INDUSTRIAL INTERNET

A European Perspective

Pushing the Boundaries of Minds and Machines

GE imagination at work

June 2013

A EUROPEAN PERSPECTIVE

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I. Preface

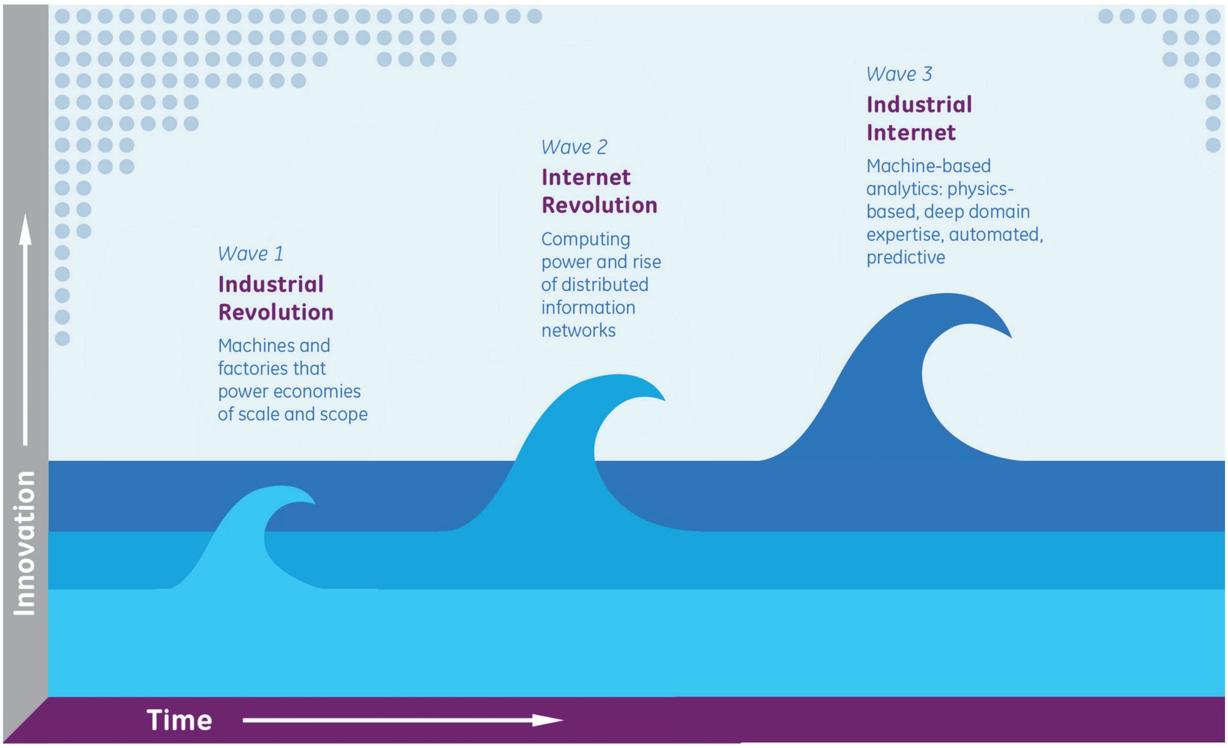
In our recent vision paper "Industrial Internet: Pushing the boundaries of minds and machines" we argued that the Industrial Internet holds the potential to transform the modern economy and to bring substantial economic benefits in terms of faster economic growth and higher living standards.[1]

The world is on the threshold of a new era of innovation and change with the rise of the Industrial Internet. It is taking place through the convergence of the global industrial system with the power of advanced computing, analytics, low-cost sensing and new levels of connectivity permitted by the Internet. The deeper meshing of the digital world with the world of machines holds the potential to bring about profound transformation to global industry, and in turn to many aspects of daily life, including the way many of us do our jobs. These innovations promise to bring greater speed and efficiency to industries as diverse as aviation, rail transportation, power generation, oil and gas development, and healthcare delivery. It holds the promise of stronger economic growth, better and more jobs and rising living standards, whether in the US or in China, in a megacity in Africa or in a rural area in Kazakhstan.

With better health outcomes at lower cost, substantial savings in fuel and energy, and better performing and longer-lived physical assets, the Industrial Internet will deliver new efficiency gains, accelerating productivity growth the way that the Industrial Revolution and the Internet Revolution did. And increased productivity means faster improvement in income and living standards. In the US, if the Industrial Internet could boost annual productivity growth by 1-1.5 percentage points, bringing it back to its Internet Revolution peaks, then over the next twenty years through the power of compounding, it could raise average incomes by an impressive 25-40 percent of today's level over and above the current trend. And as innovation spreads globally, if the rest of the world could secure half of the US productivity gains, the Industrial Internet could add a sizable $10-15 trillion to global GDP – the size of today's U.S. economy – over the same horizon. In today's challenging economic environment, securing even part of these productivity gains could bring great benefits at both the individual and economy-wide level.

[1] *Marco Annunziata and Peter Evans, "The Industrial Internet: Pushing the Boundaries of Men and Machines", http://www.ge.com/docs/chapters/Industrial_Internet.pdf*

Figure 1. **Rise of the Industrial Internet**



Waves of Innovation and Change

Over the last 200 years, the world has experienced several waves of innovation. Successful companies learned to navigate these waves and adapt to the changing environment. Between 1750 and 1900 the Industrial Revolution saw innovations in technology applied to manufacturing, energy production, transportation and agriculture, ushering in an age of economic growth and transformation. The Internet Revolution unfolded over a much smaller timeframe, allowing machines to connect and exchange information – its openness and flexibility creating the basis for explosive growth.

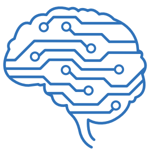
Today we are at the cusp of another wave of innovation that promises to change the way we do business and interact with the world of industrial machines. To fully understand what is taking place today, it is useful to review how we got here and how past innovations have set the stage for the next wave we are calling the "Industrial Internet."

The Next Wave

How will this be possible? The Industrial Internet brings together the advances of two transformative revolutions: the myriad machines, facilities, fleets and networks that arose from the Industrial Revolution, and the more recent powerful advances in computing, information and communication systems brought to the fore by the Internet Revolution.

