The Economy of Things

Extracting new value from the Internet of Things

IBM Institute for Business Value

Executive Report

Electronics Industry

Transforming businesses as the Internet of Things expands

As a global electronics company, IBM understands the issues facing the high-tech industry and the continuous transformation required to thrive. Across the industry, companies are turning their attention from business equipment to a new generation of connected devices that will transform not just the electronics industry, but many others. The IBM Global Electronics practice uniquely combines IBM and partner services, hardware, software and research into integrated solutions that can help you deliver innovation, create differentiated customer experiences and optimize your global operations.

From the Internet of Things to an Economy of Things

Thanks to the Internet of Things (IoT), physical assets are turning into participants in real-time global digital markets. The countless types of assets around us will become as easily indexed, searched and traded as any online commodity. While some industries will be tougher to transform than others – those with physical limitations, such as manufacturing, will be harder to digitize – untold economic opportunities exist for growth and advancement.

Our research shows this will create a new "Economy of Things" with significant consequences. Here, we explore this transformation, including what could happen to industry profit pools, as well as the likely impacts on existing players in different industries.

Executive summary

With the invention of the printing press, Johannes Gutenberg reduced the marginal cost of copying and distributing information by an order of magnitude. As the printing press matured and scaled, books and the information they carried were transformed from being luxuries for the wealthy into everyday necessities.[1]

The printing press made information cheap. The Internet made it almost free. Indexed, searchable and infinitely available, changes in the economics of digital information such as online news have been revolutionary and disruptive. Information may be as valuable and powerful as ever, but where the invisible hand of the market is not tied down by copyright laws, a marginal distribution cost of zero inevitably means a market-clearing price (the price at which the market can avail of it) that is also zero.

The widespread availability of personal computers and mobile phones brought liquidity to markets in information and for anything that could be fully represented, bought or sold entirely online, including: music, movies, traffic information, weather, news, stocks, bonds and even airline tickets. The easier it was to digitally represent the item, the faster a liquid market emerged to support that commodity.

The reach and power of this revolution has had limits, however. And they are primarily to do with the intersection between the digital world and the physical world. The greater the degree to which a marketplace depends on information and actions in the physical world, the lower the impact.

The IoT can create liquid marketplaces of physical assets by enabling real-time discoverability, usability and payment.

Instrumentation and digitization can revolutionize credit and lending by building more accurate pictures of risk.

Insights from IoT devices in industries that are not technology-intensive could yield substantial gains in efficiency.

Figure 1

The IoT will more than just connect and automate systems, it will create an Economy of Things

So while industries like newspapers and music have been completely transformed, the impact on industries like retailing and manufacturing has been much less. Companies like Amazon have had a big impact on retailers, bringing price transparency and global inventory availability into markets that were previously fragmented and information poor.

Many industries still retain their essential structure and participants even if the Internet has brought great transparency to the business as a whole. The industries least transformed by the Internet are the ones with the most unstructured or unavailable information.

From real estate to trucking to farming, many industries lack the ability to easily represent all their information digitally and to provide an integrated marketplace in which to build liquid transactions. Once products and assets leave the controlled environment of warehouses, factories and offices, it has traditionally been difficult to digitally represent their identity or status. Without that, it is challenging to create a liquid, digital marketplace for the asset, product or service.

The Internet of Things (IoT) is now poised to bring the same real-time information and liquid marketplaces by enabling searching, managing and monetizing assets in the physical world (see Figure 1). That won't just mean smart homes that light up when you arrive or washing machines that text you when the cycle is done. The IoT will turn physical assets into participants in real-time global digital markets.

We call this the "liquification of the physical world." Assets around us will become as easily indexed, searched and traded as any online commodity. The Internet of Things will become the Economy of Things. To explore the impact of this transformation, we first look at a historical case of digital industry disruption, then present the findings of macro-economic case studies that we developed in collaboration with Oxford Economics.

Lessons from the past: A full lifecycle of industry disruption

So far, forecasts of disruption have been primarily just interesting speculation. Instrumentation and data-driven transformation have been underway in a number of industries, but are far from complete. To get a better understanding of what a full cycle – of disruption, transformation and rebirth – looks like, we studied an industry that has completed the full cycle: Air transport.

