The future of manufacturing: a UK perspective
Overview and Introduction

Overview

- Introduction
- Future of manufacturing: foresight
- Industrial sustainability research
- An agenda for industry?

- David Morgan – lead researcher @ EPSRC Centre for Industrial Sustainability
- Manufacturing Engineering – MEng (2005)
The Institute for Manufacturing
Manufacturing
The full cycle from understanding markets and technologies through product and process design to operations, distribution and related services
Approach

IfM

RESEARCH

Services

EDUCATION

GOVERNMENT

INDUSTRY

UNIVERSITIES
Future of manufacturing (UK)
Economic change and uncertainty

Manufacturing (% Share of economy)

- China
- Korea
- Finland
- Germany
- Japan
- Singapore
- United States
- Italy
- Brazil
- United Kingdom

Economic change and uncertainty

Manufacturing (%)

United States
Brazil
United Kingdom


15% 10%
The Future of Manufacturing: A new era of opportunity and challenge
Foresight Future of Manufacturing Project

Objective has been to investigate changes and uncertainties facing UK manufacturing activities, to 2050 where possible, to inform how the UK can create and capture future value.

Vince Cable is the sponsoring minister. Findings available for BIS to use to inform development of future policy.

2 years: UK Roundtables, International Workshops, 37 commissioned evidence papers
How the research was done

- Lead Expert Group
- Industry High Level Stakeholder Group
- Drafting of chapters
- Engagement with BIS & HMT

Scoping
Jan-Mar 2012

Research
Apr 2012-Feb 2013

Synthesis
Feb-Jul 2013

Launch
28 October 2013

- 37 commissioned evidence papers, 2000+pages
- 3 international workshops (USA, Germany, Japan)
- Engagement with industry
- UK roundtable events
Local contributions

Lead expert group
- Professor Steve Evans
- Professor Alan Hughes
- Professor Chris Lowe

Evidence papers
- Dr Elif Bascavusoglu-Moreau
- Professor Ha-Joon Chang
- Dr Antonio Andreoni
- Ming Leong Kuan
- Dr Ken Coutts
- Professor Simon Deakin
- Professor Michael Kelly

Evidence papers ctd
- Dr Finbarr Livesey
- Dr Eoin O'Sullivan
- Nicola Mitchell
- Dr. Mike Tennant (EPSRC Centre)

Report peer review
- Prof. Sir Mike Gregory
- Professor Robert Rowthorn

Workshops
- Dr. Carlos López-Gómez
- Elliot More

Further evidence
- Professor Andy Neely
A range of indicators for value

- Direct employment
- Quality of life
- Global influence
- National pride
- Skills
- R&D investment
- National resilience
- Technology transfer
- Green capital
- Inward investment
- Exports
- Product & process innovation
- Tax
- Wealth creation
- Innovation
Manufacturing jobs are changing
1. More than making a product and selling it

- **Services with products** e.g. Rolls Royce
- Selling of **technological ‘know how’** e.g. ARM
- **Reranufacturing** of products e.g. JCB / Caterpillar

Manufacturers will increasingly make use of a wider value chain to create revenue.
By 2050 we will see a technological revolution in how products are designed, offered and used by customers. New opportunities for value creation including true mass personalisation at low cost.

- **Massive Incremental Technology**
  - New materials currently in development penetrate the mass market

- **Massive Incremental Technology**
  - Sustainable technologies reduce material and energy use

- **Massive Incremental Technology**
  - Full integration of ICT (involving digital modelling, simulation and automation) into manufacturing processes

- **Massive Incremental Technology**
  - Sensors integrated into digital networks and products

- **Radical Technology**
  - Bio and medical technology, including cell printing and production of in-vitro meat

- **Radical Technology**
  - Additive manufacturing becomes mainstream, complementing or displacing existing processes

- **Disruptive Technology**
  - Currently unknown disruptive and innovative technologies
2. Faster, more responsive and closer to customers

- Mass **personalisation** of products on demand
- **Distributed**: big high-tech, modular, home, mobile
- Greater **design freedom**
- More **digital connections** along value chains
3. Exposed to new market opportunities

- Changes to *personal wealth / ageing* populations
- **BRICs** and the ‘**Next 11**’
- Continued *global ‘fragmentation’* of the value chain
- Some ‘**onshoring**’
4. Increasingly dependent on highly skilled workers

- **Strong demand** for manufacturing workers
- A need to accommodate more **older workers**
- Importance of **STEM** qualifications
- Blending of technical & commercial ‘**hybrid**’ skills
- Potential for **human enhancement**
5. More sustainable

- Growing / urban populations raise resource demand
- Climate change and global supply chain vulnerability
- Volatility in price & availability of commodities
- Reuse, remanufacturing, recycling: circular economy
5 key findings

- More than making a product and selling it
  
  Services with products, selling know-how

- Faster, more responsive and closer to customers

- Exposed to new market opportunities

- Increasingly dependent on highly skilled workers

- More sustainable
Manufacturing will be a complex, value creating system. Emphasis not on production or services but on flexing business models and offerings to create value.
Industrial sustainability
Attempts to define safe operating limits of key planetary systems.

Key systems are
- Interconnected
- Non linear

Some safe limits have been reached and breached – although uncertainty is high.

(credit: Azote Images/Stockholm Resilience Centre)
Mega-Forces
BEYOND CLIMATE CHANGE

- Climate change, food security, water scarcity, population growth, energy and fuel, material and resource scarcity, ecosystem decline, urbanisation *(KPMG report 2012)*

‘...it is critical to understand that the drivers are **irreducibly inter-related.** They influence each other in **complex, unpredictable ways** and cannot be disentangled to elucidate determinate cause-and-effect relationships. This has implications in that industry will have to conceive of business propositions and technologies that **satisfy multiple constraints simultaneously.**’

Tennant, 2013
Impacts - Global carbon emissions (process & energy)

- Industry, 36%
- Buildings, 33%
- Transport, 23%
- Other, 8%

Global carbon emissions: 28 GtCO₂

What are we trying to sustain?

