



POLITECNICO
DI MILANO

I trend innovativi del manifatturiero e dei servizi del futuro:

sostenibilità, efficienza energetica e innovazione tecnologica



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Background: the Changing Environmental and Social Megatrends



- Europe's manufacturing technology platform Manufuture has identified eight megatrends*:
 - Changing demographics
 - Globalisation & future markets
 - Scarcity of resources
 - Climate change
 - Dynamic technology & innovation
 - Global knowledge society
 - Mass customisation
 - Sharing global responsibility
- These have a considerable impact & drive structural trends in nearly all manufacturing sectors.



(*Manufacturing 2030/Factories of the Future 2020)

People move to cities



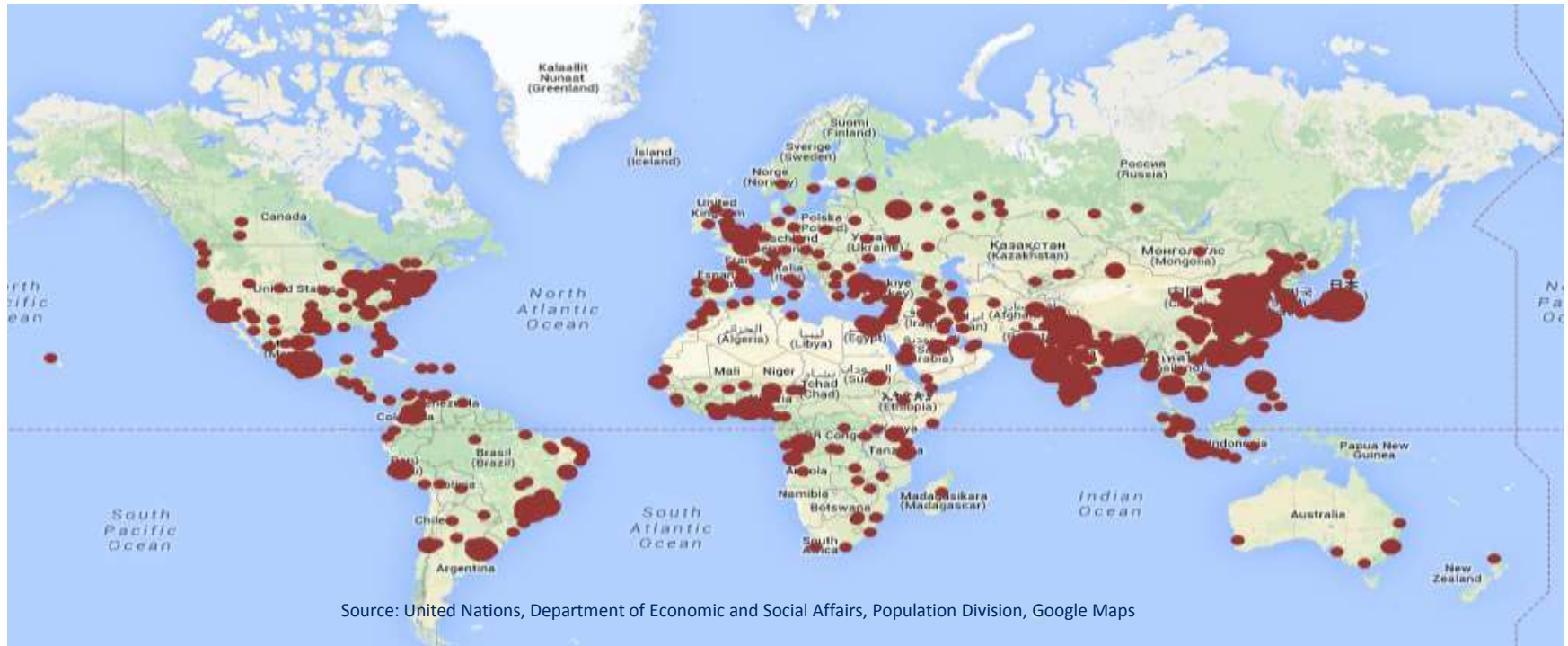
Cities with more than one million inhabitants in 2000



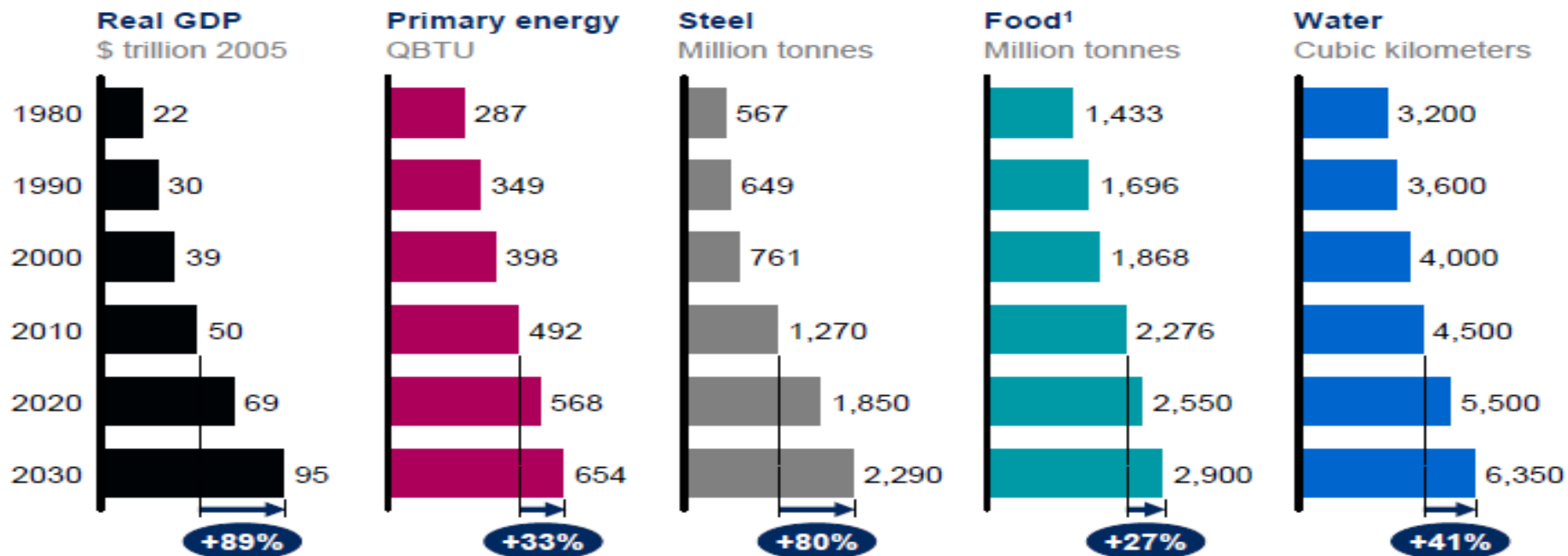
People move to cities



Cities with more than one million inhabitants in 2025



Demand for most resources has grown strongly since 2000, a trend that is likely to continue to 2030