Starting in 1953, IBM pioneered the digitization of the global airline industry.[2] The starting point was the Semi-Automated Booking & Reservations Engine (SABRE), the world's first digital online reservation system created by IBM for American Airlines. By the 1970s, online reservation systems were standard and nearly every seat on every flight in the world was part of a real-time global marketplace.[3]

Airlines, however, were not much of a marketplace at the time, since every flight, price and schedule was controlled – within the U.S. by the Civil Aeronautics Board and globally through a network of bilateral treaties. Air travel was expensive and strictly controlled.

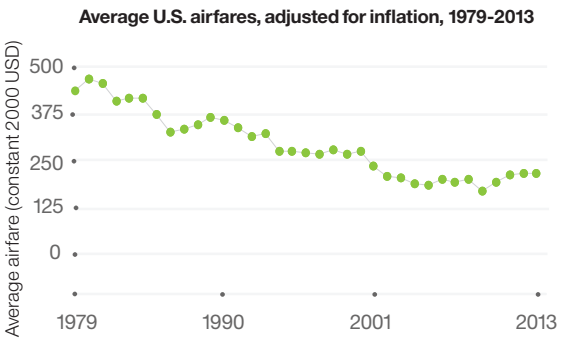
In 1978, the United States abolished much of the regulatory infrastructure on air transport pricing. The result was not just a free market in air travel, but one of the first markets where every physical asset was digitized and placed into a single global online marketplace. The result was a radical transformation of the entire airline industry, first in the U.S. and then globally.[4]

Armed with detailed information about their own asset utilization, available seats and schedules from online systems, the first thing that airlines did was try to improve their asset utilization, increasing both flight hours flown by planes each day and developing pricing systems to sell empty seats. The predictable result, in addition to increased competition, was excess capacity and plunging prices (see Figure 2).

Indeed, prices for air travel are roughly half what they were prior to deregulation and the industry itself is vastly larger and more efficient. In the 1970s, typical industry load factors were just about 55-60 percent and the average plane flew between 6-7 hours per day. Today, most

Figure 2

As a result of digital asset management, fares for air travel have halved since deregulation in 1978



flights average closer to 85-90 percent full and the most efficient airlines have planes operating up to 14 hours every day.[5]

Consumers and airline-related industries have benefitted enormously from this transformation. Airlines themselves have struggled. Legacy costs including restrictive labor agreements and poorly utilized infrastructure have driven nearly every major U.S. airline through at least one bankruptcy restructuring. Between 2000 and 2012, investors in the airline industry lost a cumulative USD 44 billion (see Figure 3).[6]

Even as the airlines were plunging into bankruptcy, the companies that manage these complex online marketplaces for them were sustainably profitable. When it was spun out of

Figure 3

Airlines have struggled through multiple bankruptcies since 2000

American Airlines in 1999, the online reservation engine SABRE was worth more than its parent company. SABRE even faced anti-trust investigation over fears that its control of the distribution system gave American Airlines an unfair advantage.[7]

The story does not end, however, with airlines going bankrupt and online marketplaces becoming all-powerful. Today, the U.S. airline industry is once again solidly and consistently profitable for the first time since deregulation (see Figure 4).

From this 50-year saga of transformation, we believe it is possible not only to validate the realism of our case studies in other industries, but also to draw some good conclusions about viable strategies for companies facing their own digital market transformations from the IoT.

