The third industrial revolution, challenges and opportunities

SLIDE ONE

Thank you. It’s a pleasure to be back in Mumbai (Delhi).

It's always a joy to be back “home”.

I want to thank the CII and Mr Godrej (Mr Shriram) for hosting this seminar on this fascinating topic.

It’s something of an honour for me.

It’s usually only twenty-somethings from Silicon Valley who get to speak on this subject!

Why am I passionate about this topic?

One reason is it’s the only way I can keep up with what my daughters!

They live their lives on blogs, facebook and twitter, buy on e-bay and amazon, and instinctively reach for digital solutions to problems.

They expect social and digital networks to be part of their lives.

I have to adapt to my daughters’ lives, but so will global business!

The third industrial revolution is a digital, networked transformation of every facet of global business, from design, validation and manufacturing, to personalisation, smart products, feedback and marketing.

This revolution of networks links products, systems, consumers and manufacturers and these new structures will also drive business transformations.

You see this in firms like Jaguar Land Rover using social media networks to cut the cost of marketing a car by seventy per cent.

You see it in the way global digitisation allows a designer in Europe to connect with an engineer in China to develop a product to sell to consumers in America; a product made, not in a factory, but in a local fabrication laboratory.

Just as the first and second industrial revolutions produced entrepreneurial giants like Ford, Benz and Nuffield, so this revolution will create new giants and transform old ones.

Behemoths new and old will be challenged by disruptive technologies and processes, some of which will seem to come from out of nowhere.
This means that innovating, building networks and partnerships, positioning yourself with change-makers, not against them, will be crucial to success.

Despite all this, some would say that our major global challenge isn't the third industrial revolution, but that after two hundred years the first industrial revolution hasn't been completed.

Just two years ago a UN Population fund report explicitly compared the looms of Bhiwandi to working conditions in 19th Century Manchester.¹

Why should we focus on the next industrial revolution when much is left to do?

*Three reasons.*

First, the third “revolution” is transformative. We must meet its challenges or face severe consequences;

Second, this “revolution” affects all existing industries and markets; It is all-encompassing and pervasive in nature.

Last, it creates an opportunity to rapidly rebalance the global economy, transforming the way manufacturing works from Bhiwandi to Berkeley.

At WMG, we’re living these changes.

I formed WMG in the early eighties to support Britain’s manufacturing sector through innovation.

Today, we continue that work, but we’ve also seen how, there has been an absolute step change in the way that global business works.

Now, we are internationally focused. We have major partnerships around the world, from China to India to Singapore and with businesses from America, Japan and Europe.

But the digital revolution goes deeper still.

Digitisation and Networks have transformed the way we trade, manufacture, and market our products. It has even changed the way businesses are held accountable, whether through regulation or consumer scrutiny

¹ “The looms of Bhiwandi employ a major part of the city’s workforce... In Bhiwandi, young men continue to arrive from the poor states of northern India, Uttar Pradesh in particular, to work in factories that look like a picture of 19th century England” P80 http://foweb.unfpa.org/SWP2011/reports/EN-SWOP2011-FINAL.pdf
At WMG we now apply our expertise in areas like CAD-CAM, materials science, 3D printing, cryptography and virtual reality. This research impacts industries like healthcare, housing and high definition imaging.

We now examine processes, services and collaboration networks alongside materials and engines advances.

This change is driven by the digital revolution.

Today, I argue that every company, every industry, every innovator will be affected by such transforming technologies.
SLIDE TWO

As Barry has said, we should remind ourselves of the nature of the first two industrial revolutions.

I won’t repeat his excellent points about the technologies, but I do want to mention how interlinked innovations created a whole range of possibilities.

The development of steam power advanced textile manufacture, while the development of cast iron improved the efficiency of steam engines, creating the possibility of the early railway.

Each technological and process change built upon and re-enforced every other innovation.

SLIDE THREE

These technologies transformed how markets worked and how people lived.

The second industrial revolution gave us steel, electricity, chemicals and the internal combustion engine as well as the development of the assembly line;

This made it easier to manufacture large quantities, and to market them through the world’s ever-stronger distribution and communication networks.