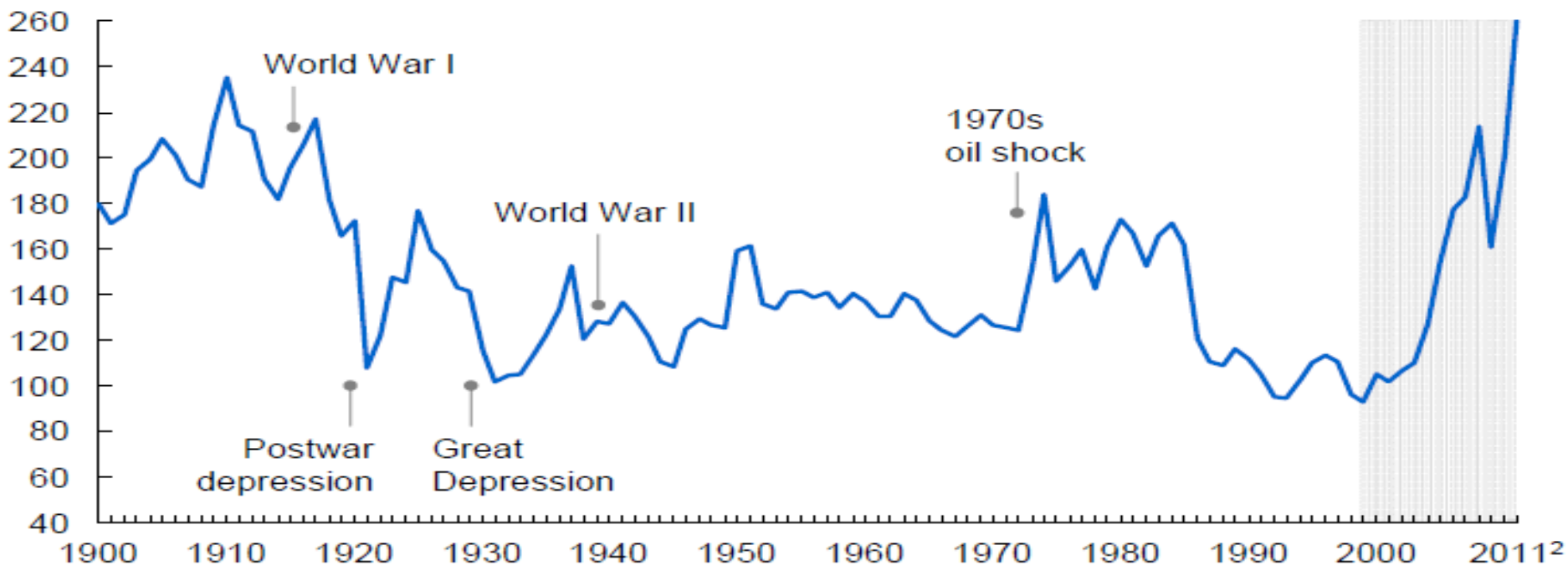


1 Only cereals.

SOURCE: Global Insight; IEA; UN Environment Program (UNEP); FAO; World Steel Association; McKinsey analysis

Commodity prices have increased sharply since 2000, erasing all the declines of the 20th century

MGI Commodity Price Index (years 1999–2001 = 100)¹

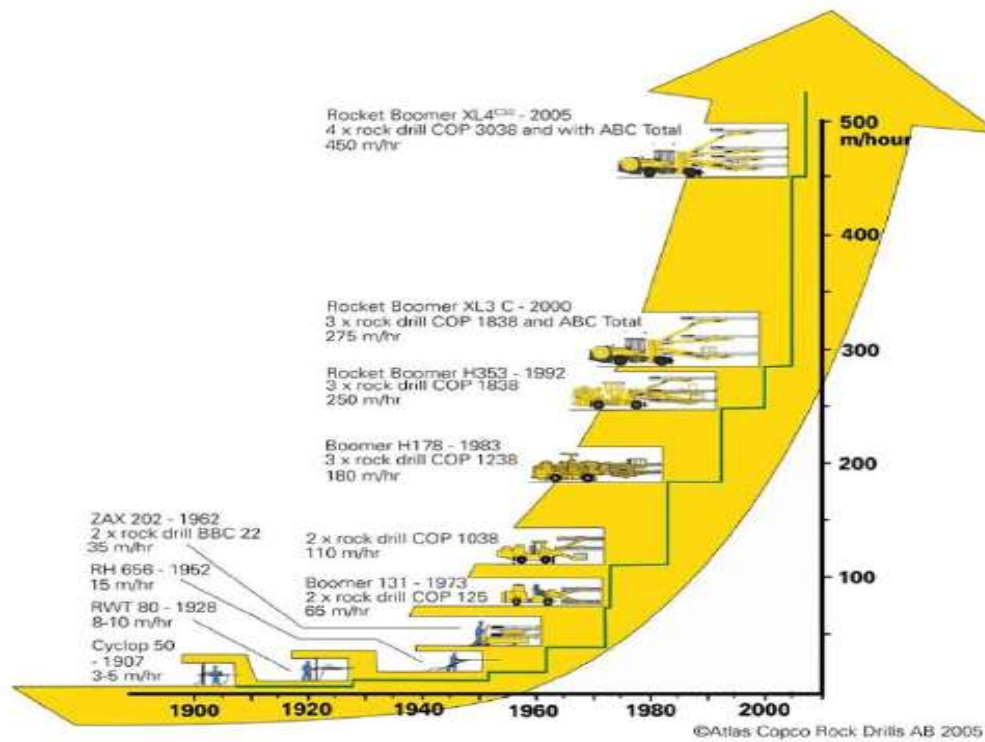


¹ See the methodology appendix for details of the MGI Commodity Price Index.

² 2011 prices are based on average of the first eight months of 2011.