Figure 4

Airline industry revenue has been steadily increasing, with airlines once again worth more than their distribution systems

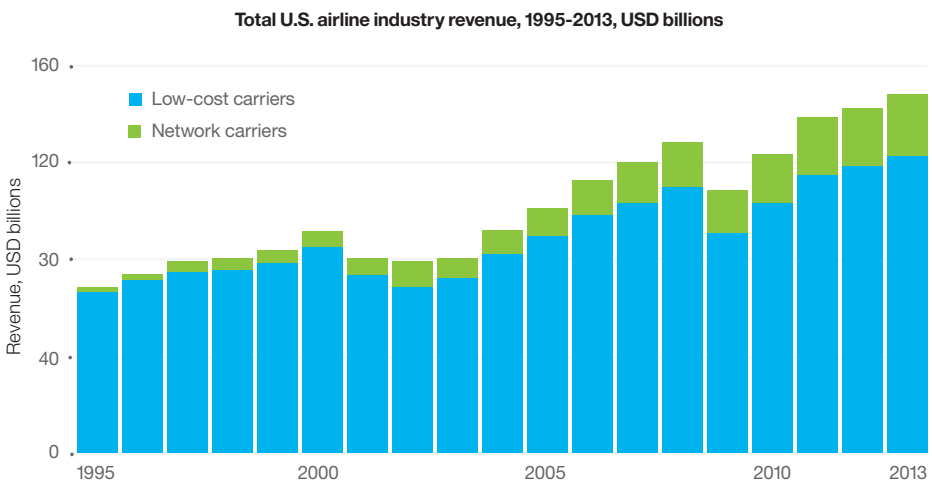
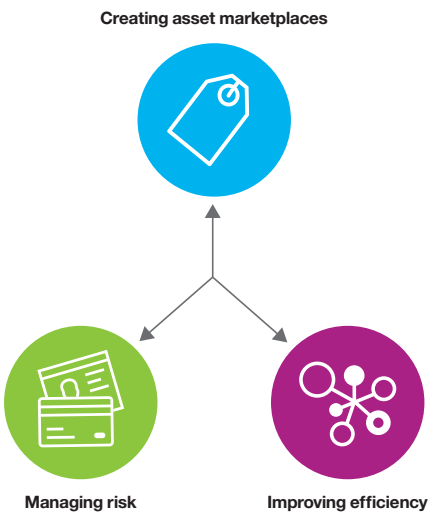


Figure 5

The economic models were constructed around the three vectors of disruption from the IoT



Modeling future transformation: Three vectors of disruption

What are the means by which the IoT will transform industries? To answer this and other questions, we developed case study macro-economic models in collaboration with Oxford Economics New York and London. Each model was designed to best represent the industry and geography being analyzed.

Our models of marketplace transformation were structured in terms of three vectors of disruption from the IoT: asset marketplaces, risk management and efficiency (see Figure 5).[8] The creation of asset marketplaces unlocks excess capacity of physical assets and enables instant search, use and payment for available physical assets. Radical re-pricing of credit and risk supports digitally managed risk and credit assessment, and virtual repossession and reduced moral hazard. Improved operational efficiency allows unsupervised usage of systems and devices, and reduces transaction and marketing costs.

In this report, we feature modeling results for three industries: commercial real estate, SMB lending and farming. While the models are industry-specific, the conclusions are scalable. They support a cohesive and globally relevant argument about digital marketplaces and new economic value from the IoT that companies must begin to prepare for.

Creating asset marketplaces

In the 1960s and 1970s, digitizing the market for airline seats was a colossal undertaking, requiring enormous manual intervention and data entry to keep an up to date global record of airline seats and aircraft movements. Today, battery-powered Bluetooth beacons and smartphones can be used to instrument all kinds of new markets and assets that were previously too complex or costly to track and manage.

The number of industries that are likely to be digitized and instrumented to unlock value from previously illiquid assets is enormous. Working with Oxford Economics, we modeled the commercial real estate industry to understand its transformation by the IoT.

Case study: Commercial real estate

The world of commercial real estate is very complex. There is a vast amount of space: 12B square feet in the U.S. alone; but only 67 percent is utilized.[9] Supply is not monolithic; 90 metropolitan areas account for 5.7B square feet of space.[10] Large tenants dominate the market: those occupying more than 50,000 square feet account for 36 percent of all rented space.[11] Demand for commercial office space is a function of geographic, cultural, strategic and industry considerations. For example, the median square footage per employee in a U.S. law firm is four times that of a U.S. call center and 5.5 times that of office space in China.[12] The commercial real estate market suffers high turnover rates, is often sub-optimal and illiquid.