These changes created the factory, urbanisation, new transport systems and a shift in the nature of the “maker” - from craftsman to labourer.

Ultimately, they created the mass market.
SLIDE FOUR
The first two industrial revolutions were primarily western revolutions.
This changed the contours of the Global economy.
These maps show Global wealth in 1500 and 1900.
Western Europe and North America have grossly swollen.
China, Africa and South America have shrivelled.
In terms of manufacturing, the picture is starker still.
In 1750, Britain created less than two per cent of global manufacturing output.
By 1880, it was well over twenty per cent.
India was producing just a tenth of its earlier share of global goods.
Much of this change was driven by the appropriations of empire.
But it was industrial advance which created imperial possibility.

SLIDE FIVE
Over the last half century, these trends have reversed.
We're witnessing the revival of the global east, led by China, now responsible for a fifth of global manufacturing.
But there's still a long way to go.
Today, China still has a lower share of manufacturing than under the Qing dynasty, while India produces only four per cent of global manufacturing.
SLIDE SIX

What does this industrial history teach us?

First, that technological shifts have enormous social and political consequences.

Next, that the networks that support and sustain industrial revolutions are as significant as the technologies of the revolution themselves.

Third, in an age of change, bureaucracy can be a killer, holding back innovation, while states and companies that encourage innovation can advance rapidly.

Finally, we should learn that disruptive technologies always win and can themselves be disrupted.

All major advances, no matter how enormous can themselves be surpassed.

In this way Bessemer Steel surpassed the Huntsman process, Japan surpassed Britain, and Toyota outpaced Ford.

So perhaps the most valuable lesson comes to us from the father of the second industrial revolution, Henry Bessemer. It is about the approach needed to prosper in an age of change. He said ‘I had no fixed ideas, derived from long-established practice, to control and bias my mind, and did not suffer from the general belief that whatever is, is right.

SLIDE SEVEN

What will this third revolution be?

Whether we date the starting point from Kilby’s integrated circuit or Abhay Bhushan’s creation of file transfer protocols, the combination of digitisation and mass communication networks is transforming our world.

Digitised information has led to ‘big data’, covering everything from product design, fabrication, marketing techniques, to product performance, consumer feedback and validation.

This data represents a new resource: controllable, analysable information about the world around us.
Meanwhile, the rapid development of communications networks, particularly mobile connected devices, creates the need for data integration, which enables systemisation and cross-fertilisation of technologies.

One example of how this revolution transforms our lives is Tal Golesworthy, a process engineer who lives in the English Midlands.

A decade ago Tal discovered that he suffered from Marfan syndrome. His aortic valve was in danger of splitting.

His options were accepting the possibility of sudden death, or a mechanical valve and a lifetime on drugs.

Tal thought he knew a better way.

He believed he could scan his heart using Magnetic Resonance Imaging, use this data to model his aorta using computer aided design and use rapid prototyping and 3-D printing to build a precise, tailor made "bandage" for his aorta.

To do this, everything had to be digitised, engineers had to share data with radiographers, materials scientists had to talk to surgeons who had to understand how the 3-D model would fit to the specific Aorta.

Four years later, Tal was the first person to benefit from his idea, being fitted with his own Aortic "bandage".

Tal says that when digitisation and communication networks come together “huge advances can be made in a very short time period, on very little money.”

That is the third industrial revolution in a nutshell.

It is the power of computing to create information about the world around us;

It is the ability of networks to share that data in unexpected ways;

It is new pressures on data sharing and compatibility;

It is new methods of fabrication;

It is using knowledge from one industry to transform the approach of an entirely different business, creating a brand new business sector in the process;

What's more, look who made this happen:
Not a medical supplies company, or a doctor, or even a 3D printing expert, but a *knowledgable patient*, someone who knew exactly what the market needed.

In this case because his life literally depended on it.
Digital modelling and fabrication are changing the way products are made, but the wider consequence of digitisation and networks is that it will be increasingly hard to define something as being “manufactured”.

Increasingly, there will be no meaningful difference between sectors like construction, manufacturing and services.

Take a tablet computer: the hardware technology, the operating system and the wider family of applications are all crucial to the success of the product.