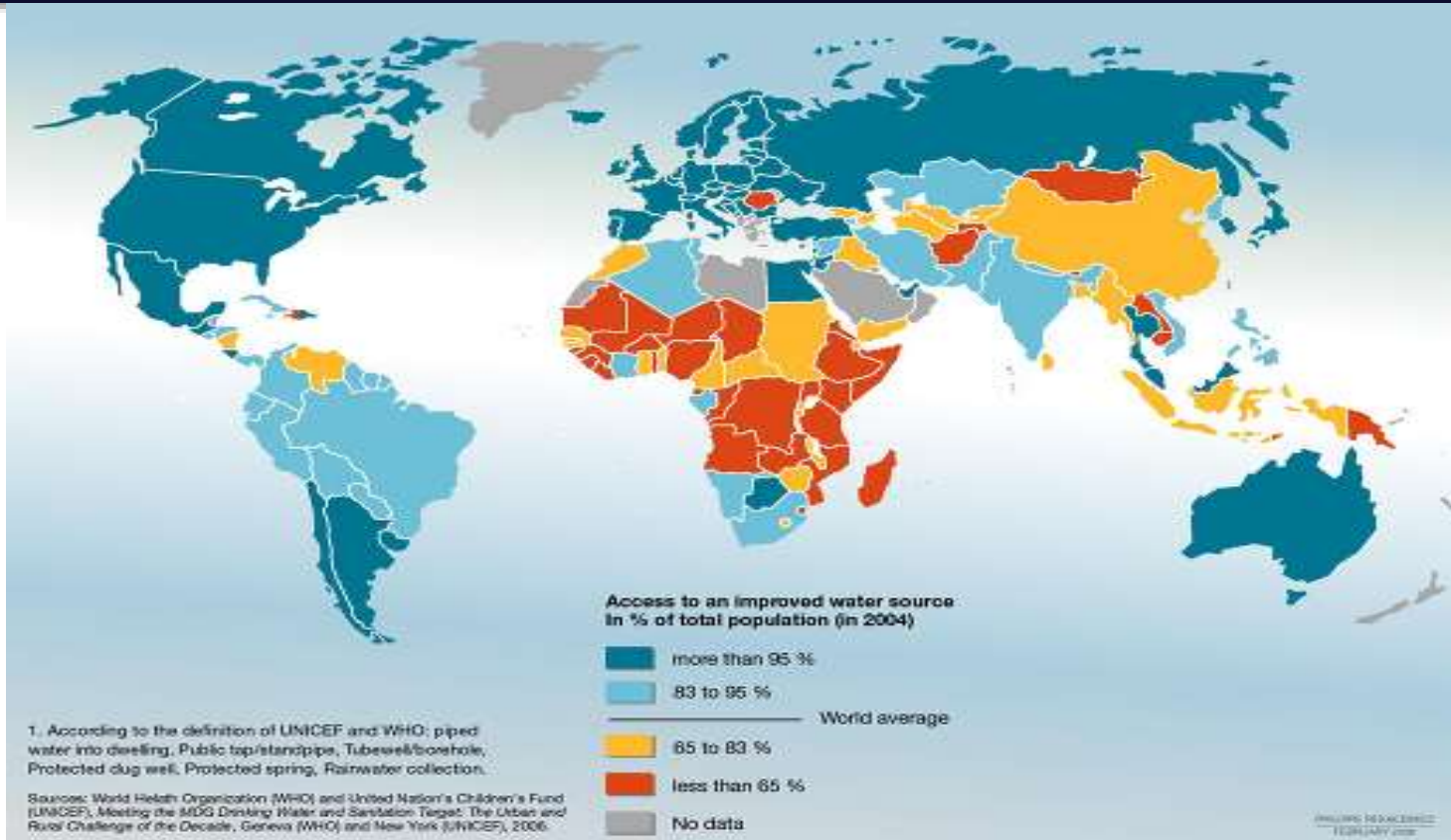
SOURCE: Grilli and Yang; Stephan Pfaffenzeller; World Bank; International Monetary Fund (IMF); Organisation for Economic Co-operation and Development (OECD); UN Food and Agriculture Organization (FAO); UN Comtrade; McKinsey analysis

Drilling technology during 100 years



Source: Stichting Materials innovation institute (M2i) 2009

Access to an improved water source



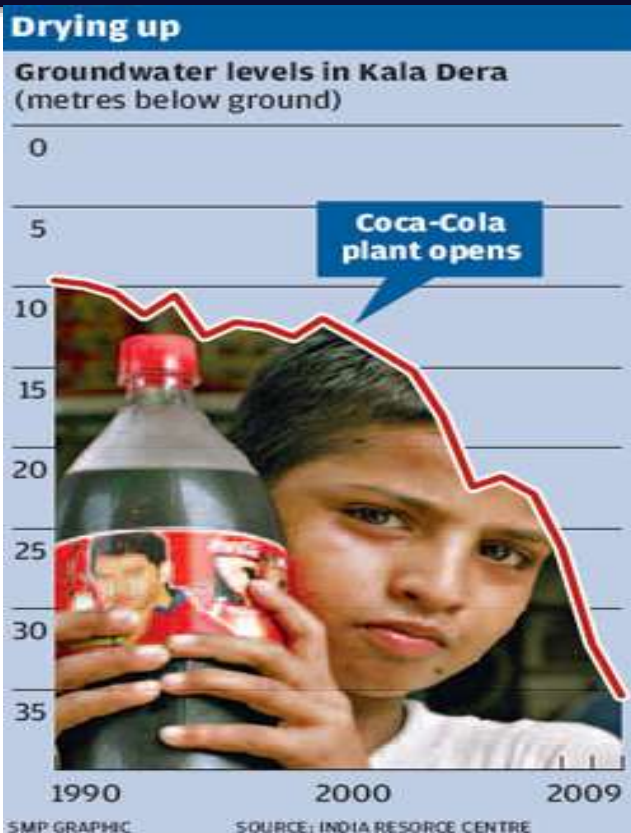


50 percent

The number of people who don't have access to the quality of water available to the citizens of Rome 2,000 years ago

