

The New Industrial Revolution: Opportunities for Britain and the World

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After the economic crisis...



What's the future for manufacturing?



Some optimistic views



“There’s a new zeitgeist: I’m seeing a global manufacturing renaissance” :
Jeff Immelt, chief executive, General Electric, April 2012.

China a big part of the picture



A mix of skills and capabilities



But production jobs becoming scarcer



Where are the people ?



EU manufacturing employment dropped 11 per cent between 2008 & 2012 (net loss 4.3m jobs)



The new industrial revolution

- What manufacturing means
- Global trends – where Britain fits in
- The 5th industrial revolution
- Business strategies

The new industrial revolution

- The meaning of manufacturing**

What lies behind manufacturing

- Manufacturing = Materials + Energy + Ideas
- The creative force behind 10bn unique products
- It accounts for 16 per cent of world economy (10pc of UK economy)
- It employs about 300m people or roughly 5 pc of world population.(In the UK, manufacturing employment about 2m, or about pc of population)
- The price effect: manufacturing characterised by deflation (compared to services)

The table of life

PERIODIC TABLE
Atomic Properties of the Elements

NIST
National Institute of Standards and Technology
U.S. Department of Commerce

Physics Laboratory physics.nist.gov
Standard Reference Data www.nist.gov/srd

Frequently used fundamental physical constants

For the most accurate values of these and other constants, visit physics.nist.gov/constants

1 second = 9 192 631 770 periods of radiation corresponding to the transition between the two hyperfine levels of the ground state of ¹³³Cs

speed of light in vacuum	<i>c</i>	299 792 458 m s ⁻¹	(exact)
Planck constant	<i>h</i>	6.626 1 × 10 ⁻³⁴ J s	(<i>h</i> = <i>h</i> /2π)
elementary charge	<i>e</i>	1.602 2 × 10 ⁻¹⁹ C	
electron mass	<i>m_e</i>	9.109 4 × 10 ⁻³¹ kg	
	<i>m_ec²</i>	0.5110 MeV	
proton mass	<i>m_p</i>	1.672 6 × 10 ⁻²⁷ kg	
fine-structure constant	<i>α</i>	1/137.036	
Rydberg constant	<i>R_∞</i>	10 973 732 m ⁻¹	
	<i>R_∞c</i>	3.289 842 × 10 ¹⁵ Hz	
	<i>R_∞hc</i>	13.6057 eV	
Boltzmann constant	<i>k</i>	1.3807 × 10 ⁻²³ J K ⁻¹	