Since no manufacturer can create every desired application, the role of the manufacturer becomes that of platform provider and making sure your platform is attractive will be key to success.

At WMG, we're developing a digital heath monitoring wristwatch, but rather than develop proprietary software, we're using Android, which will allow others to develop new applications and will give consumers more uses than we could ourselves.

The reliability, resilience, ease of use and interoperability of your manufacturing systems and processes becomes as crucial as your product.

Next, new manufacturing systems make it possible to produce both mass manufactured infrastructure and individual personalisation.

Henry Ford's mantra is abbreviated: You can have any colour you like.

Look at the impact of modular design and manufacturing on construction.

This Italian customised manufactured housing system can create more unique buildings than an architect designed estate, even before the personalisation of interiors, facilities and so on.

Further, as the divide between building, product, and service falls away, so do old ways of consuming goods.

A consumer might want, instead of buying a car, to book a fully fuelled vehicle of their choice whenever they want. Why shouldn’t they be able to?

In the third industrial revolution the creation of value lies in offering the best consumer outcomes possible from the trinity of computing power, data transfer and analysis.

This places a premium on innovation based on consumer understanding.
Think of Corning – who make almost two thirds of global glass, or YKK - who have half of the global zip market.

What do these businesses have in common?

They defend their business niche by investing heavily in understanding customer needs, using this to create ever better products, systems and production processes.

They are the data leaders, and so are the innovation leaders, and so are the market leaders.
One reason for this emphasis on *innovation* is that the third industrial revolution is driving down the relative cost of labour.

The labour cost share of an iPad is just seven per cent of the consumer price.

How much does wage competitiveness matter now, compared to production quality, the creation of new product streams, and superior consumer understanding?

Nor does this process affect the production side of manufacturing. Cost centres can change radically on the consumer side too.

In a world where products and messages can be individually tailored, marketing itself can become both targeted and co-operative.

If I can create a product specifically for you and find a way to tell you individually about it, that creates value for me.

If I use that connection to help you design the product you specifically desire, I create better value for us both, without adding any extra labour cost, and radically cutting my marketing cost.
One consequence of this “data avalanche” is that innovation is *never* finished.

We see a constant loop of data refining and developing products – from design, to validation, the creation of smart physical and software products, the integration of networks, to consumer feedback.

You might put an RFID chip in a valuable item of clothes, telling your washing machine not to run if it’s accidentally put onto a boil wash while your silk shirt is in the drum.

But what if it turns out that’s actually annoying to consumers, because they don’t know you’re washing isn’t done?

You need the washing machine to communicate with the consumer’s phone to tell them to take your silk shirt out of the wash.

You don’t need to launch a new product for that, just develop new software.

But you’re still innovating; and still producing.
SLIDE ELEVEN

Some say this will herald a shift back to “western” manufacturing.

After all, western governments have been talking about focusing on “high value” manufacturing for decades, can't compete on wages, have wealthy, connected consumers and the sorts of data networks and physical infrastructure to make data-rich products attractive.

So shouldn't the third industrial revolution mean a revival of western manufacturing?

The answer is a partial yes, but mostly no.

Being closer to big developed markets is key if you want to understand them, so as the cost of labour becomes less significant, manufacturing close to high value markets will be more attractive, while existing data networks will drive global standards.

There will be some “reshoring”. The south can't merely compete on cost.

But that isn't the whole picture.

The huge size of emerging economies means that businesses need to meet the emerging consumer needs in these markets too.

Understanding the consumer needs of consumers in growing markets will be crucial for global success.

Next, as we've seen many times before, while existing networks and infrastructure matter, new technologies can leapfrog these networks.

SLIDE TWELVE

As we see here, China's internet use is already twice the size of the US's and what's more, it is differently structured, being far more mobile based. That means China will need its own product and service eco-system.

This shift has huge impacts on manufacturer’s growth plans.
While Nokia may be struggling as ‘standard’ mobile phones become poor value to consumers it could well grow from its strong product base in emerging markets if it understands the emerging markets smart phone sector better than anyone else.

However, for that to drive success, Nokia requires superior consumer understanding of emerging markets smartphone users.

