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Can the Internet of Everything Bring Back the High-Growth Economy?

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INTRODUCTION

The United States and the other major advanced economies are currently stuck in a seemingly endless twilight of slow growth. The numbers are ugly: The April 2013 forecast from the International Monetary Fund predicts that economic growth in Europe will average only 1.7% over the next five years. Japan is projected to average only 1.2% growth. Germany, held up as a paragon of success, is expected to grow at only 1.3% annually.[1]

The United States is doing better than Europe and Japan, but not by much. The nonpartisan Congressional Budget Office is currently projecting that the underlying growth rate of the U.S. economy—the so-called 'potential' growth—is around 2.2% annually, compared to an average of roughly 3.3% in the post-war period.[2]

Both Democrats and Republicans in Washington, miles apart on most issues, have accepted the slow-growth scenario. That helps explain, in part, the political gridlock in Washington. An economy growing at barely over 2% per year doesn't generate enough income to pay for everything that Americans need: Social Security and Medicare for the aging population, defense spending sufficient to handle critical threats, and support for essential government investment in basic research, education, and infrastructure. The longer that the slow-growth assumption gets locked in, the more it becomes a self-fulfilling prophecy.

Yet we are not stuck with the slow-growth scenario and the endless and frustrating Washington policy debates about dividing a shrinking pie. Over the past year, a series of studies from research institutes and industry have laid out a compelling new vision of a high-growth future—one that that could revolutionize manufacturing and energy, create employment for the jobless generation, and bring back rising living standards.

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HOW MUCH DOES THE INTERNET OF EVERYTHING RAISE U.S. GROWTH?

We wanted to estimate the impact of the Internet of Everything on the U.S. growth rate. Starting with the McKinsey Global Institute projections, we assumed that the U.S. would get one-third of the $2.7 to $6.2 trillion in global gains from the IoE, which translates into $0.9 to $2.1 trillion. Because the U.S. is likely to be the technological leader in implementing the IoE, this one-third assumption is larger than the current U.S. share of the global economy.

Part of those U.S. gains will show up as an increase in measured gross domestic product, and part will show up in unmeasured increase in consumer surplus—that is, non-monetary improvements in welfare. We reviewed a variety of studies on the consumer surplus generated by today's Internet, including free web sites and services such as Wikipedia and YouTube. Our assessment was that it was reasonable to assume that two-thirds of the economic benefits of IoE will show up in gross domestic product, with the rest showing up in unmeasured consumer surplus, giving us a net addition to GDP of $0.6 to $1.4 trillion in 2025. This assumption reflects the projected heavy use of IoE in manufacturing, rather than consumer-oriented services.

Based on the long-term economic projections from the Congressional Budget Office, we start with $28 trillion in U.S. GDP in 2025. That gives us a projected GDP gain of 2%-5% from the IoE, translating into a 0.2 to 0.4 percentage point increase in the annual growth rate.

We note that this range, like all projections of the economic impact of new technologies, is highly uncertain. However, it gives a reasonable sense of the magnitude of the potential gain.

These new studies—from organizations such as the McKinsey Global Institute, GE, Cisco, and AT&T—describe the economic potential of a new wave of technological innovations known as the Internet of Everything (IoE)—also sometimes called the Internet of Things, the Industrial Internet or Machine to Machine.[3] (Though as discussed below, the Internet of Everything is a broader, more accurate concept than the other terms, encompassing much more than just 'things'.)

Taking the McKinsey projections as a base, we estimate that the Internet of Everything could raise the level of U.S. gross domestic product by 2%-5% by 2025.[4] This gain from the IoE, if realized, would boost the annual U.S. GDP growth rate by 0.2-0.4 percentage points over this period, bringing growth closer to 3% per year. This would go a long way toward regaining the output—and jobs—lost in the Great Recession.

Equally important, from the macro perspective, the result will be a shift to growth that is not just faster, but higher quality. Rather than being fueled by consumption and borrowing, the Internet of Everything will lead to an economy built on production and investment, with much more extensive education and training built right into the fabric of the economy rather than being separated out.

A NEW VISION FOR THE FUTURE

Why is the Internet of Everything a key element of a high-growth future? First, IoE is the natural extension of Internet-type connectivity to physical objects, so that things—such as factory equipment, cars, and buildings—are linked with data, people, and processes. It's already happening in large and small ways.