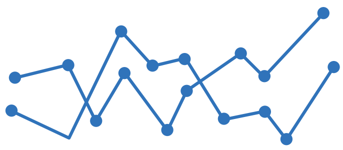
Together these developments bring together three elements, which embody the essence of the Industrial Internet:

Figure 2. **The three elements of the Industrial Internet**



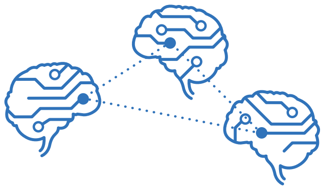
INTELLIGENT MACHINES

New ways of connecting the word's myriad of machines, facilities, fleets and networks with advanced sensors, controls and software applications.



ADVANCED ANALYTICS

Harnessing the power of physics-based analytics, predictive algorithms, automation and deep domain expertise in material science, electrical engineering and other key disciplines required to understand how machines and larger systems operate.



PEOPLE AT WORK

Connecting people, whether they be at work in industrial facilities, offices, hospitals or on the move, at any time to support more intelligent design, operations, maintenance as well as higher quality service and safety.

Building Blocks and "Things that Spin"

The Industrial Internet starts with embedding sensors and other advanced instrumentation in an array of machines from the simple to the highly complex. This allows the collection and analysis of an enormous amount of data, which can be used to improve machine performance, and inevitably the efficiency of the systems and networks that link them. Even the data itself can become "intelligent," instantly knowing which users it needs to reach.

In the aviation industry alone, the potential is tremendous. There are approximately 20,000 commercial aircraft operating with 43,000 commercial jet engines in service. Each jet engine, in turn, contains three major pieces of rotating equipment which could be instrumented and monitored separately. Imagine the efficiencies in engine maintenance, fuel consumption, crew allocation, and scheduling when 'intelligent aircraft' can communicate with operators. That is just today. In the next 15 years, another 30,000 jet engines will likely go into service as the global demand for air service continues to expand.

Similar instrumentation opportunities exist in locomotives, in combined-cycle power plants, energy processing plants, industrial facilities and other critical assets. Overall, there are over 3 million major "things that spin" in today's global industrial asset base—and those are just a subset of the devices where the Industrial Internet can take hold.

Power of just 1 percent

The benefits from this marriage of machines and analytics are multiple and significant. We estimate that the technical innovations of the Industrial Internet could find direct application in sectors accounting for more than $32.3 trillion in economic activity. As the global economy grows, the potential application of the Industrial Internet will expand as well. By 2025 it could be applicable to $82 trillion of output — or approximately one half of the global economy.

A conservative look at the benefit to specific industries is instructive. If the Industrial Internet achieves just a 1 percent efficiency improvement then the results are substantial. For example, in the commercial aviation industry alone, a 1 percent improvement in fuel savings would yield a savings of $30 billion over 15 years. Likewise, a 1 percent efficiency improvement in the global gas-fired power plant fleet could yield a $66 billion savings in fuel consumption. The global healthcare industry will also benefit from the Industrial Internet, through a reduction in process inefficiencies: a 1 percent efficiency gain globally could yield more than $63 billion in healthcare savings. Freight moved across the world's rail networks, if improved by 1 percent could yield another gain of $27 billion in fuel savings. Finally, a 1 percent improvement in capital utilisation in upstream oil and gas exploration and development could total $90 billion in avoided or deferred capital expenditures. These are but a few examples of what can be potentially achieved.

The European Opportunity

Europe is both especially well-positioned to reap the gains from this new technology revolution, and especially in need of doing so, to both restore growth and contribute to on-going debt reduction through faster increases in incomes.

Whilst Europe is well poised to meet the challenge, success cannot be taken for granted. Indeed, it is sobering to consider that Europe did not fully capitalise on the potential benefits of the first wave of the internet revolution in the 1990s - and must ensure it fully grasps the opportunity this time. Succeeding today will require greater and faster progress on a range of structural reforms, and a cooperative and integrated EU-wide approach. It will not be easy, but the benefits are well worth the effort. At stake is not only the chance to boost economic growth in the next few years, but Europe's place in an increasingly competitive global economy.

In this paper we examine the opportunity that Europe has to take advantage of this revolution. We highlight the importance of innovation and the Industrial Internet in the context of Europe's current economic challenges (Section II); we estimate its potential macroeconomic benefits (Section III); we discuss and enumerate the importance of the necessary economic structural reforms and the key enabling conditions that need to be put in place for the Industrial Internet to unfold its full potential (Sections IV and V). Finally, Section VI provides examples of the applications and attendant efficiency gains in specific sectors of industry.

Marco Annunziata & Team

II. Innovation is the Silver Bullet

The current economic and policy debate in Europe is dominated by the issue of austerity — i.e. reductions in public spending and increases in taxes implemented in a number of countries to reduce fiscal deficits. There is no doubt that identifying the right pace of fiscal consolidation and debt reduction has very important implications for Europe's financial stability and for the extent of economic and social hardship that some countries have been forced to face. But this debate has obscured two closely intertwined and important issues: (1) Technology and innovation; and (2) structural reforms.

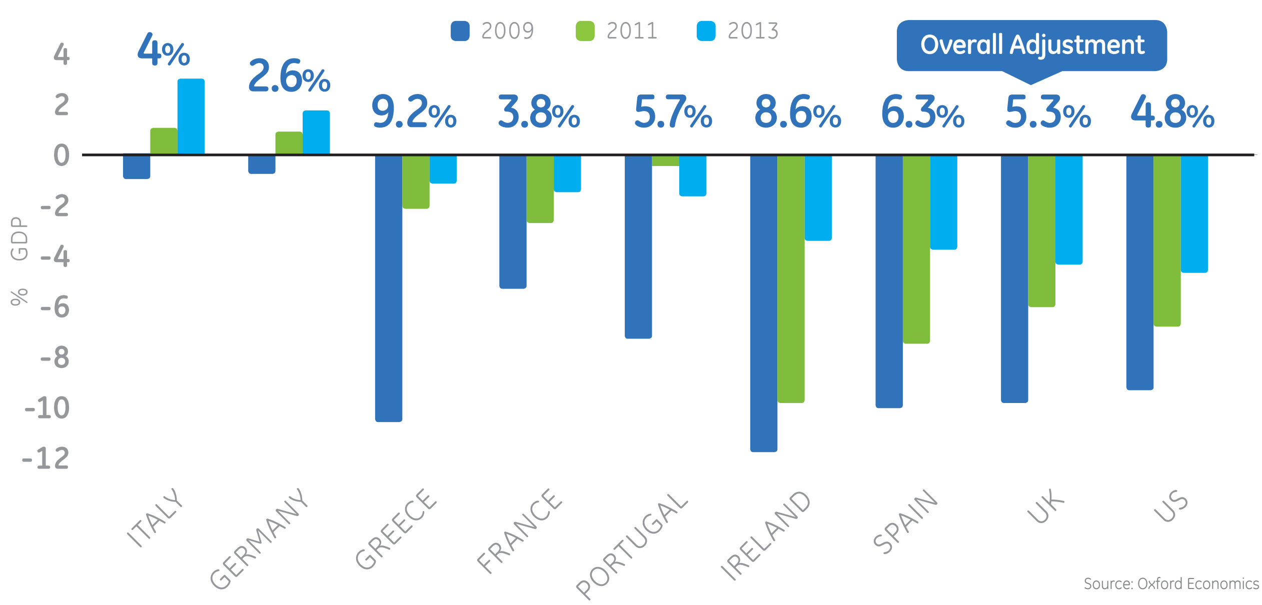
The Euro Area is experiencing its second consecutive year of recession: countries like Spain and Italy are suffering a deep contraction in output levels, and Germany, the area's economic powerhouse, has seen its growth rate drop well below 1%. The UK's economy stagnated last year, and is now struggling to regain momentum. ECB President Mario Draghi noted in the Bank's June monetary policy meeting that he sees a very gradual recovery starting later this year, and his statement may provide some support to consumer and business sentiment—but Europe should aim for a stronger economic rebound.