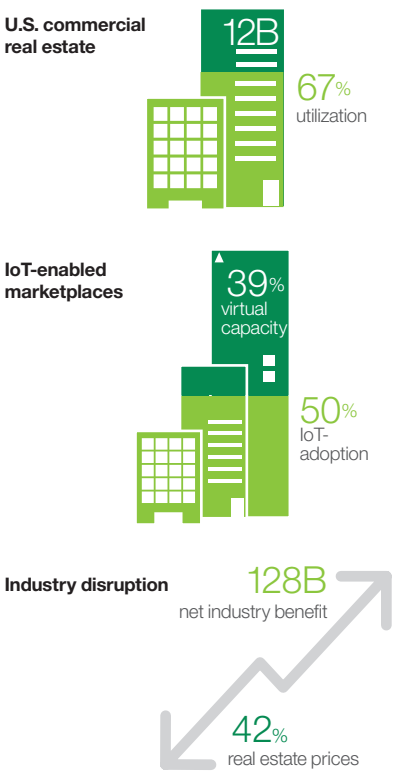
The IoT can help correct this market failure by instrumentation and digitization. Sensors, coupled with understanding of utilization, can create liquid marketplaces of real estate by enabling real-time discoverability, usability and payment. For example, as real-estate assets become digitally tagged, managed and shared, new services and marketplaces are being built to rent space during off-hours and offer conference rooms as classrooms. Vendors are already enabling these technologies and the number of digital marketplace services associated with them is growing rapidly.

Carsharing services improve auto and fleet utilization

Daimler's moovel GmbH offers the car2go carsharing service, the Park2gether platform and the moovel smartphone app. car2go is available in 26 cities in Europe and North America with more than 800,000 users. The first carsharing system in the world without fixed rental locations, car2go is creating a new segment and expanding to commercial fleets to improve fleet capacity utilization and cost. Park2gether is another innovative solution for searching and reserving parking spaces in cities.

Figure 6

Real-time markets for commercial real estate can increase capacity, lower real estate prices and increase overall profitability of the industry



We modeled the potential of this transformation in the U.S. commercial real estate market using 2014 office space and price estimates. Based on 50 percent behavioral adoption rates of IoT technologies, we analyzed the impact of unlocking capacity from vacancies, shadow space, hoteling and "hot-desking" (workspace sharing), as well as improved utilization hours. The expected result: a remarkable 39 percent increase in available space.

Our model shows that the infusion of an additional 39 percent capacity can drive a 42 percent reduction in price per square foot. This effective additional space will not become available overnight, nor will it be evenly distributed. But even small amounts of capacity coming online can have a huge impact on pricing and market expectations. As real estate rental prices fall, the industry and consumers, both existing and induced, will see a benefit of USD 142B per annum. Producers or lessors in this case would struggle, seeing a USD 14B loss as new marketplaces emerge offering alternative, lower-cost office space options. Even as profit pools shift in this transformation, the net benefit of USD 128B per annum will mean lower costs and greater productivity for the industry (see Figure 6).

As adoption of new commercial real estate services increases, consumer behavior could drive higher price sensitivity and lower margins as competition increases. Our model allows interactively exploring these effects for alternate net benefits to the industry ranging from USD 96B to USD 154B per annum.

Managing risk

As sweeping as the transformations are that will come from unlocking the capacity of physical assets, it is only one part of the industry transformation to come. Another area that promises vast new opportunities is the accurate pricing of credit and risk. The provision of credit and management of risk today in many economies is a crude business, as crude as advertising was in the era of newspapers and television.

Instrumentation and digitization enabled by mobile phones and the IoT promise a revolution in how credit and risk are managed. Combining device instrumentation, digital money, GPS logs and social networks, it will be possible for financial institutions to build much more accurate pictures of risk and simultaneously reduce the cost of repossession. Working with Oxford Economics, we modeled the impact of the IoT on SMB credit markets in South Africa.