Source: GE Citing Blue Planet Run, Smolan, Er Witt

The Coca-Cola Water controversy in India

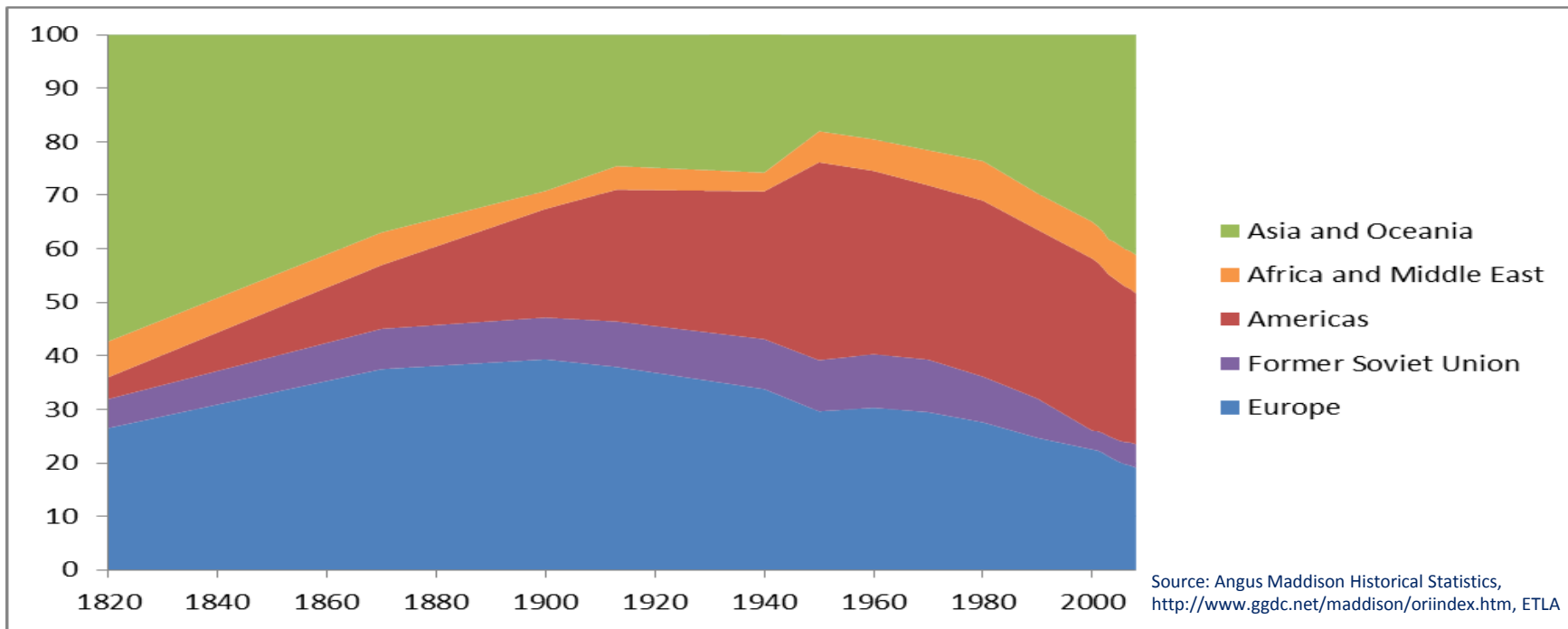


Background: the Changing Operational Megatrends

Asia reclaims its natural position



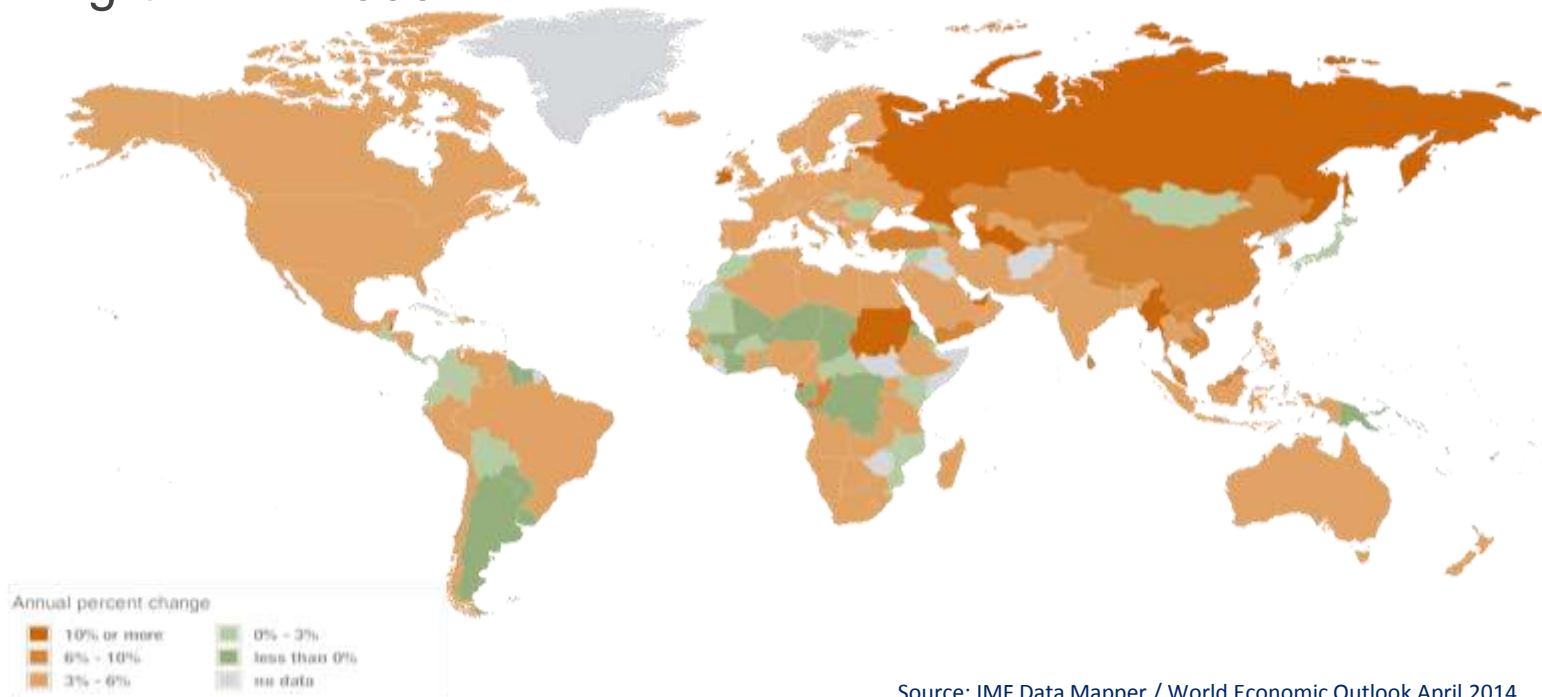
Share of world GDP, %



Growth gravitates to the East and South



GDP growth in 2000

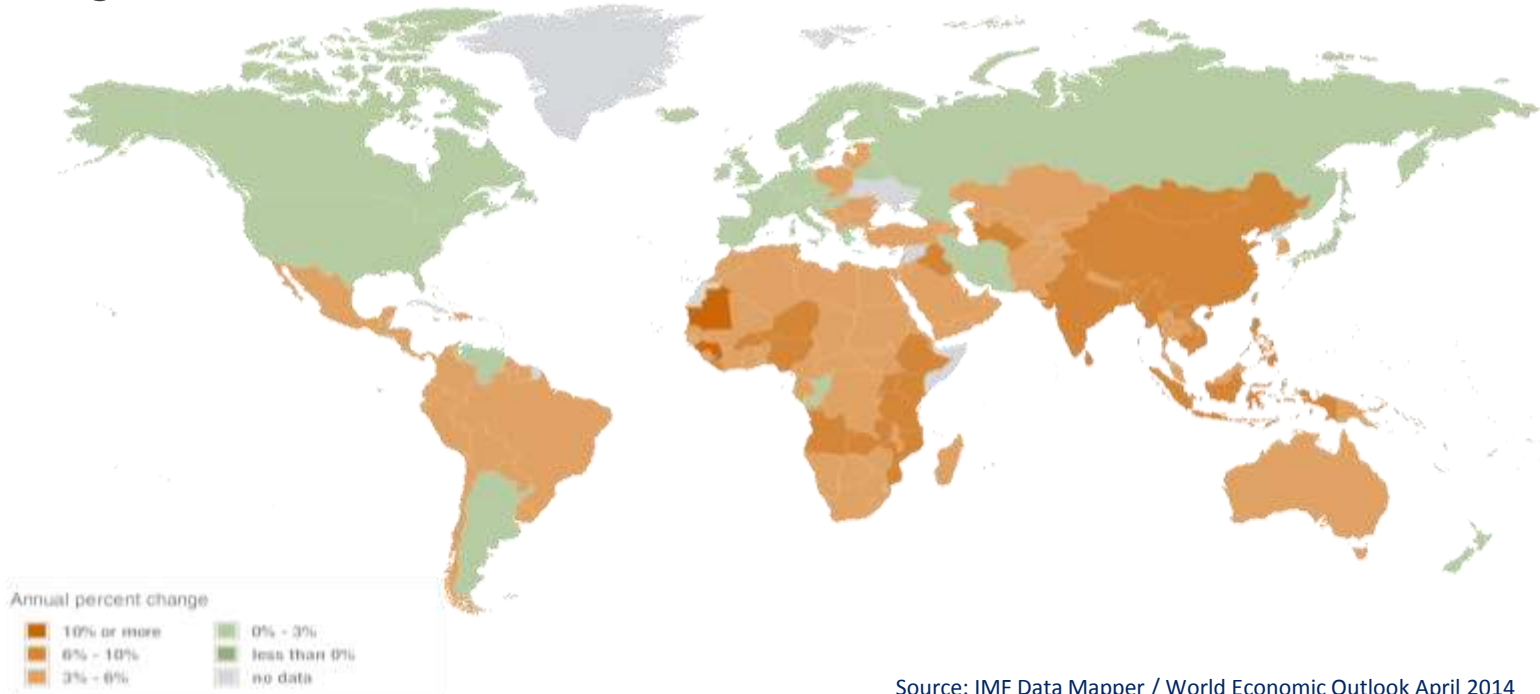


Source: IMF Data Mapper / World Economic Outlook April 2014

Growth gravitates to the East and South



GDP growth, forecast for 2019

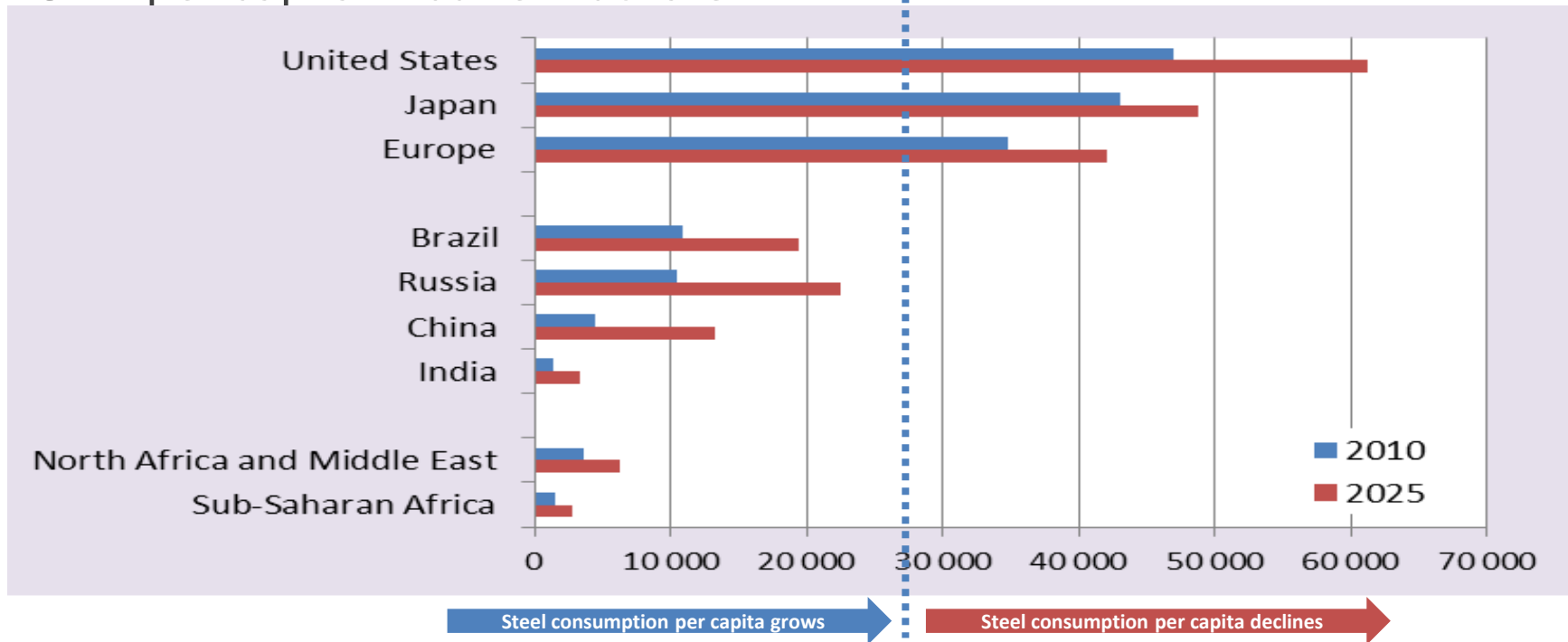


Source: IMF Data Mapper / World Economic Outlook April 2014

Room remains for catching up



GDP per capita in current dollars



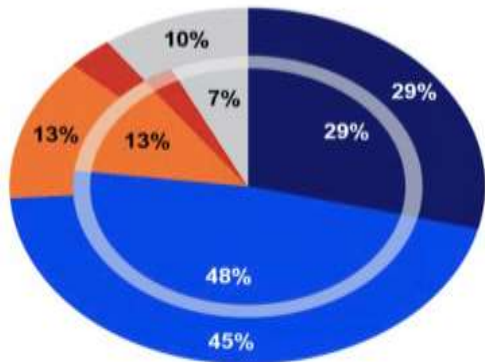
Sources: World Bank, Döhrn – Krätschell: Long Term Trends in Steel Consumption, Ruhr Economic Papers 415, 2013

Products