Austerity is often blamed for Europe's current economic plight, and tighter fiscal policy has certainly played a role. There has been a lively, at times heated policy debate on the issue. In its October 2012 World Economic Outlook, the International Monetary Fund argued that the impact of fiscal tightening on economic growth (technically called the "fiscal multiplier") had been underestimated — or more precisely, that fiscal tightening in the current situation where interest rates are already close to zero has a greater negative impact on growth than one could infer from historical experience (in many past episodes of fiscal tightening, monetary policy would have provided a counter-balancing impact via interest rate cuts).[2]

But austerity is not simply driven by a misguided faith in faulty economic models. It has been adopted as a necessary response to the weakened state of public accounts and the consequent adverse impact on financial market conditions, which made government funding harder and more expensive. And it is required by a challenging medium term outlook for many countries' debt dynamics.

The worst of the crisis is, hopefully, behind us. European countries have made substantial progress in fiscal consolidation, as evidenced by the visible improvement in primary fiscal balances.

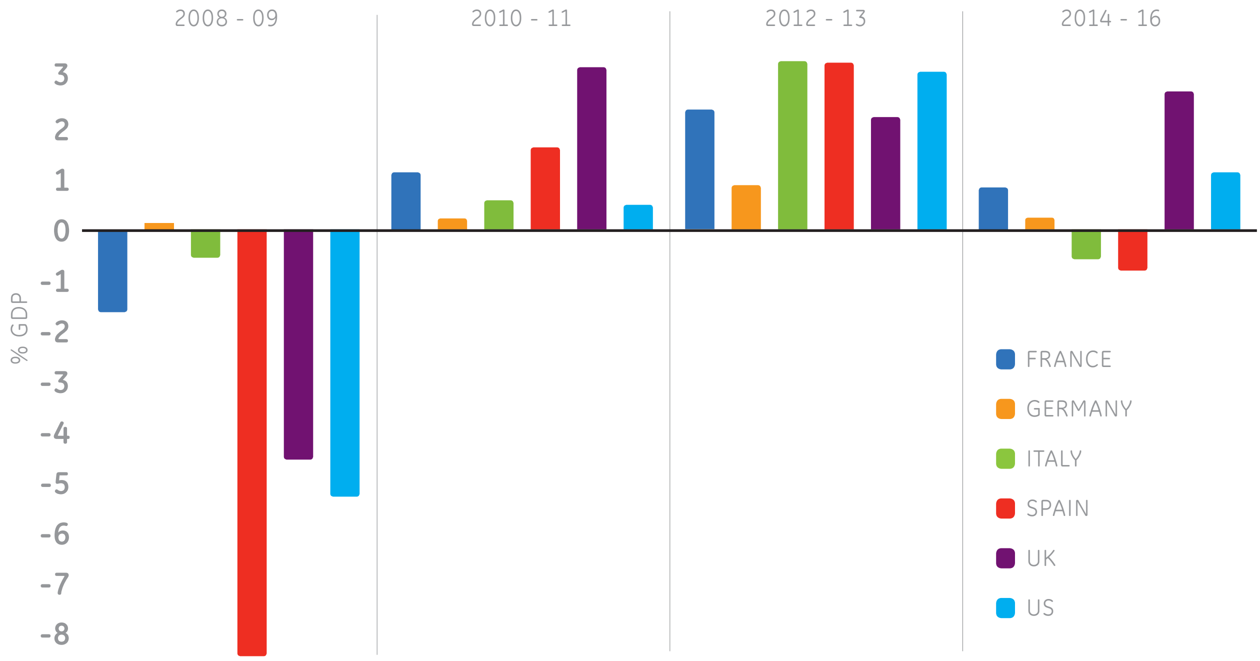
Figure 3 – *Primary Fiscal Balances of countries*



Source: Oxford Economics

[2] http://www.imf.org/external/pubs/ft/weo/2012/02/pdf/text.pdf

Figure 4 – *Cumulative change in structural fiscal balance*



The extent of the required and planned fiscal effort should therefore be significantly reduced over the coming few years, after a very significant effort during 2012-13.

Two sobering considerations are in order, however:

1. While the pressure of deficit reduction will ease substantially, few European countries will be able to count on expansionary fiscal policy as an engine of growth: national budgets will still need to be managed in a prudent manner to foster a continued decline in excessive debt-to-GDP ratios.

2. While austerity has hobbled short-term growth performance, its removal will do little to boost long-term growth potential, which suffers from a number of structural rigidities. Worst, countries where deficit reductions have been achieved mostly from cuts in public investment or from tax hikes which reduced private investment, will find it harder to quickly recover their full growth potential.

The current round of fiscal tightening has been triggered by tensions in financial markets, which have driven up funding costs for some EU countries, and have been exacerbated by fears that one or more members might decide or be forced to abandon the single currency area. Reforms are now underway to strengthen the Euro Area's institutional setup, including plans towards a banking union and a closer fiscal union. Together with the crucial supportive role played by the European Central Bank, these steps have already gone a long way towards alleviating market tensions.