Case study: SMB credit in South Africa

The credit market for small and medium businesses (SMBs) in South Africa represents a very interesting case study. The SMB credit market in South Africa is very polarized. A sophisticated banking system serves large enterprises and formal SMBs with credit and other financial services. But informal SMBs, accounting for 51 percent of the SMB market, have little to no access to reasonably priced credit and amount to only 8 percent of all bank lending.[13, 14] The market failure is two-fold: financial institutions have no credit profile to lend against and no reliable methods of contract reinforcement.

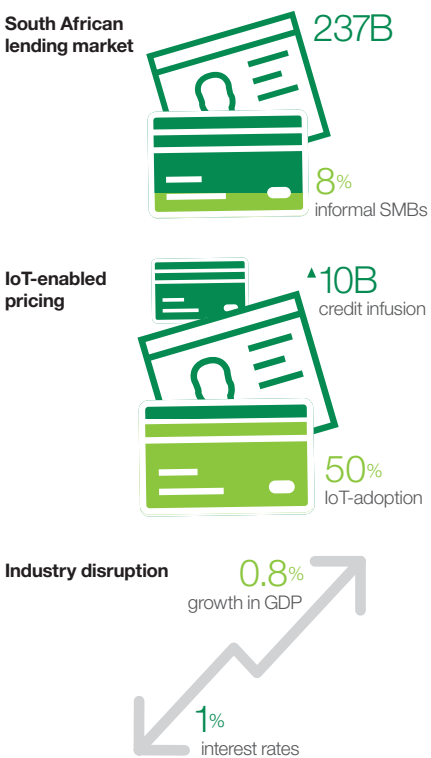
The IoT can help address these market failures by providing very granular data on users and usage of assets. Financial institutions could better understand and price risks associated with informal SMBs that were previously too opaque to deal with. Remote tracking and virtual disabling of assets and devices could help improve borrower behavior and reduce loan delinquency.

Digital verification reduces lending risk

Bancoomeva is a financial organization that is part of the Coomeva Group with a long history of issuing credit to the unbanked population. Bancoomeva is primarily a personal banking company with 90 locations in 40 cities in Colombia and a customer base of 300,000. Using digital ID verification, the bank's mobile loan sellers are now armed with qualifying data on credit history and loan behavior that decreases risk, and increases closing ratios and customer access to credit.

Figure 7

By turning the usage history of devices into credit-rating data, the IoT can transform credit and risk pricing in South Africa



Informed by the role information opacity plays in the informal credit market in South Africa, we constructed scenarios where IoT technologies reasonably allow for capture of up to 50 percent of the informal SMB credit market.[15] By accessing 50 percent of informal SMBs, the quantity of credit supplied could increase by USD 10B in 2014 dollars. This is equivalent to a 9 percent increase in total corporate lending. The combined effect of virtual enforcement reducing the cost of lending could provide up to 1 percentage point reduction in interest rates (see Figure 7). To a washerwoman choosing between buying a washing machine on credit and four hours of hard laundry labor a day; access to reasonably priced credit represents a path to prosperity.

Over time, the expansion of credit has enormous potential to grow the broader economy. Using the Oxford Economics global economy model we estimated that by 2020, even in isolation, this infusion of credit to the informal SMB sector could result in a 0.8 percent growth in South African GDP.

Improving efficiency through insights

Finally, there are whole sectors of the economy where information technology is yet to make a significant impact. In these sectors, not only is there the possibility to create new markets and better manage risk, but the opportunity is highest to create entirely new value.

Historically, industries that are not technology-intensive have represented 49 percent of the US economy.[16] The IoT will bring the benefits of the information revolution to these industries. Working with Oxford Economics, we modeled the sector of the economy with the lowest IT intensity: farming, where IT accounts for just 1 percent of all capital spending.[17]

Case study: The frontiers of farming

Agriculture is a driving force of the economy, but it remains a challenging business. For all the scientific progress that has been made, much remains to be understood. Crop yields are the result of complex biochemical and physical interactions of land, seed and weather over a growing season and are subject to uncertain variation. Within the space of just two years, U.S. average corn-for-grain yield varied 39 percent from 123 bushels per acre during the drought of 2012 to a record 171 bushels per acre in 2014.[18] As a bumper sticker says, "Farming is legalized gambling." The challenge is to know what to do where and when to do it.