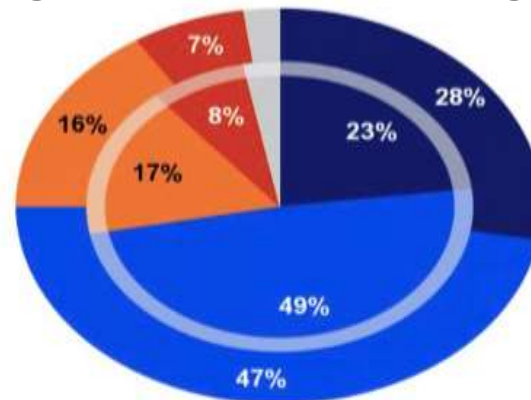
Green products: the consumer view

PROTECTION OF THE ENVIRONMENT CAN BOOST ECONOMIC GROWTH



● Totally agree
 ● Tend to agree
 ● Tend to disagree
 ● Totally disagree
 ● Don't know

EUROPEANS ARE PREPARED TO PAY MORE FOR ENVIRONMENTALLY-FRIENDLY PRODUCTS



● Totally agree
 ● Tend to agree
 ● Tend to disagree
 ● Totally disagree
 ● Don't know

Inner pie: 2011
 Outer pie: 2014

Special Eurobarometer, Survey conducted by TNS Opinion & Social at the request of
 the Directorate-General for Environment, 2014



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Products become highly Personalised



Products become lighter and stronger



Pictures: Audi, UPM

- Raw-material and energy efficiency improves
- Strong special steels
- Aluminium
- Titanium
- Alloys
- Composites
- Bio-composites
- Ceramics
- Hybrid materials