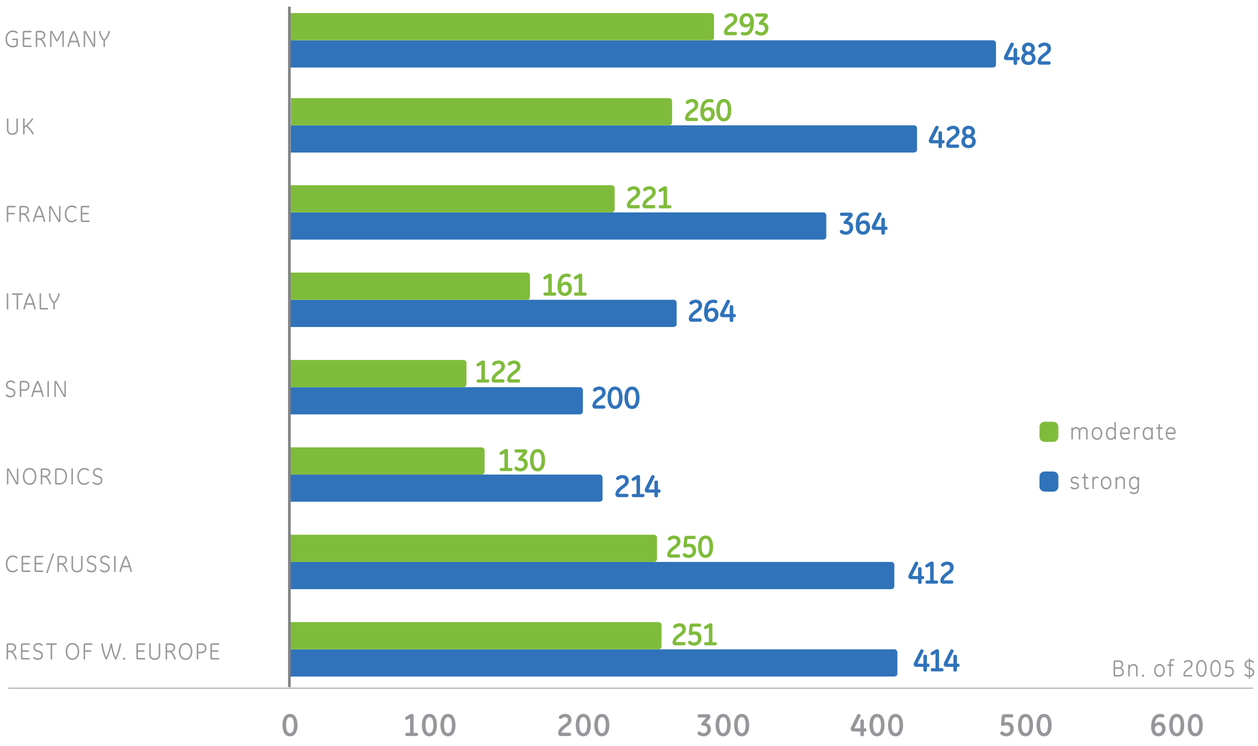
At the same time, however, Europe faces a substantial rise in expenditures on entitlements, that is pension and healthcare benefits that will accrue to an increasing share of the population as a consequence of aging. This challenge is by no means limited to Europe—but given the intense scrutiny that Europe's public finances are already experiencing, it will be especially important that these coming pressures are managed effectively. This also implies that changes in taxation and public expenditures should as much as possible avoid a negative impact on public and private investment, which is essential to generate faster growth—and faster economic growth will in turn help cover entitlements.

President of the European Union Commission, José Manuel Barroso's recent assertion that we need to move beyond austerity towards policies that drive growth should be a positive signal that we need to be willing to promote and invest in new areas of potential growth for the EU like the Industrial Internet.

III. Economic benefits of the Industrial Internet

It is here that technology can come to the rescue. In our "Minds and Machines" paper, we estimated that adoption of the Industrial Internet could add $2.8 Trillion to Europe's GDP by 2030 —this is close to one quarter of the current size of the Euro Area's economy[3]. That estimate was based on what we consider to be a conservative assumption, namely that Europe (and the rest of the world) would be able to capture just one half of the productivity gains which we believe are within reach in the US: in other words, we assumed that European productivity growth would be boosted by 0.75 percentage points over a baseline where the Industrial Internet has no impact.

Figure 5 – *Benefits of Industrial Internet Diffusion to Europe*



The actual gains might well be greater, but they might also be a lot smaller, depending on how Europe plays its cards. Consider the following.

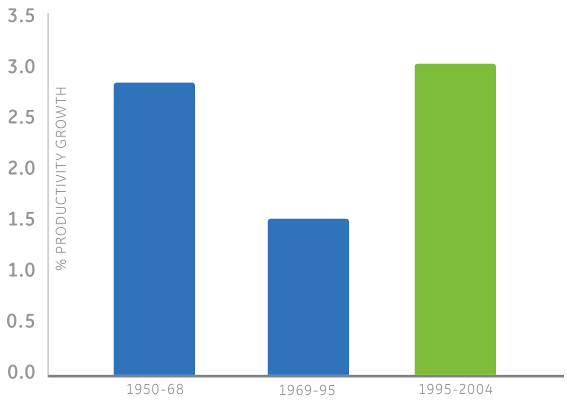
As we noted in our "Minds and Machines" paper, during the decade starting in 1995 the United States experienced a resurgence in productivity growth, driven by the Information and Communication Technology revolution, the first wave of the internet revolution. US productivity growth, which had stagnated at a relatively low 1.5% over the previous twenty-five years, suddenly bounced back above 3% — higher still than the rate it had enjoyed during the fifties and sixties when it was still reaping the gains of the industrial revolution.

But while productivity growth accelerated in the US, it decelerated in the European Union, by nearly 1 percentage point, dropping to 1.5% from 2.4%.[4]

[3] *The IMF (Apr il 2013 WEO) estimates that nominal GDP in the Euro Area amounted to $ 12.2 T in 2012.*

[4] *Bart Van Ark, Mary O'Mahony and Marcel P. Timmer,* The productivity gap between Europe and the United States: Trends and causes, *(Journal of Economic Perspectives Vol. 22, nr.1, 2008).*

Figure 6 – *The US ICT Productivity Rebound*



To understand why Europe "missed the train" of the ICT productivity boom, it is useful to take a step back and briefly summarise developments in European labour productivity. In their insightful 2008 paper, Van Ark, O'Mahony and Timmer (VOT) identify three distinct periods: (a) during 1950-73 European productivity grew at a rapid pace, reflecting in part a catching-up to the US's higher levels of productivity and per capita incomes. Import and imitation of existing technology played an important role, similarly to that which is currently benefiting a number of emerging markets; (b) during 1973-95 productivity growth slowed down in both Europe and the US, but productivity growth in Europe outpaced that in the US, reflecting a European decline in both labour force participation and working hours[5]; (c) during 1995-06 European labour productivity plunged, at the same time as US productivity rebounded.