But simply saying that the Internet of Everything is about connecting things to the Internet is like saying that an automobile is about wheels—it's true, but misses the rest of the vehicle. The Internet of Everything is about building up a new infrastructure that combines ubiquitous sensors and wireless connectivity in order to greatly expand the data collected about physical and economic activities; expanding 'big data'

processing capabilities to make sense of all that new data; providing better ways for people to access that data in real-time; and creating new frameworks for real-time collaboration both within and across organizations.

The result: Individuals, companies, and governmental organizations will be able to near-instantaneously adjust decisions to a continually changing complex environment. We are already seeing the start of this, as drivers have become accustomed to using the traffic data from Google Maps—garnered from smartphones in cars—to change their routes on the fly.

More broadly, the Internet of Everything is essential for broadening the economic impact of the Information Revolution. Computers, routers, and smartphones are in every sector of the economy, of course. Nevertheless, up to this point, the Internet has had its biggest impact on data-intensive industries such as media, entertainment, and finance. David Kirkpatrick, CEO of Techonomy, makes the case that today's Internet is so far mostly serving as a "souped-up communications and information tool for individuals — a sort of phone/telegraph/library catalog on steroids."[5] Or as the venture capital firm run by entrepreneur and investor Peter Thiel has said, "We wanted flying cars, instead we got 140 characters."[6]

By comparison, the Internet of Everything potentially has the capability of transforming "physical" activities such as manufacturing, energy, transportation, healthcare, and public sector services such as waste collection. As we show later in this paper, many of these industries have not shown much productivity acceleration in the Internet era. But a network of sensors in a factory, for example, hooked to powerful data analysis capacity, could greatly improve the productivity and flexibility of production, and perhaps lead to a rebirth of manufacturing in the U.S.

Third, if the Internet of Everything is implemented, it could give us much better utilization of all of our assets, both physical and human. As we will see, the IoE would enable us to unlock more of the potential of workers by dramatically improving on-the-job training. That will reduce the skills mismatch between what the labor force can do and what employers need. Workers will become more employable.

> Rather than being fueled by consumption and borrowing, the Internet of Everything will lead to an economy built on production and investment, with much more extensive education and training built right into the fabric of the economy rather than being separated out.

The result will be a gain not just in labor productivity but in a much more important measure known to economists as multifactor productivity growth, which has slowed sharply in recent years. Effectively, an increase in multifactor productivity growth means that the U.S. will be able to increase its output with the same capital and the same workers. The result will be higher living standards.

The McKinsey report estimates the global economic impact of the Internet of Everything as being in the range of $2.7 trillion to $6.2 trillion annually by 2025. The GE report pegs the gain to global GDP at $15.3 trillion by 2030. On a global scale, Cisco projects that there is $14.4 trillion in "value at stake" over the next ten years in economic benefits for companies and countries that can successfully implement the Internet of Everything.[7] Cisco's calculations include better asset utilization, higher worker productivity, improved supply chain logistics, a better customer experience, and faster innovation.

Despite the lack of attention from Washington—or perhaps because of it—there is already tremendous momentum building up for the Internet of Everything. How do we make sure that