Slide courtesy of

Products become energy aware



Pictures: Neste Oil, Fortum, Woikoski

- Greenhouse gas emissions diminish
- Several alternatives: biofuels, electricity, hydrogen...
- Choice of driving power depends on price, availability and operating range
- Biofuels benefit from the use of existing distribution network
- Electricity is affordable, but operating range is short (at least for the moment)
- Hydrogen is "cleanest", but distribution network largely under planning
- Future is a question mark, options should be kept open

Slide courtesy of

Products become smarter



Pictures: Sandvik, Ponsse, Metos

- Information technology helps to improve energy efficiency
- Digital steering and control systems enable improved ergonomics
- Machines can be remotely controlled – humans are freed from working in uncomfortable and dangerous surroundings
- Machines can measure processes and output to optimise performance
- Machines can send data on output, lapsed time, and their own condition over mobile internet
- Improved conditions for fleet management
- Need for repair and maintenance can be anticipated to minimise downtime

Slide courtesy of

How to react: The vision for a competitive Sustainable Manufacturing

Sustainability Matters



Rio w

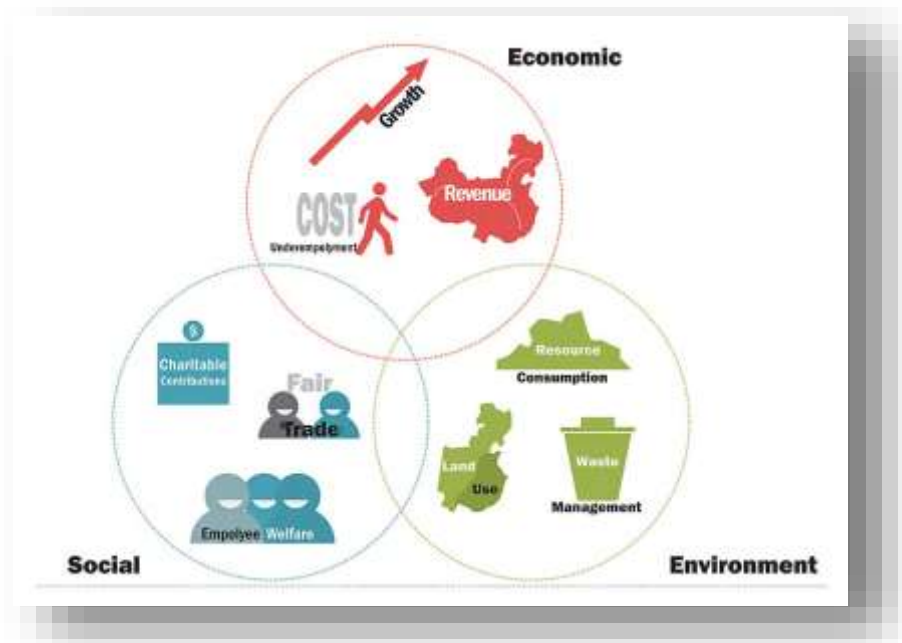


WORLD
ECONOMIC
FORUM

... global manufacturing as it stands
is unsustainable
on the long run.

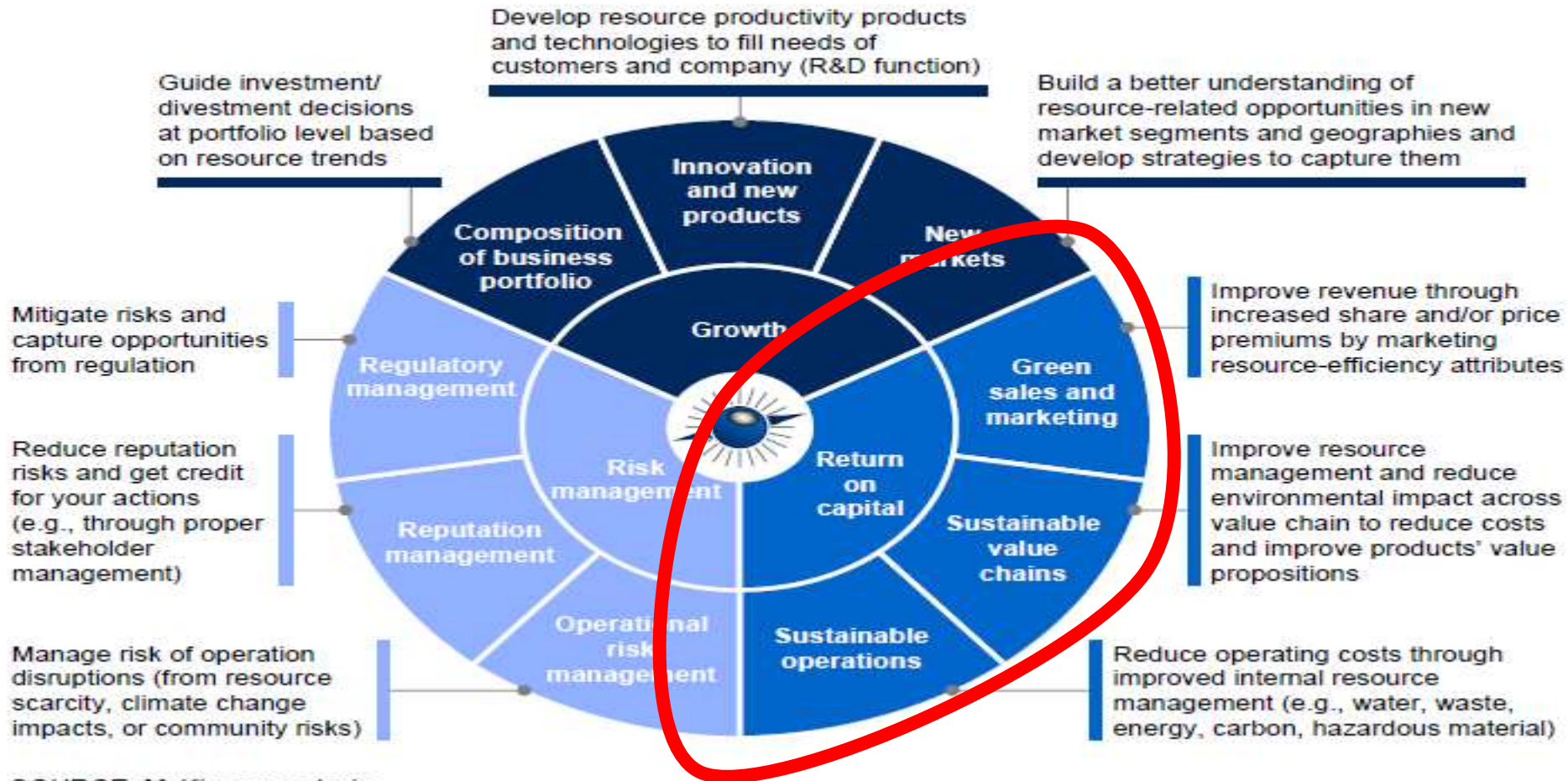
(Global Agenda, WEF, 2012)