VOT find that the deceleration in European productivity growth was indeed linked to a failure to leverage the benefits of the information and communication technology revolution, due to lower investment in the relevant technology and to the relatively smaller share of technology-producing industries in Europe.

But why did Europe fail to leverage the benefits of the first internet revolution? It was not for lack of skills—in fact VOT find that in the preceding period, Europe had been doing as well as the US in raising the average skill level of its workforce. Structural rigidities in markets for labour, products and services appear to have played a very important role in hindering the rapid re-allocation of resources that would have accelerated the adoption of new technologies and maximised the attendant productivity gains.

Management practices also appear to have played a role: Bloom and van Reenen (2007) find evidence that US multinationals operating in Europe have been experiencing higher productivity gains than non-US multinationals, and tend to be more ICT-intensive.[6] Nimbler management strategies deployed in a more flexible institutional environment are the best way to take advantage of rapidly evolving technologies.

We can draw two lessons from the above discussion:

1. First, by adopting the Industrial Internet, Europe could reap substantially greater productivity gains than those which we have conservatively estimated in our "Minds and Machines" paper. By adopting the technologies of the Industrial Internet, Europe could recover the productivity gains missed in the first round of the internet revolution and compound them with the new ones, at once catching up and moving ahead of the curve.

2. To do so, however, Europe will need to remove the obstacles that have prevented from joining the ICT productivity boost in 1995.

[5] *This has generated a lively academic debate, see for example Blanchard (2004).*

[6] *Nicholas Bloom, Raffaella Sadun andJohn Van Reenen,* Americans do it better: US multinationals and the productivity miracle, *(American Economic Review nr. 102, 2012)*

IV. The Need for Reforms

This brings us back to the issue of structural reforms. We mentioned at the outset that the current focus on austerity is excessive, and that given the progress made on fiscal consolidation it should now be moved to the backburner. This, however, should not be a reason to relax, but rather to re-double the efforts on the structural reform front. Increasing the flexibility of labour, products and services markets should be at the top of the list, in order to maximise efficiency in the allocation of resources. With sufficient progress on this front, Europe would be able to leverage some of the considerable advantages it currently holds.

First of all, while progress on structural reforms is needed, there are clearly features of Europe's environment which are extremely conducive to innovation and competitiveness. The latest Global Competitiveness report of the World Economic Forum shows that Europe can boast six out of top ten countries in the competitiveness ranking, and ten in the top twenty.

Secondly, a number of European firms hold positions of excellence in global industry; some European countries, notably Germany, have powerful industrial sectors. While the Industrial Internet will eventually spread its benefits to the whole economy, including the services sector (which in Europe, as in most advanced economies, accounts for the largest share of the economy), the revolution starts with the machines, and hence in industry. A strong industrial base, especially in the more advanced areas of manufacturing, constitutes an important advantage.

Figure 7 – *WEF Global Competiveness Rankings*

1	SWITZERLAND
2	SINGAPORE
3	FINLAND
4	SWEDEN
5	NETHERLANDS
6	GERMANY
7	UNITED STATES
8	UNITED KINGDOM
9	HONG KONG SAR
10	JAPAN
11	QATAR
12	DENMARK
13	TAIWAN, CHINA
14	CANADA
15	NORWAY
16	AUSTRIA
17	BELGIUM
18	SAUDI ARABIA
19	KOREA, REP.
20	AUSTRALIA

V. Enablers of the Industrial Internet

As we discussed previously, Europe failed to exploit the full potential of the first wave of the internet revolution. As the EU Commissioner for Research, Innovation and Science, Maire Geoghegan-Quinn noted in a recent opinion piece: "It is true that Europe has been missing out on some cutting-edge technologies which is why the EU has fewer fast-growing innovative enterprises than the US. It is also true that this situation is in danger of deteriorating... We nevertheless have the power to prevent this decline and the key is investing in our own potential."[7]

Given the scale of the opportunity that the Industrial Internet presents, Europe will be best placed to maximise its gains by acting together in realigning investment to rapidly incorporate new technologies into its capital stock, building and developing the necessary talent bank, and creating a framework that facilitates the secure and easy flow of data across borders. No one country will succeed alone. Acting in a joint fashion will have three related advantages. First, it will ensure harmonisation of the relevant legal and institutional frameworks, for example on cyber security and privacy, and of communication networks. Second, this will in turn maximise the economies of scale that have been at the core of European economic and financial integration from the very beginning. Third, it will help reduce growth and macroeconomic imbalances across European countries—imbalances which have played an important role in the recent economic crisis. Policymakers need to move squarely beyond sectoral and territorial thinking when planning Europe's Industrial Internet strategy. Instead, they should focus on the interdependence of industries and countries in the EU.

A Single Market

In this regard there is a compelling case for the completion of the Single Market in Europe which would facilitate the streamlining of the environment for doing business across the EU 27, reduce the cost of doing business, stimulate greater investment and facilitate greater cross border co-operation including the mobility of goods, services business and importantly skills and talent. It would also, as is the aim outlined in the Single Market Act of 2011, create a fully integrated 'Digital Economy' which would be crucial to Europe's success.

Talent/Skills Pool

Europe faces a huge skills challenge. According to the European Commission by 2020 the number of jobs for highly-qualified people will rise by 16 million, while the number of jobs held by low-skilled workers will decline by around 12 million. 50% of jobs today require technology skills, and 77% of all jobs will require these skills within the next decade.

The Industrial Internet will be built on new technology but it will rely on the availability of adequate talent and skills. To maximise the potential of the Industrial Internet in Europe we will need to nurture a new skills pool not only by training more people in sciences, engineering and data science, but also by developing a new set of skills that combines expertise in software and in different branches of engineering. To this purpose, we will need a cross border framework which facilitates this including greater mobility of skilled labour. In the short term that means reskilling and using existing talent to meet evolving needs. In the medium term it requires a realignment of both the talent markets and educational institutions to meet the realities of the Industrial Internet. Greater co-operation between all players can help facilitate this as can more targeted investment. In a nutshell, this implies not only bolstering the European education system, but also aligning it more closely with industry, to improve the co-ordination between the demand and the supply of talent in a forward-looking manner.