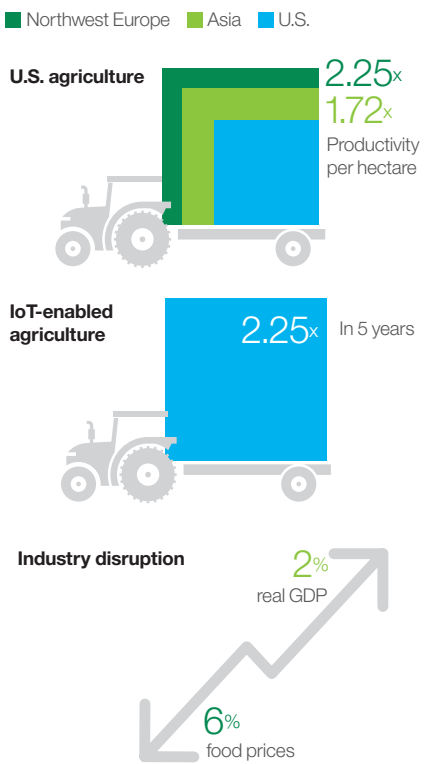
The IoT is at the center of a digital transformation in agriculture that addresses this challenge. Sensor technologies are enabling the coupling of real-time data collection with accurate position information to better correlate production decisions and farm yields with environmental factors.[19] Uniform field management is being replaced by intelligent variable-rate, site-specific treatments, thanks to an array of IoT technologies, including field sensors for detailed monitoring, instrumented farm equipment for optimized planting and spraying, and drones for large-scale surveillance. These technologies could enable more intensive farming of land and better-integrated farm management practices that will bolster productivity through efficiency.

Integrated IoT platform increases farm productivity

OnFarm, founded in California, one of the richest agricultural regions in the world, integrates field and cloud data from multiple partners into a single cloud-based farm information system. OnFarm's platform aggregates and analyzes real-time data – from soil moisture data to weather data to image data on crop health – for better farm management. Farmers gain insights through an intelligent dashboard to make more informed decisions that improve farm productivity and profitability.

Figure 8

By instrumenting and digitizing the agriculture process, the IoT can improve productivity in farming



The relative abundance of arable land in the U.S. has lent itself to maximizing scalable efficiency of capital equipment rather than the output of land. While studies indicate that North America leads in agricultural output per worker,[20] Northwest Europe's land productivity is 2.25 times greater per hectare than the U.S. and Asian land productivity is 1.72 times greater.[21] Informed by the potential of digital agriculture to achieve the benefit of the world's best labor and land management practices, we examined the economic value from the U.S. realizing the highest land productivity of Northwest Europe over a time horizon of 5 years. By increasing land productivity to the same level as Northwest Europe, the U.S could achieve a 2 percent increase in real GDP from an increase in agricultural gross value added (GVA) of 125 percent.[22] This would also result in a 6 percent drop in food prices (see Figure 8).[23]

According to the FAO, to feed the estimated 8.5 billion world population in the year 2025, current world food production will have to more than double.[24] Instrumenting and digitizing every step in the agriculture process could yield significant return for farmers and their ecosystem partners to meet the rising need.

How to prepare for digital transformation

Warren Buffet famously remarked that if a farsighted capitalist had been present at Kitty Hawk, he would have done his successors a huge financial favor by shooting down the Wright brothers before they could fly the first airplane.[25] His statement seems to be an accurate (if bleak) assessment of the airline business: the U.S. airline industry has not, collectively, made a profit since 1978.

As other industries start to go through similar cycles of digital transformation enabled by the IoT, we can help prepare companies for this transformation. Important actions include:

Evaluate opportunities for new digital marketplaces
From airlines to taxicabs, hotels and office cubicles, traditional measures of capacity have not been well understood. Our case studies show that capacity utilization of fixed assets is much lower than was believed prior to instrumentation and the ultimate potential is even higher. As the IoT instruments everything around us and unleashes significant new capacity, new marketplaces will emerge everywhere.