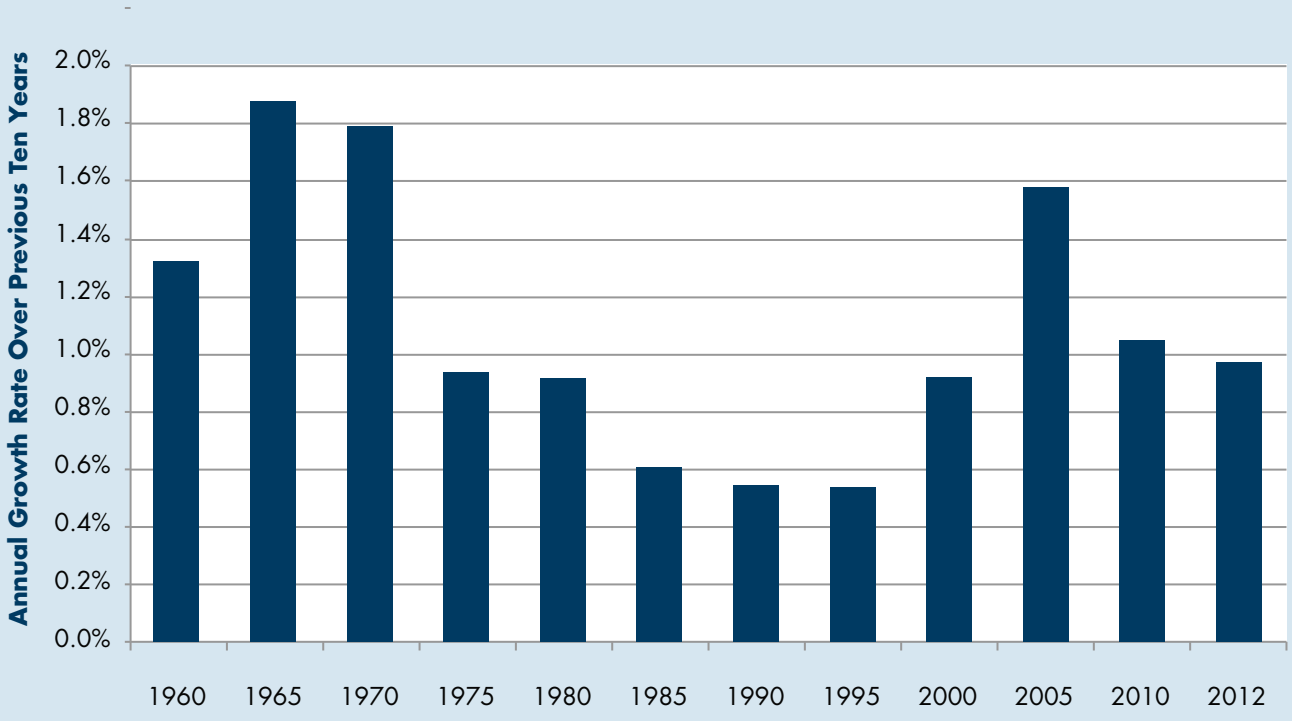
we get the economic benefits of IoE? How do we use the Internet of Everything to escape the slow-growth trap that has curdled the political debate across the developed world?

The Internet of Everything is not an easy concept to execute, from the technological, business, and regulatory standpoints. The physical world is complex and almost overpowering in the amount of data that it can produce, making a big data approach essential. One executive at GE notes that one sensor on a gas turbine generates 500 gigabytes per day of reported data, and there are 20 sensors on a turbine.[8] Moreover, until recently the technology to build inexpensive wireless links that could reliably and cheaply transmit large amounts of data did not exist.

Second, it will take time for industry to develop the appropriate degree of coordination among devices sold by different companies, with sufficient security. Writing on a Harvard Business Review blog, Christopher J. Rezendes and W. David Stephenson point out:

> Today, growing numbers of customers recognize how that data could inform their own operations, and even feel it is rightfully theirs, leading to battles over who owns and has access to what data, who is responsible for securing it, and a long list of other related questions. What's more, as systems built by different OEMs interact, there is infighting among them as to what constitutes sensitive or competitive intelligence.[9]

FIGURE 1: MULTIFACTOR PRODUCTIVITY GROWTH: SOME GAINS, BUT MORE ROOM FOR IMPROVEMENT
(GROWTH RATE IN U.S. MULTIFACTOR PRODUCTIVITY OVER PREVIOUS TEN YEARS)



Data: Bureau of Labor Statistics

Given these technical and business obstacles, the government has to refrain from throwing additional difficulties in the development and deployment of the Internet of Everything. For example, the Federal Trade Commission is in the process of holding workshops on "consumer privacy and security issues posed by the growing connectivity of consumer devices."[10] That's a good thing, but not if it leads to regulation that slows down the progress of the IoE.

BACKGROUND: THE IOE AND THE DEBATE OVER GROWTH

The Internet of Everything is arriving at a time when many economists are skeptical of the ability of innovation to accelerate the growth rate of developed economies, and in particular the U.S. economy. In an August 2012 working paper, economist Robert Gordon of Northwestern wrote: "Invention since 2000 has centered on entertainment and communication devices that are smaller, smarter, and more capable, but do not fundamentally change labor productivity or the standard of living in the way that electric light, motor cars, or indoor plumbing changed it."[11]

Gordon has been making the same point since the 1990s, but that doesn't mean he's completely wrong. In 2009, I wrote a cover story for BusinessWeek called "Innovation, Interrupted," where I argued that innovation across a wide range of fields over the previous decade had fallen short of expectations, with the important exception of the Internet and mobile.[12] In 2011, economist Tyler Cowen followed with his best seller *The Great Stagnation* that argued that the "low-hanging fruit"—the high-impact innovations—had already been plucked.