Solids
 Liquids
 Gases
 Artificially Prepared

Period	Group 1 IA												Group 13 IIIA		Group 14 IVA		Group 15 VA		Group 16 VIA		Group 17 VIIA		Group 18 VIIIA
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18					
1	H Hydrogen 1.00794 1s																			He Helium 4.002602 1s ²			
2	Li Lithium 6.941 1s ² 2s	Be Beryllium 9.012182 1s ² 2s ²											B Boron 10.811 1s ² 2s ² 2p	C Carbon 12.0107 1s ² 2s ² 2p ²	N Nitrogen 14.0067 1s ² 2s ² 2p ³	O Oxygen 15.9994 1s ² 2s ² 2p ⁴	F Fluorine 18.9984032 1s ² 2s ² 2p ⁵	Ne Neon 20.1797 1s ² 2s ² 2p ⁶					
3	Na Sodium 22.98976928 [Ne]3s	Mg Magnesium 24.3050 [Ne]3s ²										Al Aluminum 26.9815386 [Ne]3s ² 3p	Si Silicon 28.0855 [Ne]3s ² 3p ²	P Phosphorus 30.973762 [Ne]3s ² 3p ³	S Sulfur 32.065 [Ne]3s ² 3p ⁴	Cl Chlorine 35.453 [Ne]3s ² 3p ⁵	Ar Argon 39.948 [Ne]3s ² 3p ⁶						
4	K Potassium 39.0983 [Ar]4s	Ca Calcium 40.078 [Ar]4s	Sc Scandium 44.955912 [Ar]3d ¹ 4s ²	Ti Titanium 47.867 [Ar]3d ² 4s ²	V Vanadium 50.9415 [Ar]3d ³ 4s ²	Cr Chromium 51.9961 [Ar]3d ⁵ 4s ¹	Mn Manganese 54.938045 [Ar]3d ⁵ 4s ²	Fe Iron 55.845 [Ar]3d ⁶ 4s ²	Co Cobalt 58.933195 [Ar]3d ⁷ 4s ²	Ni Nickel 58.6934 [Ar]3d ⁸ 4s ²	Cu Copper 63.546 [Ar]3d ¹⁰ 4s ¹	Zn Zinc 65.38 [Ar]3d ¹⁰ 4s ²	Ga Gallium 69.723 [Ar]3d ¹⁰ 4s ² 4p	Ge Germanium 72.64 [Ar]3d ¹⁰ 4s ² 4p ²	As Arsenic 74.9216 [Ar]3d ¹⁰ 4s ² 4p ³	Se Selenium 78.96 [Ar]3d ¹⁰ 4s ² 4p ⁴	Br Bromine 79.904 [Ar]3d ¹⁰ 4s ² 4p ⁵	Kr Krypton 83.798 [Ar]3d ¹⁰ 4s ² 4p ⁶					
5	Rb Rubidium 85.4678 [Kr]5s	Sr Strontium 87.62 [Kr]5s	Y Yttrium 88.90585 [Kr]4d ¹ 5s ²	Zr Zirconium 91.224 [Kr]4d ² 5s ²	Nb Niobium 92.90638 [Kr]4d ⁴ 5s ¹	Mo Molybdenum 95.96 [Kr]4d ⁵ 5s ¹	Tc Technetium (98) [Kr]4d ⁵ 5s ²	Ru Ruthenium 101.07 [Kr]4d ⁶ 5s ¹	Rh Rhodium 102.90550 [Kr]4d ⁷ 5s ¹	Pd Palladium 106.42 [Kr]4d ¹⁰	Ag Silver 107.8682 [Kr]4d ¹⁰ 5s ¹	Cd Cadmium 112.411 [Kr]4d ¹⁰ 5s ²	In Indium 114.818 [Kr]4d ¹⁰ 5s ² 5p	Sn Tin 118.710 [Kr]4d ¹⁰ 5s ² 5p ²	Sb Antimony 121.760 [Kr]4d ¹⁰ 5s ² 5p ³	Te Tellurium 127.60 [Kr]4d ¹⁰ 5s ² 5p ⁴	I Iodine 126.90447 [Kr]4d ¹⁰ 5s ² 5p ⁵	Xe Xenon 131.293 [Kr]4d ¹⁰ 5s ² 5p ⁶					
6	Cs Cesium 132.9054519 [Xe]6s	Ba Barium 137.327 [Xe]6s		Hf Hafnium 178.49 [Xe]4f ¹⁴ 5d ² 6s ²	Ta Tantalum 180.94788 [Xe]4f ¹⁴ 5d ³ 6s ²	W Tungsten 183.84 [Xe]4f ¹⁴ 5d ⁴ 6s ²	Re Rhenium 186.207 [Xe]4f ¹⁴ 5d ⁵ 6s ²	Os Osmium 190.23 [Xe]4f ¹⁴ 5d ⁶ 6s ²	Ir Iridium 192.217 [Xe]4f ¹⁴ 5d ⁷ 6s ²	Pt Platinum 195.084 [Xe]4f ¹⁴ 5d ⁹ 6s ¹	Au Gold 196.966569 [Xe]4f ¹⁴ 5d ¹⁰ 6s ¹	Hg Mercury 200.59 [Xe]4f ¹⁴ 5d ¹⁰ 6s ²	Tl Thallium 204.3833 [Hg]6p	Pb Lead 207.2 [Hg]6p ²	Bi Bismuth 208.98040 [Hg]6p ³	Po Polonium (209) [Hg]6p ⁴	At Astatine (210) [Hg]6p ⁵	Rn Radon (222) [Hg]6p ⁶					
7	Fr Francium (223) [Rn]7s	Ra Radium (226) [Rn]7s ²		Rf Rutherfordium (261) [Rn]5f ¹⁴ 6d ² 7s ²	Db Dubnium (268) 6.0?	Sg Seaborgium (271)	Bh Bohrium (272)	Hs Hassium (277)	Mt Meitnerium (276)	Ds Darmstadtium (281)	Rg Roentgenium (280)	Cn Copernicium (285)	Uut Ununtrium (284)	Uuq Ununquadium (286)	Uup Ununpentium (288)	Uuh Ununhexium (293)	Uus Ununseptium (294)	Uuo Ununoctium (294)					
			La Lanthanum 138.90547 [Xe]5d ¹ 6s ²	Ce Cerium 140.116 [Xe]4f ¹ 5d ¹ 6s ²	Pr Praseodymium 140.90765 [Xe]4f ³ 6s ²	Nd Neodymium 144.242 [Xe]4f ⁴ 6s ²	Pm Promethium (145) [Xe]4f ⁵ 6s ²	Sm Samarium 150.36 [Xe]4f ⁶ 6s ²	Eu Europium 151.964 [Xe]4f ⁷ 6s ²	Gd Gadolinium 157.25 [Xe]4f ⁷ 6s ²	Tb Terbium 158.92535 [Xe]4f ⁹ 6s ²	Dy Dysprosium 162.500 [Xe]4f ¹⁰ 6s ²	Ho Holmium 164.93032 [Xe]4f ¹¹ 6s ²	Er Erbium 167.259 [Xe]4f ¹² 6s ²	Tm Thulium 168.93421 [Xe]4f ¹³ 6s ²	Yb Ytterbium 173.054 [Xe]4f ¹⁴ 6s ²	Lu Lutetium 174.9668 [Xe]4f ¹⁴ 5d ¹ 6s ²						
			Ac Actinium (227) [Rn]6d ¹ 7s ²	Th Thorium 232.03806 [Rn]6s ² 7s ²	Pa Protactinium 231.03688 [Rn]5f ² 6d ¹ 7s ²	U Uranium 238.02891 [Rn]5f ³ 6d ¹ 7s ²	Np Neptunium (237) [Rn]5f ⁴ 6d ¹ 7s ²	Pu Plutonium (244) [Rn]5f ⁶ 7s ²	Am Americium (243) [Rn]5f ⁷ 7s ²	Cm Curium (247) [Rn]5f ⁸ 6d ¹ 7s ²	Bk Berkelium (247) [Rn]5f ⁹ 7s ²	Cf Californium (251) [Rn]5f ¹⁰ 7s ²	Es Einsteinium (252) [Rn]5f ¹¹ 7s ²	Fm Fermium (257) [Rn]5f ¹² 7s ²	Md Mendelevium (258) [Rn]5f ¹³ 7s ²	No Nobelium (259) [Rn]5f ¹⁴ 7s ²	Lr Lawrencium (260) [Rn]5f ¹⁴ 7p ¹						