As these new marketplaces evolve, it will become apparent that it's not just about asset utilization: it's about whole new business models. Higher asset utilization rates will lead to price wars from excess capacity. Online marketplaces will become more valuable and powerful than big market participants. Existing market participants will restructure to take out cost. As direct costs come under control and asset utilization becomes optimized, market participants will turn their attention to slashing distribution costs and building direct client relationships, making the market power of intermediaries ephemeral.

Recommendations: Electronics executives must take into account that the digitization of physical assets will impact not just industry players, but also the way products and services are experienced. Companies should begin to use IoT instrumentation to obtain a better understanding of asset utilization and identify their roles in digital marketplaces that could evolve with respect to under-utilized assets. Electronics companies will need to lead the way – not just participate – in the Economy of Things, by connecting devices with back-end systems to support new marketplaces.

Analyze IoT data and act on the insights

Different industries and economies will experience a mix of different effects from the IoT, as our case studies demonstrate. The IoT will create growth, but profit pools will not be preserved. Nor will the distribution of benefits be even. But, in so transforming the physical world around us, the Economy of Things will unleash unprecedented opportunities for the global economy.

Industry growth and transformation are not the same as profitability. The airline industry is an order of magnitude larger today than in 1978. Massive growth in air travel has created enormous value for hotels, tourism, airports and aircraft manufacturers, if not for the airlines themselves. Though some marketplace participants will struggle like this, at a macroeconomic level we are all winners in the transformation of industries by the IoT.

Recommendations: The IoT is no longer just about instrumenting devices, it is about using insights from devices. Electronics executives must understand that IoT data generated from devices has potential for insights across the value chain. The winners in this transformation

will use IoT data to obtain deep, personal insights and make real-time decisions, integrating real-time data and insights directly into business operations. In the process, companies must redefine how they control that data and use it to securely deliver value across the system while maintaining privacy.

Begin the journey for collaborative value

The cycle time for change is compressing. Though it is early, the rate of these industry transformations is getting much faster. What took from 1960 to 2010 in the airline industry will probably be happen in other industries in less than a decade. Today, the ability to create fully distributed online marketplaces that can operate securely without transaction fees will further accelerate this transformation.

Where consumers lead, enterprises will follow. Consumers have been much faster to embrace online marketplaces, using aggregators and jumping on new apps and services to take advantage of good deals. Consumers consistently have embraced these opportunities before enterprises, so whatever consumer marketplace services exist today, expect to see enterprises adopting them tomorrow.

Recommendations: Companies need to seize the opportunities from IoT industry disruption to their advantage. A first step is to start with projects that promise clear ROI – implementing asset optimization, and designing products and services to take advantage of intelligent systems. Leaders in this transformation will study usage patterns, refine their approaches and optimize their processes.

Explore our model assets
The model assets can be downloaded from the study landing page, ibm.com/business/value/economyofthings. They are interactive, allowing the user to explore alternate effects by varying the inputs to the models.

How can you profit from the Economy of Things?

Companies across industries must grasp the scale of IoT transformation that will occur over the next decade and get ready for its impact. These questions identify useful steps that executives across industries can take:

- What is your plan to manage products with IoT instrumentation and real-time insights?
- How will your IoT devices generate new value through improved asset utilization, risk management and efficiency?
- In what ways can your organization analyze IoT data and act on the resulting insights to monetize physical assets before the rest of the industry catches up?
- How will you define your role(s) in new marketplaces that emerge in the new Economy of Things?

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Related publications

Pureswaran, Veena. "Device democracy: Saving the future of the Internet of Things." IBM Institute for Business Value. September 2014. www.ibm.biz/devicedemocracy

Pureswaran, Veena, Sanjay Panikkar and Nair, Sumabala. "Empowering the edge: Practical insights on a decentralized Internet of Things." IBM Institute for Business Value. March 2015. www.ibm.biz/empoweringedge

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Acknowledgments

The authors would like to recognize the contributions of: Oxford Economics for their collaboration on this study, as well as Paul Brody, former Vice President and North American Leader for the IBM Mobile and Internet of Things practice. We also thank IBM SMEs across the various industries modeled for their reviews and feedback, as well as Angela Finley and Joni McDonald of the IBM Institute for Business Value for helping to produce this executive report.