Indeed, if we look at the performance of the economic index known as 'multifactor productivity,' we can see some of the reason for the disappointment. Multifactor productivity, also known as 'total productivity' is the lesser-known cousin of labor productivity. Recall that labor productivity in a country is defined as the amount of output per hour of domestic work. Labor productivity can go up if companies provide more capital for each worker to use, in the form of faster computers, say, or better assembly machines. Alternatively, labor productivity can rise if companies outsource more tasks to other countries. Technically, that means companies increase their use of 'intermediate inputs'.

Multifactor productivity is a more comprehensive measure. Multifactor productivity goes up if the company can boost output without changing the amount of labor, capital, and intermediate inputs. In some sense it's a better measure of 'true' productivity gains. Big innovations push up multifactor productivity because they offer

MEASURING THE INTERNET OF EVERYTHING

It's important to note that our conventional measures of gross domestic product (GDP) may not be adequate to track the full impact of the Internet of Everything. There are several reasons for this. First, the sensors connected to the IoE will generate enormous flows of data. That suggests our definition of economic output—GDP—needs to be expanded to encompass not just goods and services, but data as well. Second, the Internet of Everything will create new opportunities for cross-border flows of data that will have great economic significance, but are not currently being well-measured.

However, on the positive side, the IoE will mean that we will have the opportunity to improve our picture of the domestic and global economies by actually directly tracking production and consumption of goods and services, rather than relying on indirect measures as government statisticians do now.

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"something for nothing"….increases in output without having to spend or invest more.

Multifactor productivity is a measure of the magic of capitalism—the ability to raise living standards far faster than the amount of capital or the amount of education. Basically, by being smarter and more innovative, we can create something out of nothing. Increases in multifactor productivity are unambiguously positive.

Unfortunately, the gains in multifactor productivity in recent years have been mediocre. Consider Figure 1, which shows the average annual multifactor productivity gain for the nonfarm business sector for ten-year periods.

> The Internet of Everything, if successful, would allow us to potentially wirelessly instrument entire factories, and give us far better links between the physical world and the digital world.

We can see that the low point was the decade ending in 1995, where multifactor productivity growth only averaged half a percentage point annually, a truly anemic performance. Given that Netscape introduced the first true web browser at the end of 1994, we can consider this the 'pre-Internet' era.

After the broad consumer and business dissemination of the Internet, multifactor productivity growth appears to run at roughly one percentage point annually, a half percentage point gain over the pre-Internet era. Should we be applauding that gain? Is the glass half empty or half full?

Studies have shown that the Internet has contributed to the acceleration of multifactor productivity growth. Still, one percentage point annually is still only back to the level of the 1970s, which is not remembered as a good decade for the U.S. economy. Moreover, the gain from the Internet is much less than many economists were predicting during the Internet boom of the 1990s. In the next section we will see some reasons for the shortfall, and why the Internet of Everything can help.

THE PROBLEMS IN MANUFACTURING

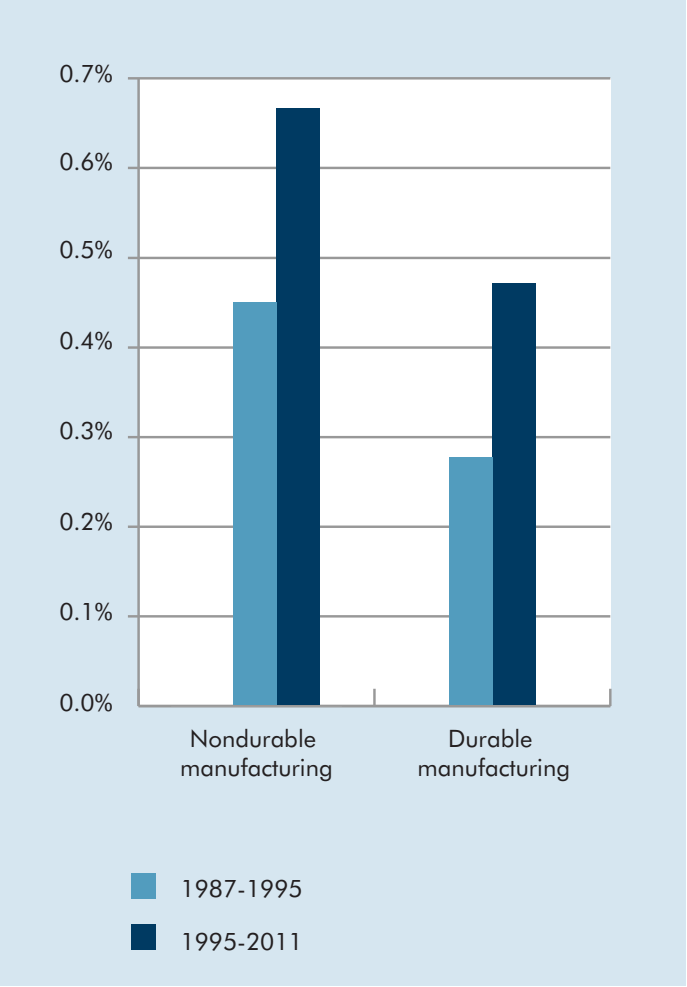
Since the mid-1990s, the Internet has clearly transformed data-intensive sectors such as entertainment and finance. However, heavy industry—manufacturing, construction, utilities, and the like—have been only partly affected by the Internet up to now. Yes, supply chains have been transformed by the ease of global communication. But the actual production process itself within factories and at construction sites has remained mostly disconnected from the Internet.