Corporate Sustainability



Triple Bottom Line (Elkington, 1998)

There are several resource-related value-creation levers for businesses



SOURCE: McKinsey analysis



The transfer of business operation back to its country of origin

“We expect net labor costs for manufacturing in China and the U.S. to converge by around 2015”

“Take a hard look at the total costs”

Source: BCG group press release 5/5/11

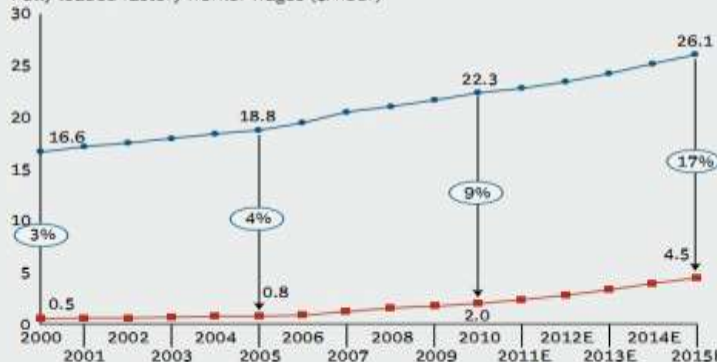
“End the practice of awarding business on the basis of price tag. Instead, minimize total cost”

Source: “4th key principle for management,” Out of the Crisis, W. Edwards Deming

EXHIBIT 1 | China's Wage Rates Are Growing Rapidly

Average wages could approach 17 percent of those in the U.S. by 2015, up from 3 percent in 2000

Fully loaded factory-worker wages (\$/hour)



	2000–2005 (%)	CAGR 2005–2010 (%)	2010–2015 (%)
U.S.	2	4	3
China	10	19	17

Ratio of average Chinese to average U.S. wage rates



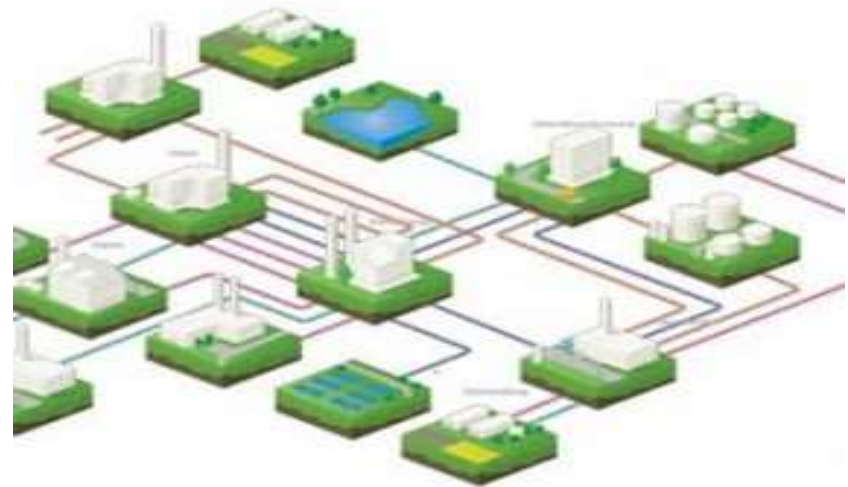
- Cleaner and greener
- Transparent Factory
- Local and Small
- Living and Working
- Vertical and Dense



Industrial Symbiosis



- Co-evolution of products–
processes–production systems
- Physical exchanges of materials,
energy, water, and/or
by-products
- Optimised interaction of
manufacturing with transport
and critical infrastructures





Advanced manufacturing processes that will be focused on by the 'Factories of the Future' partnership are:

- Additive manufacturing (i.e. 3D Printing)
- Photonics-based materials processing technologies
- Shaping technology
- High productivity & 'self-assembly' technologies (see video)
- Methods for the handling parts, metrology & inspection
- Flexible sheet-to-sheet & roll-to-roll
- Innovative physical, chemical & physiochemical processes
- Replication equipment for flexible, scalable production
- Integration of non-convention technologies



**FACTORIES OF
THE FUTURE**

*Multi-annual roadmap
for the contractual FPFP
under Horizon 2020*

Prepared by



Additive manufacturing advances



- 3D printing creates new opportunities



Pictures: EOS

- Capable of producing forms that cannot be made by traditional methods
- Light but strong structures one possible application
- Enables distributed production of spare parts
- Siemens has 3D-printed spare parts for gas turbines since January
- GE is also starting to utilise additive manufacturing methods in production
- Additive manufacturing is not likely to replace traditional methods in serial production



Polymer Powder



250,000

Courtesy of Jordan Brandt-Autodesk



Future robots are capable of interacting with humans



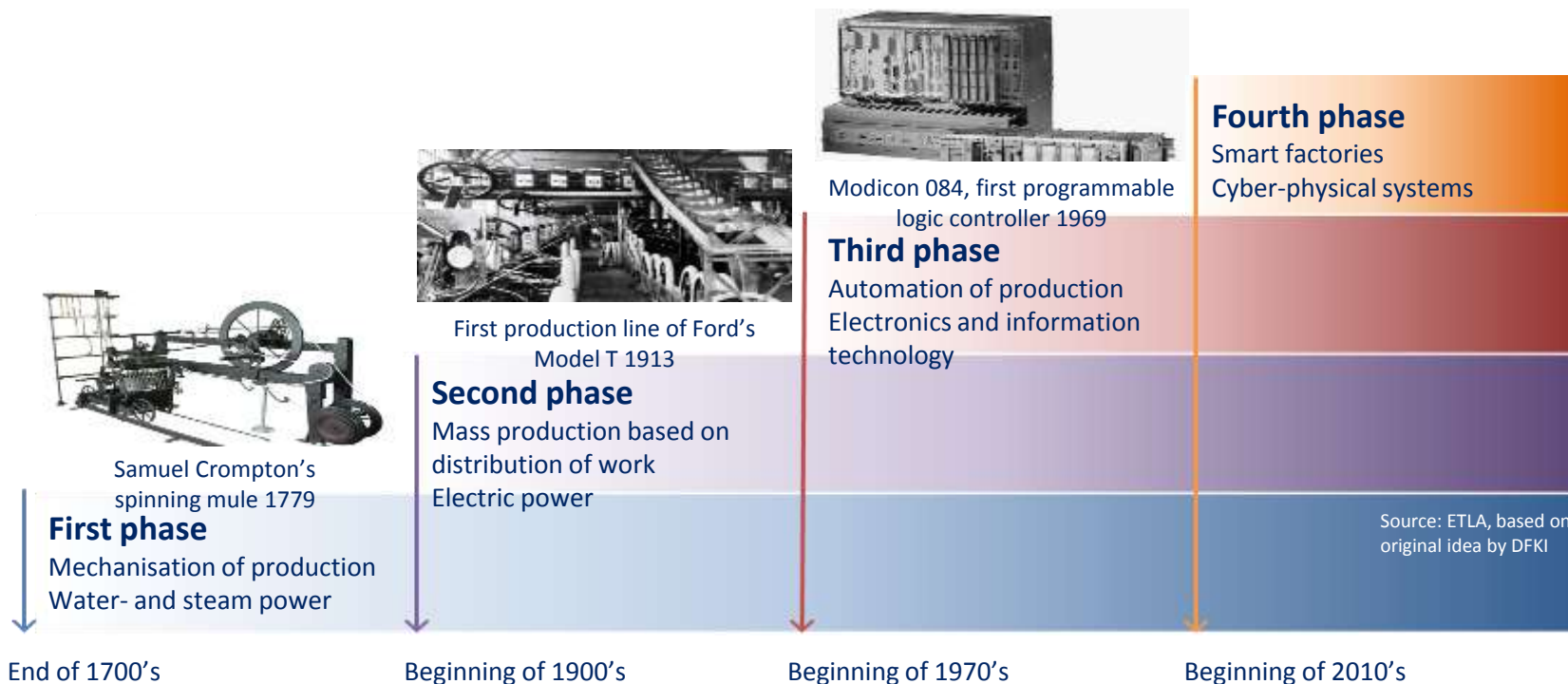
Pictures: Robot Hall of Fame, Rethink Robotics