Notes and sources

1 Kreis, Steven. “The printing press.” http://historyguide.org/intellect/press.html

2 “Sabre: The first online reservation system.” http://www-03.ibm.com/ibm/history/ibm100/us/en/icons/sabre/. Accessed on March 01, 2015

3 Our history, Sabre: http://www.sabre.com/index.php/about/our-history. Accessed on March 1, 2015

4 Airline deregulation: The concise encyclopedia of economics. http://www.econlib.org/library/Enc/AirlineDeregulation.html. Accessed on March 01, 2015

5 Bureau of Transportation Statistics, IBM Institute for Business Value analysis

6 International Air Transport Association, IBM Institute for Business Value analysis

7 Phillips, Don. “AMR to spin off its stake in Sabre.” Washington Post. http://www.washingtonpost.com/wp-srv/WPcap/1999-12/15/073r-121599-idx.html. Accessed on March 01, 2015

8 Brody, Paul and Veena Pureswaran. “Device democracy: Saving the future of the Internet of Things.” IBM Institute for Business Value. September 2014. www.ibm.biz/devicedemocracy

9 Miller, N. (2014). “Workplace Trends in Office Space: Implications for Future Office Demand.” http://www.normmiller.net/wp-content/uploads/2014/04/Estimating_Office_Space_Requirements-Feb-17-2014.pdf

10 ibid.

11 Miller, N (2014) and Miller, N (2012). “Estimating Office Space per Worker.” https://www.ccimef.org/pdf/2012-6.Estimating-Office-Space-per-Worker.5-1-12.pdf

12 ibid.

13 IMF, IFS data via Haver. Oxford Economics analysis.

14 Berg, G. and M. Fuchs. “Bank Financing of SMES in Five Sub-Saharan African Countries: The role of competition, innovation and the government.” The World Bank, 2013.

15 “Literature Review on Small and Medium Enterprises’ Access to Credit and Support in South Africa” National Credit Regulator 2011. Relating to FinScope Small Business Survey, South Africa 2010. Oxford Economics and IBM Institute for Business Value analysis.

16 Jorgenson, Dale W., Harvard University, Mun Ho, Harvard University and Jon Samuels, Bureau of Economic Analysis. “Long term estimates of U.S. productivity and growth.” http://www.worldklems.net/conferences/worldklems2014/worldklems2014_Ho.pdf

17 ibid.

18 USDA National Agricultural Statistics Service. http://www.nass.usda.gov/Charts_and_Maps/Field_Crops/cornyld.asp; IBM Institute for Business Value analysis.

19 IBM Institute for Business Value analysis. http://www.gps.gov/applications/agriculture/

20 Fuglie, Keith and Sun Lin Wang (2012) New Evidence Points to Robust But Uneven Productivity Growth in Global Agriculture. http://www.ers.usda.gov/amber-waves/2012-september/global-agriculture.aspx#.VXOpPGMkHp8

21 Fuglie, Wang and Ball (2012). http://www.ers.usda.gov/amber-waves/2012-september/global-agriculture.aspx#.VRsJMCm7OHw. Data from the FAO of the United Nations.

22 United States Department of Agriculture. Economic Research Service. http:/www.ers.usda.gov/data-products/international-agricultural-productivity.aspx; Oxford Economics analysis.

23 FAO food price index. http://www.fao.org/worldfoodsituation/foodpricesindex/en/; Oxford Economics analysis.

24 FAO corporate document repository. Feeding the world: The search for food security. http://www.fao.org/docrep/U8480E/U8480E0a.htm

25 Lawson, Dominic, Robert Peston and Grant Ringshaw. “Warren Buffett: My elephant gun is loaded.” The Telegraph. September 2, 2002. http://www.telegraph.co.uk/finance/personalfinance/investing/shares/2774088/Warren-Buffett-My-elephant-gun-is-loaded.html

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Produced in the United States of America, June 2015

GBE03678 -USEN-03