing is it possible to make full use of knowledge and information" that is dispersed among individuals in society. Does the current data movement change that fundamental insight? Some experts, like Harvard Law School's Cass Sunstein, have suggested data innovations mean that "in the modern era, regulators are in a far better position to collect the dispersed information of the public" to conduct the economic calculus needed to design regulations that improve public welfare.

Some regulation *is* necessary to establish clear rules that give people the confidence to invest, enter into contracts, meet untapped consumer needs, and reap rewards of hard work and innovation. In the United States, however, there is growing concern that our regulatory system has gone beyond the rules needed for an efficient, competitive market and may be a drag on productivity.

While data and communications technology may improve our ability to design regulations, these advances also make the regulations themselves less necessary. Many of our regulations are designed to account for asymmetric information, which leaves consumers vulnerable to unaccountable sellers. New technologies and social media have changed that by enabling individuals to learn, not only from their own experiences, but from others', and reputations may thrive or fail based on customer reviews.

In the hands of entrepreneurs who are subject to competitive pressures and a light regulatory hand focused on protecting privacy and property, data and the Internet of Everything can yield innovations beyond our imagination. For this to occur, government regulators must resist the

temptation to think that more data should be used to design more detailed interventions in private activities.

Instead, they should be guided by the principle of "epistemic humility," appreciating that many problems do not need a collective solution and valuing the role competition and choice play in regulating undesirable behavior. When regulation is necessary, policies should be designed in ways that encourage competition and allow for experimentation, such as the natural experiments that emerge when policies are developed at state and local levels.

They should also appreciate that behavioral insights, while important, must be applied to regulators too. Like everyone else, government actors are susceptible to what behavioral psychologists call "confirmation bias." Regardless of what data they collect or what analytical requirements they face, their single-mission focus will lead them to discount data, research, values, and perspectives that do not corroborate their preferred regulatory action.

Ever-faster data generation and greater connectivity bring us to a regulatory crossroads. Will regulators try to use these data to achieve greater control over private resources? Or will they have the humility to "marvel" (as Hayek did) at the ability of price signals in a competitive marketplace to combine dispersed information and induce individuals to act in ways that benefit society as a whole? Only time will tell.