That implies more emerging market manufacturing, so they can be first to market with better software, better targeted products, and better price points.

Not least it helps companies like Nokia adapt to the government putting a levy on imported phones!²

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² 5% levy on phones over Rs 2000 in 2013 Budget http://www.eeherald.com/section/news/onws2013030101.html
SLIDE THIRTEEN

Nokia reminds us that just because emerging markets will grow, it doesn't mean that emerging market companies will be the winners.

In an industrial revolution, as we've seen, it's those with the innovative products and processes who win.

Despite the crash, global R&D spend is at an all-time high, driven by an increase in Asian economies.

However, there is still a huge gap between developed economies and emerging markets R&D spend.

This chart shows the R&D world last year.

The further right, the greater the share of R&D as total GDP.

The higher you go, the more scientist and engineers per million citizens.

The bigger the circle, the bigger the total R&D spend.

The big bubbles in the top right are the US, Japan, South Korea and Germany.

The big bubble in the middle is China.

The small bubble in the bottom left is India.

We must ask the question: who is going to develop the new products and systems that will make the third industrial revolution real, and who will keep the profits?
SLIDE FOURTEEN

How our innovation structures copes with this new digital network revolution is a defining challenge.

However, it's not the only challenge. I want to touch quickly on two others, both with special relevance to India.

The first is carbon emissions. Whatever you think of anthropogenic global warming, there is going to be a huge demand for goods as the economy grows, but there will at the same time be a major, sustained, irreversible pressure on carbon emissions. This will impact every area of business, every process and every system.

SLIDE FIFTEEN

The next challenge is equally crucial.

If we live in a world of mobile data, then the security of that data is vital.

First, if much of our personal data is online, who do we trust to hold it? Most people keep their phone within a metre of themselves all day.

Do you trust your mobile phone company to know where you are every minute of the day? Do you trust the government?

As for product issues, users will upload these and make problems visible to anyone who cares to look. How do you cope with a world where not only a pop song can go viral but so can demands for a product recall?

The second, crucial element is the need to protect safety critical systems. For example, Drive-by-wire will become essentially unsellable if people believe it can be remotely controlled by a hacker. It has to be utterly robust.

Protecting intellectual property will also become harder in the digitally networked age.

The first cease and desist letter for a 3D printed copyright infringement is now two years old.

We are already seeing rights infringement notices for 3D printed products.

As J P Titlow says, as entertainment companies have had to cope with the impact of digitisation on their intellectual property, so will manufacturers.
SLIDE SIXTEEN
The scale of digital transformation is huge and the resulting challenges are equally wide ranging.

The good news is that the opportunities are equally significant.

In the Third Industrial revolution, there are a wide range of technologies that will drive growth and transform markets, linked by the common themes of digitisation and networks.

This represents a challenge for companies to invest broadly in the innovation required to enable growth.

It also represents an opportunity for building new partnerships.

No company or nation is big enough to lead on all of these fronts.

The focus needs to be on the creating a collaborative eco-system of innovation, building partnerships which bring together technical and data expertise, process and systems management, all in the service of better consumer understanding.
SLIDE SEVENTEEN

The first opportunity is the development of new supply chains and lateral networks, or supply “communities”.

We see this in the eBay-like simplicity of Ali-Baba, to bespoke manufacturing solutions like online manufacturing marketplace MFG.com, where prospective purchasers upload their RFQs and find suppliers willing to make *their product, their way*.

As well as these new supply networks comes the fabrication laboratory, or “fab lab”, small workshops that offer digital fabrication, with CAD-CAM combining with 3D printing, digital milling, cutting and circuit board production. The fab lab aim of being able to make “almost anything, almost anywhere” is now very close.

These factors hugely increase speed to market.

Come up with an idea, find a network of experts to help you design a solution online, make it yourself at a fab lab, contract out production via MFG.com, get parts through ali-baba – suddenly you have created a “factory in the cloud”, and you’ve done it cheaply, quickly and precisely.