[7] *Commissioner Geoghegan-Quinn's opinion piece Europe's World (Spring Edition 2013) entitled "Europe's potential for innovation is our strongest asset in a competitive world"*

Even amid the current economic crisis, Europe is facing a shortage of skilled labour. An estimated 2 million unfilled jobs are available across Europe. While the problem has traditionally been linked to low-skilled jobs, filling jobs in high-skill sectors, such as science, engineering and IT, is also becoming increasingly challenging. By 2020, 20% more jobs will require higher level skills and Europe's relatively low take up of STEM subjects must be an area of concern and focus for Governments and indeed industry.

Investment

The Industrial Internet will require smart investment by both the public and private sectors. It also requires strategic EU-wide common investment targeted at promising sectors and sectors of strategic importance as is the case in the USA, China and Korea.

The best way of achieving this is to promote a competitive business environment rather than focusing on subsidies – this will ensure that resources are reallocated to best performing businesses and sectors.

Governments can play a creative role in driving investment in the necessary infrastructure required to facilitate intra/inter-state communication to support the growth in data flows created as well as developing the skills required to exploit the full potential. Significant investment is required to rapidly incorporate new technologies into capital stock.

European Governments can stimulate investment in the development of the Industrial Internet by a range of measures including; smart purchasing and public procurement which will facilitate investment in technologies and skills development which optimise long term impacts, re-orientating existing funding mechanisms, creating a European Venture Capital framework for investments which have a cross border focus, and putting in place incentives (regulatory and financial) to promote private sector investment. We welcome the moves by Commissioner Almunia to adapt state aid rules to help foster private sector innovation.

Networks and Clusters

By its very nature the development of the Industrial Internet will only be made possible by collaboration between all the stakeholders across a wide range of sectors. Clusters of specialised expertise will play an important role, as will networks enabling the flow of data and information. To maximise efficiency, both clusters and networks should be defined by common interests, needs and expertise. Restricting them artificially based on local or national geographic boundaries would be counterproductive. Instead, the greatest efficiency gains can be reaped by pulling together best in class players in to EU-wide virtual networks which cross region and boundaries allowing for strategic and smart specialisation. This is all the more true in the context of the current push for greater economic and institutional integration, seen as a necessary response to the economic crisis.

A Sound Policy Framework to enable the Industrial Internet

At the heart of the Industrial Interest are the vast quantities of data generated by machines, and the advanced algorithms that convert this data into actionable information for use by equipment operators. By remotely aggregating this data and applying unique software-based algorithms, equipment anomalies can be rapidly identified and repaired, and unit performance, efficiency and reliability can be enhanced. If the promise of the Industrial Internet is to fully materialise, European governments must create a robust policy framework for the digital economy that allows for the free flow of data in a trusted and secure environment, and without different rules and standards for every country and dataset.

Much of the real time data analytics of the Industrial Internet is happening in the cloud, which brings vast and unprecedented computing power to businesses, and to citizens and the public sector alike. The cloud is by definition global, and it would be counterproductive to implement local server requirements and other similar measures, often invoked for data protection or security reasons. The physical location of a data server is far less important than the processes and controls utilised by the service provider under local law. If not properly managed, new regulation in these areas could become significant non-tariff trade barriers to the digital economy.

A robust policy framework also encourages the development of international industry-driven standards, technical regulations and best practices in relevant forums in Europe and globally.

Europe can take a leading role here and pursue global public-private partnerships, nourish the development of industry-driven, voluntary international standards, and minimise the ability of countries to engage in digital protectionism.

VI. Industrial Sector Benefits – The Power of 1 Percent in Europe

The previous section has outlined the benefits that the Industrial Internet can bring at the macroeconomic level, boosting productivity and GDP growth. But it is also important to assess how these benefits emerge at the microeconomic level, in individual sectors of the economy. For this purpose, it is instructive to consider the substantial gains that can derive from just a 1 percent efficiency improvement. We call this "the power of 1 percent". Note that we consider this to be a lower bound for the efficiency gains that the Industrial Internet will bring, given our knowledge of the sectors discussed below—the actual benefits are likely to be significantly bigger still. Table 1 illustrates the magnitude of the efficiency gains that can be reaped in individual sectors over a 15-year period.

Table 1 – *Industrial Internet: The Power of 1 Percent in Europe*

Industry	Segment	Type of Savings	Estimated Value Over 15 Years (Billion nominal US dollars)
Power	Gas-fired Generation	1% Fuel Savings	$15B
Aviation	Commercial	1% Fuel Savings	$9B
Oil & Gas	Exploration & Production	1% Reduction in Capital Expenditures	$10B
Rail	System-wide	1% Reduction in Capital Expenditures	$6B
Healthcare	System-wide	1% Reduction in System Inefficiency	$15B

Note: Illustrative examples based on potential one percent savings applied across specific European industry sectors. Source: GE estimates

These are very big numbers—and we have considered here only those sectors that we know well from our direct involvement; just as in the first wave of the internet revolution, however, the impact of the Industrial Internet will be much more widespread.

The reason why the benefits are so large is that the range of applicability is very wide. By way of illustration, consider that rotating parts, or "things that spin", are a crucial component of many machines, so that equipping them with sensors can produce an enormous amount of useful data, which smart analytics can then translate into better performance. Table 2 gives a sense of how many "things that spin" there are in the installed industrial asset base in Europe:

Table 2 – *Things that Spin: Illustrative List of Rotating Machines in Europe*

Sector	Rotating Machinery	Number of European assets and plants	"Big" Things that spin (machines with rotating parts)
Transportation			
Rail: Diesel-Electric Locos	Wheel Motors, Engine, Drives, Alternators	21,600	378,000
Aircraft: Commercial & Freight Engines	Compressors, Turbines, Turbofans	9,200	27,600
Marine: Bulk Carriers	Steam Turbines, Reciprocating Engines, Pumps, Generators	1,500	13,500
Power Plants			
Thermal Turbines: Steam, CCGT etc.	Turbines, Generators	4,800	20,300
Other Plants: Hydro, Wind, Engines etc.*	Turbines, Generators, Reciprocating Engines	3,900	16,500
Industrial Facilities			
Steel Mills	Blast and Basic Oxygen Furnace Systems, Steam Turbines, Handling Systems	530	15,500
Pulp & Paper Mills	Debarkers, Radial Chippers, Steam Turbines, Fourdrinier Machines, Rollers	1000	45,000
Cement Plants	Rotary Kilns, Conveyors, Drive Motors, Ball Mills	250	3,700
Sugar Plants	Cane Handling Systems, Rotary Vacuums, Centrifuges, Crystallisers, Evaporators	110	4,600
Ethanol Plants	Grain Handling Systems, Conveyors, Evaporators, Reboilers, Dryer Fans, Motors	40	1,500
Ammonia & Methanol Plants	Steam Turbines, Reformer and Distillation Systems, Compressors, Blowers	50	1,700
Medical machines			
CT Scanners	Spinning X-Ray Tube Rotors, Spinning Gantries	11,600	23,200
		TOTAL	**551,100**