On first glance, it looks like American manufacturing is really doing much better in the Internet era. According to data from the Bureau of Labor Statistics, multifactor productivity growth in manufacturing accelerated from 0.8% in the period 1987-1995, to 1.6% in the period 1995-2011.[13] That's a decent jump, consistent with the idea that the existing Internet has benefitted factories.

But a closer look at the data suggests that most of the Internet era gains come from a small slice of manufacturing. The Bureau of Labor Statistics tracks multifactor productivity for 18 individual manufacturing industries, ranging from "machinery" to "plastics and rubber products." Out of those, a couple have seen outsize gains in the Internet era, principally the "computer and electronics products" industry.

But gains have been meager in other parts of manufacturing. Roughly 40% of manufacturing industries have seen negligible or even negative changes in multifactor productivity growth, comparing the pre-Internet to the Internet eras. For example, the very important food

FIGURE 2: U.S. MANUFACTURING: LIMITED GAINS IN THE INTERNET ERA (MEDIAN GROWTH RATE OF MULTIFACTOR PRODUCTIVITY)



Data: Bureau of Labor Statistics. Based on 18 manufacturing sectors.

manufacturing industry saw multifactor productivity growth slow from an 0.3% growth rate in the pre-Internet era to a -0.3% annual growth rate in the Internet era.[14]

The only industries with multifactor productivity growth in excess of 3% in the later period were computers and semiconductors. Overall, the median multifactor productivity growth rate has risen only moderately in both durable and non-durable manufacturing (as shown in Figure 2).[15]

This relative shortfall of productivity gains in 'physical' industries is holding back the developed economies. Can the Internet of Everything help?

THE REBIRTH OF INVESTMENT AND MANUFACTURING?

Stefan Ferber of Bosch Software recently wrote a post for a Harvard Business Review blog entitled "How the Internet of Things Changes Everything."[16] A recent report from GE on the industrial internet waxed equally poetic, saying "we believe that the second, most powerful, and disruptive wave of the Internet Revolution is arriving now…..Nothing like this has been seen before."[17]

Yet beneath the hype is a rather large nugget of truth. Organizing the digital world with the Internet was a major accomplishment, but applying the principles of the Internet to the physical world requires an even higher level of sophistication and capabilities.

The Internet of Everything, if successful, would allow us to potentially wirelessly instrument entire factories, and give us far better links between the physical world and the digital world. The gains would come not just in manufacturing but in other physical industries as well, such as transportation and power generation. GE estimates that there are "over 3 million major 'things that spin' in today's global industrial asset base." Each of these can be instrumented and monitored separately, for speed, for position, and for amount of work being done.

Obviously the Internet of Everything requires an enormous amount of investment before it comes to fruition. It's very difficult to retrofit current equipment with necessary sensors, so companies have to be persuaded that it makes sense to invest in upgrading their entire systems.

As the saying goes, this is both good news and bad news. The good news is that the Internet of Everything could eventually spur a much-needed investment boom by encouraging companies to invest in new equipment. The bad news is that companies are going to wait until they see proof of the gains before they lock in their spending plans. That may slow down the arrival of the Internet of Everything.

However, there is one thing that could accelerate the process: Environmental and energy concerns. A recent AT&T-sponsored report from the Carbon War Room—an organization founded by Richard Branson that focuses on market-based solutions to climate change—estimates that machine to machine communications, a subset of the IoE, could reduce greenhouse gas emissions by 9.1 million metric tons annually, through a variety of cost-saving measures.[18]

> The role of Washington is to provide a supportive environment for innovation and investment in the IoE.