58 Ce
 Atomic Number: 58
 Ground-state Level: 1G_{5/2}
 Symbol: Ce
 Name: Cerium
 Atomic Weight: 140.116
 Ground-state Configuration: [Xe]4f¹5d¹6s²
 Ionization Energy (eV): 5.5387

¹Based upon ¹²C. () indicates the mass number of the longest-lived isotope.

For a description of the data, visit physics.nist.gov/data

Bringing order to chaos (countering the 2nd law of thermodynamics)



10,000 years of evolution in adding information to materials



Stone age axe : resources needed to make one unit

Number of manufacturing workers: 1

Number of sites: 1

Number of materials: 1

Skills honed by learning over decades

Where we are now



The iPhone 5: resources needed to make one unit

Number of manufacturing workers: 5,000

Number of sites: 50

Number of materials: 50

Skills honed by science and technology advances

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1800 – At the dawn of modern manufacturing

Share of world production



Early Chinese astronomical clock

1. China	33.3%
2. India*	19.7%
3. Russia	5.6%
4. UK	4.3%
5. France	4.2%
6. Germany**	3.5%
6. Japan	3.5%

Source: Paul Bairoch data; *includes Pakistan;

** German states

1900 – Britain's century; but the US taking over

Share of world production



Isambard Kingdom Brunel, pioneer of the
First Industrial Revolution

1. US	23.6%
2. UK	18.5%
3. Germany	13.2%
4. Russia	8.8%
5. France	6.8%
6. China	6.2%
7. Japan	3.5%

Source: Paul Bairoch data

2012– China regains the lead

Share of world production



Giant Sany crane

1. China	22.4%
2. US	17.5%
3. Japan	9.4%
4. Germany	6.0%
5. South Korea	2.8%
6. Italy	2.4%
7. Russia	2.3%

Source: UN data

Growth in manufacturing output 2000-12

China +241%

Britain - 9%

Europe + 14%

World + 52%

France + 1%

Germany + 23%

Japan + 13%

US +20%

(Constant 2005 dollars, Source: UN)

Who's re-shoring?

Changes in shares of world manufacturing (2011-12)

China	+1.8 percentage points
US	+ 0.3 percentage points
Mexico/Australia/Russia	+ 0.1 percentage points
Brazil/Germany	- 0.5 percentage points
Italy	-0.4 percentage points
Japan	-0.3 percentage points
Spain/India	-0.2 percentage points
Switzerland/UK	-0.1 percentage points

(Source: UN)

World manufacturing output 2012 (\$bn, current prices)

1. China	2,556 (22.4%)
2. US	1,994 (17.5%)
3. Japan	1,076
4. Germany	686.6
5. S Korea	315.8
6. Italy	279.9
7. Russia	262.4
8. Brazil	253.8
9. India	239.5
10. France	233.1

World 11,426 Source: UN

World manufacturing output 2012 (\$bn, current prices)