As Chris Anderson, author of the Long Tail, says:

“*Anyone with an invention or good design can upload files to a service to have that product made, in small batches or large, or make it themselves with increasingly powerful digital desktop fabrication tools such as 3-D printers.*

*Would-be entrepreneurs and inventors are no longer at the mercy of large companies*”

Chris Anderson isn’t just talking. He developed his own product, a digital garden sprinkler built in this open source way, called open sprinkler. It retails at $79, a quarter the cost of its competitors³.

One other element of such networks is worth considering.

Imagine if your product did the manufacturing equivalent of going “Gangnam Style” becoming globally popular overnight.

Would existing supply chains be able to deal with this? Where would you look for solutions if they didn’t?

I suggest you’d look at supply networks and communities like these.

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³ [http://rayshobby.net/?page_id=160](http://rayshobby.net/?page_id=160)
These new networks link directly to digital design and validation.

As we've seen, digitisation of the design process means it's possible to get a clear picture of your product at pre-prototype stage, anticipating any production challenges and needs, and making it possible to discuss requirements with supplier and customers alike.

We can see this in the virtual prototypes for the next generation of first class air and train seats we helped develop at WMG.

You can also see Ratan Tata, using WMGs 3D digital design studio to inspect the body design of a new vehicle. He is of course, both a consumer and a producer!

Such digital systems can be used to allow the personalisation and refinement of consumer experience, so for example, you might develop ten separate car finishes systems, based on consumer preferences at the design stage.
SLIDE NINETEEN

Both of the examples I mentioned above are from my own group, WMG. That's no coincidence, because the next opportunity is the importance of tapping into, and supporting the knowledge eco-systems that will support digital innovation.

University-Business partnerships, like those we support at WMG, or those at CalTech and MIT are vital to creating value, and particularly to bridging the “valley of death” between exciting research ideas and deliverable products.

It is this insight that is behind President Obama’s $1 billion dollar investment in new manufacturing innovation institutes, creating fifteen “global centres of advanced manufacturing”.

The digital, networked revolution is even changing the nature of these eco-systems of knowledge clusters.

These networks can now be global and increasingly, virtual – such as the innovative materials programmes we at WMG are developing with the IITs in Bhubaneswar, Kharagpur and Guwahati, bringing global research expertise in advanced materials to local businesses in Bengal, Odisha and Assam.
One example of such a network is the National Automotive Innovation Campus we're building at Warwick.

This will develop new technologies for low carbon mobility, working with partners from OEMs to components makers to create a critical mass of research capability at a single location.

This is vital because over the next ten years, we'll see an increasing emphasis on products that are both cleaner and lighter.

Over the next 10 years we will see research into polymer composites and multi-materials make their way into advanced manufacturing helping both our products and improve their performance.
SLIDE TWENTY-ONE

All these changes will create a need for new business systems and models.

The challenge here is not developing new technologies, but integrating technologies to better meet consumer needs.

Data management and consumer behaviour technologies can be used to transform how we consume and sell products.

A car that can analyse a breakdown, inform a local fabrication plant what part is required and supply instructions to the user for fitting it both creates value, and raises the question of how we pay for this “product”.

Similarly, portals like Etsy integrate bespoke crafts with the internet and global logistics, so if a customer in Michigan wants a block print cotton sari from Delhi, they can find it easily and get it fast.

This can go one step further, with consumers helping to design products, or “co-creation”. So Tanishq are launching consumer designed jewellery ranges.

One way such new business models will be built is by using the information that mobile digitisation creates as we go about our daily lives.

Knowing how we use or get frustrated with existing technologies will help those looking to find improved products and processes. But this runs straight into concerns about privacy.

A project we’ve begin at WMG is a “Hub of all things”.

This is a data storage facility, designed to hold the information our digitised products create about us, but only sharing the detailed data with businesses that meet standards of confidentiality, earning consumers trust to use the evidence of their lives.
We need access to this sort of information about consumer habits, because in every field, smarter, more connected products will provide huge amounts of information to innovators, which could create significant improvement in meeting consumer needs.

These smarter products will become part of the internet of things, communicating with the consumer, the manufacturer and other products to create value.

In automotive, we're seeing huge interest in driver assistance and active safety features. But these are useless if people just turn them off because they don't trust them, so innovators will need to know exactly how their technologies are being used.