Notes: Not exhaustive. (1) Only counting engines in large scale power generation greater than 30MW
Sources: Multiple aggregated sources including SCI Verkehr GmbH, EADS, Clarkson Research, Platts UDI, CEPI, European Commission, CEFS, Reuters, Continental Engineering BV, COCIR, GE Aviation & Transportation, GE Strategy & Analytics estimates of large rotating systems

Once again, these are very big numbers. Consider also the potential impact on people and merchandise in just the aviation sector: In 2011, Europe recorded over 7.6 million aircraft departures, carrying over 750 million passengers[8] and involving 9,200 commercial and freight engines[9]. Fewer delays and more fuel savings would make a significant difference to passenger experience and to transportation costs.

Over the page, we consider briefly how the Industrial Internet will impact selected sectors of the European economy.

[8] *ICAO: http://www.icao.int/publications/Documents/9975_en.pdf*

[9] *EADS: Market Forecast "Navigating the Future Full Book", 2012: www.airbus.com/company/market/forecast Information compounded by GE calculations*

POWER GENERATION:

The absence of an efficient European Emission Trading System currently counteracts the widespread progress that has been made with regard to renewable energy installations since it leads to a shift in the fuel structure of the generation mix – from clean gas to dirty coal. As new, lower cost extraction methods are not likely to play a vital role in the near future, alternative means to reduce costs are required. Here, the Industrial Internet comes into play.

Industrial Internet-induced savings of only 1 percent in gas-fired power generation alone represent $66B globally and $15B within Europe over the next 15 years in fuel savings. In a market where large utility companies hold a high share of the generation capacity, what could this mean at the company level? Would the necessary investments in Industrial Internet technologies pay off? The answer will of course depend on the individual situation—we have seen in the first section of this paper that the way in which a company is run will also impact its ability to deploy new technologies efficiently and profitably. We can, however, provide an indication of the pay-offs that can be reaped. Analysis of the European electricity market has shown that a major utility company with an annual natural gas-based power generation of 90 TWh (which resembles a realistic electricity generation based on natural gas and oil by a major German utility) could save cumulative fuel costs up to $0.5bn from 2014 to 2025, equaling an average of $40M per year. Representing only 1 percent of its annual fuel costs, such savings could allow a major German utility to increase its EBIT by approximately 0.5% or support almost 90% of its annual software R&D expenses.

AVIATION:

The European commercial airline sector spends about $47B per year on jet fuel[10]. If Industrial Internet technologies can achieve a 1% saving, this would represent nearly $9B in fuel cost savings over 15 years.

At an average of 40% of the final bill, fuel consumption is the highest proportional cost for the airline industry, and most carriers are currently looking to increase fuel efficiency in order to boost competitiveness. Environmental concerns also come into play. The airline industry has committed to a reduction of global CO2 emissions by increasing fleet fuel efficiency by 1.5% annually from 2010 to 2020. After 2020, carbon-neutral growth is foreseen with a target reduction of 50% carbon emissions compared to 2005 levels by 2050. This, together with EU measures to control aviation emissions (ETS) and–potentially–future market based measures at global level, more than ever before, increases the need for airlines to optimise fuel usage.

[10] *GE Strategy and Analytics calculations.*

The smart analytics of the Industrial Internet can help optimise flight paths and equipment usage, and guide the development of better and more efficient machines. If the airline industry could save even only 1% of its fuel consumption, this could not only help airlines offset their financial burden from the EU ETS but also ensure environmental targets can be achieved.

OIL & GAS:

In the Oil & Gas (O&G) industry, there is high value concentration in upstream Exploration & Production (E&P), in terms of EBIT, margin and capex. The potential for value creation is great, as just a 1% reduction in E&P capex in Europe can be valued at $9.7B of savings over 15 years.
The days of "easy" O&G may largely be in the past, but energy prices and other geopolitical factors are extending North Sea production life. Additional North Sea investment is estimated at a record $50B in 2013 and over $350B by 2020.[11]

The Industrial Internet has a significant role to play in field life extension in the North Sea – managing and rejuvenating ageing assets – through preventative maintenance and improving estimated recovery rates of just 35% i.e. for every 100 barrels in the ground, just 35 are brought to surface.[12]

The Industrial Internet also comes to the fore when looking to the frontiers of Europe, such as the region west of the Shetlands and the Barents Sea. Fields in these tougher geologies and deeper waters require a far greater level of digitalisation than exists today. Here, the Industrial Internet could connect intelligent machines on the sea floor with analytics in the cloud to O&G staff on land – allowing processing solutions to take place remotely on the sea floor, closer to source.

The potential for the Industrial Internet in E&P looks bright, both improving productivity in brownfield sites today and realising the "digital field" vision for greenfield sites tomorrow.

[11] *Norwegian Petroleum Directorate (January 2013). http://npd.no/en/news/News/2013/The-Shelf-in-2012--press-releases /Oil and Gas UK (February 2013). http://www.oilandgasuk.co.uk/news/news.cfm/newsid/824 / GE estimate*

[12] *Maugeri, Leonardo. "Oil: The Next Revolution" Discussion Paper 2012-10, Belfer Center for Science and International Affairs, Harvard Kennedy School, June 2012. http://belfercenter.ksg.harvard.edu/files/Oil-%20The%20Next%20Revolution*

RAIL

Post the recession, rail transport continues to grow in importance in the EU27. Rail moved 18.4% of total freight tonne-km in 2011, up from 16.6% in 2009. This is the highest modal share for freight rail in ten years.[13] Likewise rail's modal share of passenger traffic has retained its gains since 2009.[14]

As the Eurozone returns to growth, there will be increased pressure around important traffic hubs (Paris, Lyon, Brussels, Cologne, Frankfurt etc.), between passenger and freight traffic. Infrastructure managers will need to be more precise to prioritise requests for railway path allocation. Constraints on infrastructure budgets will direct funds to network maintenance and less towards construction of new routes. Regional entities allocate the budget they receive from national governments and the EU in accordance with regional imperatives, leaving less attention to freight. Thus with freight trains forced to use residual capacity, it becomes increasingly challenging to meet market requirements of timely delivery and quality of service.