- The first industrial robot Unimat was installed in 1961 to GM's Ternstedt factory in New Jersey
- 2 470 000 industrial robots had been sold by the end of 2012
- 1 235 000 – 1 500 000 industrial robots were in commission
- Robot density (number of industrial robots per 10 000 employees) is highest in Korea, Japan and Germany
- Highest density in automotive and electrical/electronics industries
- Use is growing in small and medium-sized companies
- Robots become more affordable, simpler to use and capable of collaborating with humans

Industrial revolution is progressing



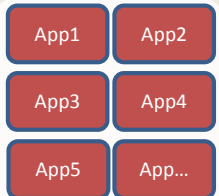
Fourth phase: Smart factories (Industrie 4.0)



From MES to MOS (Mfg Operating System)



M-Apps Store



M-Apps are aggregated and customized based on user and business needs

Manufacturing Workspace



User/Process X



MOS – Manufacturing Operating System



User/Process Y



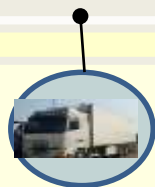
User/Process Z



Enterprise network (office)

Manufacturing Service Bus / Real time / Industrial Middleware

(Shop floor)



CPPR – Cyber Physical Production Resource

Real/virtual production plant

Migration from MES world

Existing Monolytic Applications (e.g. ERP, MES, ...)

Interface Layer

Migration from Standard Equipments World



CPS enabled production resources

encapsulation



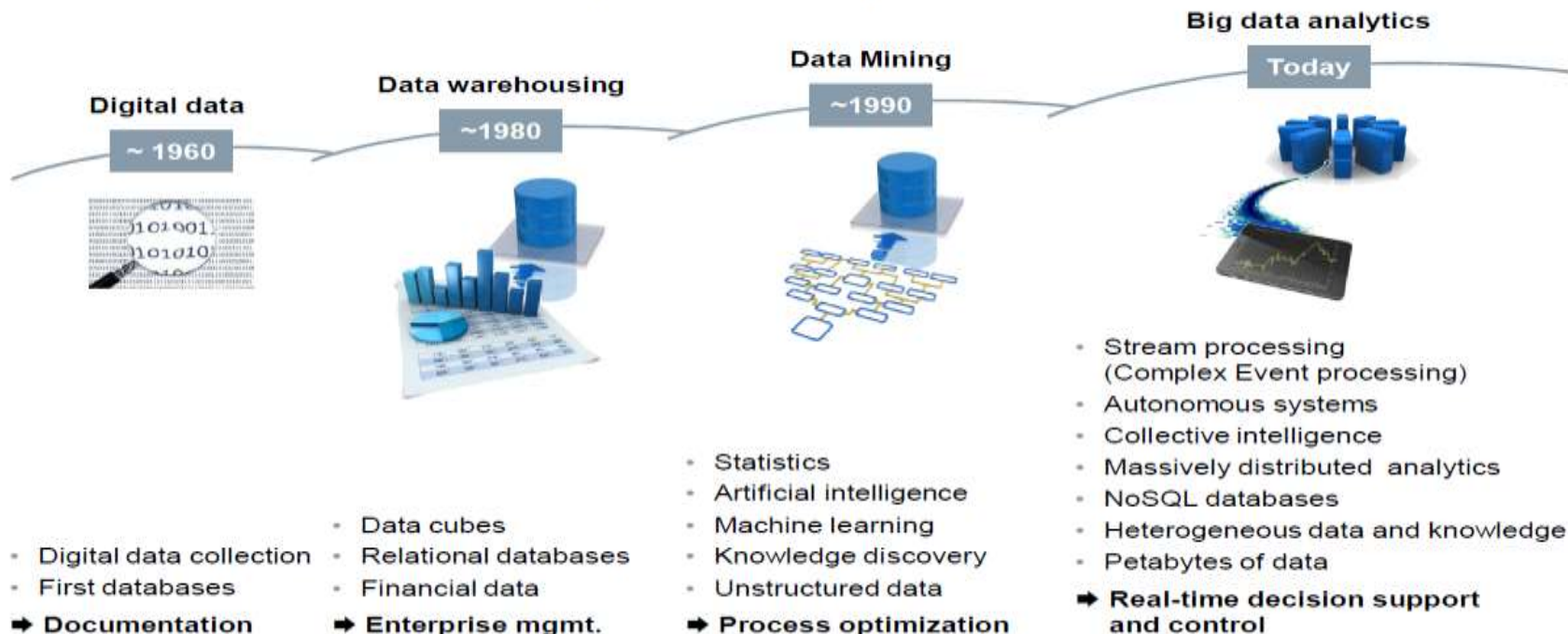
Additional control intelligence



Standard Production equipment



Innovation waves lifting Business Intelligence / Data Analytics



*** Cyber Physical Systems for Manufacturing and Production

Thomas Runkler, Siemens Corporate Technology

Session: The role of Cyber-Physical Systems (CPS) for manufacturing

Cyber-Physical Systems in manufacturing and production workshop Brussels 30th October 2014

Cyber Security in Manufacturing



Incident rates across monitored industries



Cyber Security

German jitters over cyber attacks

W32.Stuxnet Dossier

Version 1.4 (February 2011)



Manufacturing: a 1 in 3 chance of being targeted by at least one Spear Phishing attack in 2013

Symantec Internet Security Report 2014

▶ WHO'S SPYING ON YOU?

No business is safe from cyber-espionage





Factories of the future are expected to create a large amount of employment opportunities for citizens. Factory workers are key to competitiveness but challenges such as changing demographics & new skills must be addressed.

Policies should address the following items:

- New approaches to accommodate different demographics
- New technical, educational & organisational ways to increase attractiveness of factory work
- New approaches to development of skills & competences
- New ways to organise factories: Human-centred work environments
- Ways to integrate future factory work into social patterns





“Stay hungry,
stay foolish.”

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