What's more, connected smart products create a huge range of possibilities for new applications - imagine being able to download an engine mapping system tailored specifically to your driving style, or for a specific journey, in order to save fuel.
SLIDE TWENTY-THREE

Combining these digital and network based innovations will change the nature of being a manufacturer.

Perhaps in this revolution, a manufacturer will become more like a Doctor, as the Financial Times Peter Marsh has argued. Here makers will use a digitally driven, detailed understanding of the consumer to prescribe a tailored solution to their specific needs.

In some cases, like the 3D printing of hip replacements we see being worked on at WMG’s Institute of Digital Health, this is literally, as well as metaphorically, true!
The surge in demand for personalised products will create pressure for more effective use of resources.

This is important because resources are finite, and as we all know, tensions over resources can lead to dramatic consequences.

It's imperative that we reduce waste, eliminate toxicity, use raw material more efficiently and emphasise recycling and recovery.

The third revolution makes it possible to use new technologies to use resources more effectively, whether through materials lightweighting advances or helping smart cars driving more efficiently.

Recycling and recovery also applies to resources themselves.

At WMG, Dr Rohit Bhagat is researching the use of electrochemical remediation to bring back contaminated industrial land into residential use.

Again, this is a digital technology developed for one purpose now being used to transform another sector, hopefully releasing thousands of acres of land in our crowded cities for development.
This linking of electro-chemistry and housing is an example of one of the key features of the third industrial revolution – the pervasiveness of technologies.

As Omar Ishrak says, “It’s not enough to know about different technologies, you have to be able to combine them”.

This can create, new, unexpected breakthroughs.

The UK National Synchrotron facility is not the first place you’d look for a solution to Foot and Mouth disease.

But bringing together a particle accelerator with pathogenic research made it possible to understand viruses at the nano-scale. That helps create better vaccines.

In construction, Polli-Brick turns recycled PET bottles into modular building materials and uses CAD to create dramatic new buildings like the eco-ark in Taipei; the first building to be made entirely from garbage.

Technologies combining, creating new systems and approaches.
This pervasiveness of digitally driven technology will play a huge role in managing future energy markets.

Jeremy Rifkin argues that millions of people will produce their own energy, transforming how power is created and distributed through what he calls an “energy internet”.

Such self-generation will emphasise energy conservation as users seek to contribute to the grid.

At WMG, we're working with manufacturers Bladon Jets to develop micro gas turbines that improve energy usage in range extended electric vehicles.
Finally, there is one resource essential to all of the above. The people who will develop these technologies. A major problem facing economies around the world is a lack of skilled engineers. Companies need to take responsibility for securing this essential resource! We need integrated education programmes to create a stream of highly skilled young people. At WMG this starts with our Academy for Young Engineers, training 14-19 year olds. However, in both the UK and India, there is a chronic and growing shortage of graduate engineers throughout engineering and advanced manufacturing. As DRDO's Vijay Saraswat has said, “In India a meagre four persons out of every 1,000 are choosing S&T or research, as compared to 110 in Japan, 76 in Germany and even eight in China”. Without a graduate-level skilled workforce, innovative companies cannot grow, adopt new technologies or create new products. We can only address this through new industry funded undergraduate programmes. These courses need to exploit the latest technologies to impart research-driven knowledge and be taken by individuals part time at their workplace. We're doing this at WMG, applying the unique customer focused approach of WMG’s postgraduate programmes at undergraduate level. Whether in the UK or India, Business needs to invest in this precious resource now, before the gap grows too great.

The third industrial revolution is already here. It is all around us. We're seeing new business models, new ways of developing, simulating and validating products. We're seeing new markets, a new emphasis on the integration of physicality, software, systems and processes.
We're seeing new methods of manufacturing, new resource pressures, new supply chains and networks.

The effects of this cannot be avoided, but they can be anticipated and profited from.

Last year, digital photography firm Instagram was sold for one billion dollars.

Kodak, the giant of pre-digital photography, went into bankruptcy.

Not all companies will have such starkly divergent fates, but the third industrial revolution means we must **all** seize the opportunities the new global, digital, networked economy offers us.