The EU is supporting and looking at the development of longer freight trains that would help in increasing the railway's share of freight transportation. The restriction on freight train lengths comes from the existing "siding lengths" of 600 to 700 meters.

These short sidings restrict the length of freight trains, and hence limit the tonnages hauled per train. The NEW OPERA (MARATHON Project) supported by the EU is a case in point of this type of approach. The longer freight trains would operate on dedicated freight routes while insuring that passenger traffic is also taken into account.

Technologies that could be useful and help in the longer freight train operations could be remotely operated locomotives, and computer based locomotive control systems that assist the driver in optimizing train journeys to achieve on time delivery while reducing energy costs.

Moreover, rail executives have placed an increased focus on planning that is more nimble and yet incorporates more variables to provide a broader scope of the increasingly complex environment. More data and better tools are needed.[15]

The Industrial Internet could unlock residual capacity of the European railway network through integration of systems, data and operations, thus becoming the cornerstone, a decision making tool for network optimisation. Combining terminals, stations, ports, railway undertakings and infrastructure managers, it could increase the visibility and predictability of railway operations, as well as improve the railway path allocation process. This could lead to better resource allocation, prevention and quick reaction to delays, as well as improve safety and customer service.

[13] *Eurostat - Modal Split of Freight Transport. http://epp.eurostat.ec.europa.eu*

[14] *Eurostat – Model Split of Passenger Transport. http://epp.eurostat.ec.europa.eu*

[15] *Roland Berger - Executive Rail Radar March 2013. http://www.rolandberger.com/media/pdf/Roland_Berger_Executive_Rail_Radar_20130408.pdf*

HEALTHCARE

The Healthcare sector is perhaps the last major sector yet to be transformed by Big Data. Analysing health data can provide the foundation of knowledge to enable a move from episodic care to a more integrated patient-centric approach to healthcare delivery. At the same time empowering research and innovation in Europe to drive better health outcomes, increasing productivity and contributing to economic growth.

Over $1.7 trillion was spent on Healthcare in the EU in 2012[16]. Globally, it is estimated that 10% of this expenditure is wasted due to system inefficiency, of which 59% is in clinical and operations inefficiency[17]. This is where the Industrial Internet could yield the greatest benefits: a 1% reduction in these clinical and operations inefficiencies would translate into $15B of savings over the next 15 years.

Currently in the UK, healthcare effectiveness is at the top of the agenda for the Department of Health (DH). It is estimated that the NHS needs to make savings of up to £20B over the 2011-15 period whilst maintaining the quality of healthcare, not limiting patient access to treatments and maintaining the financial stability of NHS organisations[18]. In the meantime, the demand for healthcare services continues to increase due to many factors including the aging population and increased life expectancy.

Cost cutting and freezing wages were seen as ways to deliver short term savings but this approach alone will not lead to the desired outcome. It is widely agreed that the only way of sustaining the level of care at lower cost is to improve the effectiveness of healthcare delivery, which in turn will require fundamental changes in the approach to care delivery.

The economic imperative is inescapable: the reduction of the prices that commissioners (currently primary care groups) pay to hospital trusts for the provision of healthcare is the clearest and most tangible sign that the DH has resolved to force the NHS to improve its efficiency. This reduction in income illustrates the increasing need that hospitals have for solutions that help them to optimise their workflows, from asset management to patient flow.

The Industrial Internet can help hospitals optimise their work and in turn enable the delivery of 1% savings, whilst at the same time maintaining levels of care. As we see more and more software solutions in healthcare, we can confidently predict that algorithms will provide a far better and more sophisticated analysis of our medical data and history. This will help enable doctors to make more effective decisions on treatment, or alert them more effectively if there is a potential deterioration in a patient's condition.

[16] *European Commission – Eurostat: http://epp.eurostat.ec.europa.eu/portal/page/portal/health/introduction*

[17] *PwC Health Research Institute (2010)*

[18] *UK Department of Health – Making the NHS More Efficient and Less Bureaucratic: https://www.gov.uk/government/policies/making-the-nhs-more-efficient-and-less-bureaucratic*

VII. Concluding Remarks

A new technological revolution is beginning to unfold: the Industrial Internet, a combination of intelligent machines and powerful analytics that can deliver sizable efficiency gains, boosting productivity, economic growth and living standards.

This opportunity presents itself at the right time: an innovation-driven boost to economic growth would help Europe create jobs and accelerate incomes growth, keep on track the current debt-reduction process, and meet the challenge of future pension and healthcare commitments. Europe, with a traditionally strong industrial system, and with ten countries ranking in the top twenty most competitive in the world, is well positioned to reap these benefits.

We estimate that the Industrial Internet could add \$2.8 Trillion to Europe's GDP by 2030—this is close to one-quarter of the current size of the Euro Area's economy. Over the next 15 years the "power of 1", an increase in efficiency of just 1%, could deliver savings of \$15 billion each in the power and healthcare sectors, \$6 billion in rail, \$10 billion in oil and gas; and \$9 billion in aviation. We see these estimates as a lower bound—and the benefits of the Industrial Internet would be felt beyond these sectors, throughout the economy.

But these benefits cannot be taken for granted. Once before, in the 1990s, Europe did not fully capitalise on the opportunity of the internet revolution. We cannot afford to repeat that.

Europe must redouble its efforts to put in place the enabling conditions that will allow the Industrial Internet to unfold its full potential. These include further reforms to increase the flexibility of labour, products and services markets; completing the Single Market; developing a stronger pool of human capital-boosting skills in software and engineering; boosting investment in infrastructure; and incentivising investment to accelerate the incorporation of new technologies in the capital stock. All these challenges should be tackled in a EU-wide perspective to the attendant benefits.

European policymakers, business leaders and consumers all feel that it is time to move beyond austerity and focus on growth-enhancing strategies. Innovation and technological progress offer the key to boost economic growth in a sustainable manner. With the right combination of coordinated efforts at the policy and private sector level, the Industrial Internet can help Europe secure a leadership position in an increasingly competitive global economy.

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