11. UK	219.5
12. Indonesia	210.2
13. Mexico	205.0
14. Canada	185.6
15. Spain	161.8
16. Taiwan	130*
17. Turkey	123.2
18. Australia	120.7
19. Switzerland	113.4
20. Thailand	111

Source: UN, IHS Global Insight

* estimate

World manufacturing output/ population 2012 (\$bn, current prices)

(top 20 manufacturing nations only)

1. Switzerland	14,125
2. Japan	8,459
3. Germany	8,277
4. S Korea	6,428
5. US	6,280
6. Taiwan	5,579
7. Canada	5,344
8. Australia	5,260
9. Italy	4,588
10. France	3,535
World	1,616

World manufacturing output / population 2012 (\$bn, current prices)

(top 20 manufacturing nations only)

11. UK	3,492
12. Spain	3,468
13. Mexico	1,690
14. China	1,865
15. Russia	1,832
16. Thailand	1,664
17. Turkey	1,662
18. Brazil	1,291
19. Indonesia	867
20. India	190

World 1,616

World manufacturing output 2012 (percentages)

Asia 43%

Europe 26%

N America 22%

S America 3%

Africa 2%

Rest of world 4%

Source: UN

World manufacturing deflation

A typical factory-produced item today typically sells for half the price it sold for in 1970 (relative to overall global inflation)

The new industrial revolution

- The meaning of manufacturing
- Global trends – where Britain fits in
- The 5th industrial revolution**

The New Industrial Revolution (Fifth Industrial Revolution)-Key factors

1. Blended technology
2. Mass personalisation/customisation
3. Focus on specialisation/niches
4. Environmental stewardship
5. Service dimension
6. Global networking
7. Cluster dynamics
8. The new geography – China/India/S America
9. The maverick manufacturer

The New Industrial Revolution

1. Blended technology

The A350: many key technologies



Glass for flat-screen TVs/monitors...



Blended technology: the biotech/electronics mix



The New Industrial Revolution

1. Blended technology
- 2. Mass personalisation/customisation**

Technology/business methods make customisation more affordable and practicable...



The Zara production model – short production runs, made near the customer – Tibard chef's uniforms (Manchester)



The New Industrial Revolution

1. Blended technology
2. Mass personalisation/customisation

3D Printing adds new tools

The new technology of “additive manufacturing”

3D PRINTING

THE NEXT TECHNOLOGY GOLD RUSH



**FUTURE FACTORIES AND HOW TO CAPITALIZE ON
DISTRIBUTED MANUFACTURING**

By Christopher D. Winnan

How 3D printing machines work



Renishaw enters this new field with a £400,000 machine



Abe Reichental and his 3D-printed guitar



3D printing machines...use in fashion industry



The New Industrial Revolution

1. Blended technology
2. Mass personalisation/customisation
- 3. Focus on specialisation/niches**

Manufacturing specialisation : leverage innovation



Tunnelling machines – Herrenknecht (made in Germany)



The New Industrial Revolution

1. Blended technology
2. Mass personalisation/customisation
3. Focus on specialisation/niches
4. **Environmental stewardship**

Environmental stewardship: Dando Drilling (Littlehampton)



Environmental stewardship: grow your own wool



The New Industrial Revolution

1. Blended technology
2. Mass personalisation/customisation
3. Focus on specialisation/niches
4. Environmental stewardship
- 5. Service dimension**

Service dimension at Cammell Laird (Birkenhead)



Different industries, same skills



Servitisation : Manufacturers as consultants



The New Industrial Revolution

1. Blended technology
2. Mass personalisation/customisation
3. Focus on specialisation/niches
4. Environmental stewardship
5. Service dimension
- 6. Global networking**

What's the link between.....



.....Chinese electronics factories....



...the Westwind air bearing company in Dorset



.....and a factory in Cheshire countryside?



Global networking: R.A.Chilton coatings company near Chester



The New Industrial Revolution

1. Blended technology
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5. Service dimension
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- 7. Cluster dynamics**

Clusters: NW England textiles sector (Panaz)



The New Industrial Revolution

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8. **The new geography – China/India/S America**

China dimension: Jaguar Land Rover (Halewood plant)



Jaguar Land Rover: long-term promise paying off



Made in Rochdale: the Chongqing connection



The New Industrial Revolution

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- 9. The maverick manufacturer**

Maverick approach: Thomas Heatherwick – designer/engineer



The maverick manufacturer: go with the flow



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- The 5th industrial revolution
- Opportunities for Britain**

Encourage entrepreneurs: Ning Li of Made.com



Support specialists : Sir David McMurtry of Renishaw



Develop cluster thinking



Add skills to old industries



Add service skills: manufacturers as physicians



Possibilities abound