One example: The 'smart' trash and recycling stations from BigBelly Solar can sense how full or empty they are, and communicate wirelessly with the trash collection agency. Armed with this information, pickup trucks can go directly to the bins that are full, while skipping trash and recycling stations that are empty. The result: Cleaner streets, lower fuel usage, and fewer greenhouse gas emissions. Big Belly reports that its technology is used in more than 30 countries.

EDUCATION, TRAINING, AND JOBS

So far we have not mentioned jobs. If the Internet of Everything accelerates productivity growth, won't it make the job problem worse? In a word, no. In fact, the Internet of Everything has the potential for creating jobs in the U.S. and other developed countries, while raising living standards.

For one, most domestic manufacturing industries have lost competitiveness precisely because they have not been able to use the Internet to raise their multifactor productivity. A factory in China or Mexico is always going to be able to employ cheaper workers, so the U.S. comparative advantage has to be the use of cutting edge technology. It's going to be a lot easier to expand employment at a U.S. factory if it uses the Internet of Everything to produce higher-quality goods at a lower cost. As the GE report notes, "to be consistent with a sustained rise in wages and living standards, a revival of manufacturing in an advanced economy needs to be driven by higher productivity growth."

The Internet of Everything also has the potential to completely transform the training of workers. Because one essential feature of IoE is better feedback loops between things and people, it becomes easier to build worker training right into the equipment itself.

One illustration: Cisco has embedded sensors in a basketball, which turns it into a training tool. As one article notes:

> "Although it looks and handles like an ordinary basketball, it can measure factors such as arc and rotation in real time. Such variables might be useless to a sharpshooter like Steve Nash, but could pinpoint correctable technique errors for the Dwight Howards of the world."[19]

Potentially, a networked basketball could be used to train anyone who wanted to learn the game.

The networked basketball may sound like an offbeat example, but it directly addresses a key problem that domestic companies, particularly manufacturers, repeatedly complain about: The lack of enough skilled workers. The solution, of course, is more on-the-job training, but that's expensive for companies, requiring them to pay an experienced trainer as well as the new worker. If on-the-job training could be made much cheaper and more efficient with the IoE, then it would be easier for companies to justify hiring unskilled and semi-skilled workers. The U.S. would be able to chip away at the pool of unemployed workers and raise the skill level of the workforce.

More generally, the Cisco report notes that "[s]ocialization of knowledge flattens the skills curve; IoE maximizes access to human talent pools at lower cost." This is an absolutely crucial point. One of the biggest drags on growth is the inability of much of the U.S. and

global population to easily reach the skill levels needed for the increasingly sophisticated tasks of today's economy.

Many economists have lauded the German apprenticeship system as a model for how to train workers for skilled positions, without forcing them to sit through college courses that may not be necessary. The Internet of Everything will allow us to build that sort of training right into the economy.

CONCLUSION: THE ROLE OF WASHINGTON

When the Internet was first arriving on the scene in the mid-1990s, policymakers were slow to absorb its potential impact. Few believed that a country as big as the U.S. could shift from the slow-growth jobless recovery of the early 1990s to the high-growth, low-unemployment years of the latter half of the 1990s.

Now we are at the next stage of the Internet Revolution, where the physical world gets connected to data, people, and processes. No one can predict the ultimate course of innovative technologies, but it appears that the Internet of Everything has the potential to help revive the high-growth economy.

The role of Washington is to provide a supportive environment for innovation and investment in the IoE. On the macro level, building the infrastructure for the IoE into place requires high levels of investment. Such investment generates jobs and growth, of course, but it has to be profitable. That will require a close look at the tax code.

At the same time, the Internet of Everything will bring up a large number of important regulatory issues, from privacy to security to employee relations. The same tools that improve worker training can also make it easier for employers to monitor workers. The same privacy issues that pervade online data collection today will be even more salient when your car and appliances are connected to the Internet as well.

Policymakers will have to carefully balance the very real needs for privacy and security in the IoE against the equally important needs for economic growth and innovation. There is no way to get increased prosperity without being willing to try new technologies, even if they may sometimes bring short-term questions.

And finally, there's the political angle. The stagnant economy that we have now pits American against American, fighting over slices of a shrinking pie. That curdles the political discourse in dangerous ways, and makes it much harder to achieve progressive goals such as improving the standard of living for all.

That changes if the Internet of Everything can fulfill its promise as an economic stimulant. Technology is not predictable, but embracing the IoE offers a good chance of bringing back the High-Growth Economy.

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