“you can be profitable without being resilient, but you cannot be resilient without being profitable”

Industrial Collaborator
Visible and affecting pollution
HANGZHOU - 2013

Hangzhou, Summer 2013

Hangzhou, Winter 2013

Courtesy of Miying Yang
The Urgent Challenge: The Benefits of Industrialisation Without the Bad Bits

- To quadruple output,
- To emit 80% less GHGs,
- To halve resource use
All by 2050

The challenge requires new approaches and new understanding that we term *Industrial Sustainability*, which leads to nothing less than a new industrial revolution.
Research Themes
WHAT ARE TODAY’S KEY CHALLENGES?

From ‘why do factories vary?’ to ‘which business models help?’

- efficiency
- technology
- system innovation

- How to make current products in a low-carbon, resource efficient manner.
- How to transform our factories and products.
- Explore how the entire industrial system might change.
Who do we work with?

Members

Project Partners

Associated British Foods plc

Airbus

Asics

Dyson

COLLABORATORS

CLAAS
ELCON Solution Oy
FIDIA S.p.A.
Luxottica
Airbus
Digital Green
Vera Solutions
Frontier Markets
Indian Institute of Management in Ahmedabad
Vilgro Innovations Foundation
Acumen Fund
Venture Studio
ASICS
Cambridge Programme for Sustainability Leadership (CPSL)
Angelantoni (Archemedes Solar)
Stanley-DeWalt Italia
Campana
Colocon
CSC
Cucchinelli
Dupont
ILVA
Lacconi
Umbra Group
Vefron
AB Sugar
Boots
Kyocera
Xeros
Lavery Pennell
2degrees
VTT Technical Research Centre of Finland
Politecnico di Milano
University of Stavanger
RWTH Aachen University
DIN, The German Institute for Standardization
University of Genova
Research: Efficiency
Energy needed to make chocolate bars
WHY DO FACTORIES VARY?

Factory A

Factory B
Toyota Manufacturing Europe
MORE EFFICIENT PRODUCTION

VOC emissions per vehicle (g/m²)
Over 70% Reduction

Water usage per vehicle (m³)
Over 75% Reduction

Energy usage per vehicle (KWh)
Over 70% Reduction

Waste produced per vehicle (kg)
Over 60% Reduction

Courtesy of Steve Hope.
Toyota Motor Europe
Environmental performance variation
GRAND CHALLENGE RESEARCH PROJECT

PhD & Industry Projects
- Eco-efficient changeovers
- Efficiency practices and their application
- Maturity of management systems and how performance can be advanced
- Factory modelling & decision making tools
- Building eco-efficiency into supplier relationships

Outputs
- Integrated tool kits, techniques and games to help manufacturers engage and improve their environmental performance

Grand challenge questions
How far can the best companies go?
What is the size of the prize?
What techniques help people deliver efficiency?
How do we spread those techniques?
Business models
Develop frameworks and underpinning ideas from studying the literature, and working with / studying multiple industry case studies.

Embedding ideas in tools and techniques which can then be used by other companies.

Bocken, Short, Rana, Evans et al.

Business model research: Value rationale

Opportunities for New Value Creation
- New forms of value for existing stakeholders
- Value for new stakeholders

Generate solutions that capture new value through the reduction or elimination of destroyed value

Current Value Proposition

Capture currently missed value through new activities, relationships, and network reconfiguration

Value Destroyed
- Negative social impacts
- Depletion of non-renewables
- Environmental damage

Value Missed
- Under-utilised assets, resources, capabilities
- Overcapacity
- Failure to capture value
- Waste streams

Re-conceptualize destroyed value as missed value
Use and test at 40+ workshops:

- Firm level - start-ups, SMEs, MNCs
- Industry events
- Multiple stakeholders – Riversimple custodian workshop (1), Finnish Furniture Industry (3)
- Teaching material – Cambridge and Genoa (4)

Used with other tools – business model canvas, roadmapping tool

Input towards PhD work
System innovation
**Sustainability**

**Business as usual, focus on efficiency, growing market**

Location decisions increasingly affected by utility availability; energy availability; strong focus on efficiency; growing market for enabling ‘low carbon’ technology (product & process); Increased information enables increased provenance.

**Disruption, experimentation**

Circular economy; information replaces materials; lightweight & complex materials; bio-materials; new business models gain share; robust supply chains; critical material availability affecting UK industry.

**New configurations for a constrained world**

Manufacturing supply chain flattens & spreads geographically; local making; PassivFactory (Berlin); enabling product architectures; public good internalised; base of pyramid fully engaged.
Systems research

- Design language for industrial systems
- Scenarios for systems change
- System mapping and capability analysis for sustainability transformations
- The role of the individual in radical, sustainability oriented innovation
- Sense making in circular modularity

Themes: Experimentation, systems thinking
Business model and supply chain innovation
MARKS AND SPENCERS CLOTHING

- REDRESS
  - 2 year project investigating opportunities to increase volume and value of textile recovery

- Ambition

LAUNCH OF REDRESS PROJECT WITH M&S

REDRESS is a collaborative project between M&S and Cambridge and funded by the TSB competition ‘Supply Chain Innovation Towards A Circular Economy’. This is a 2-year project to drive garment recovery and retained value through business model and supply chain innovation. This project seeks to accelerate M&S Plan A commitments around reducing waste. The focus for this project will be to reduce the environmental impact of raw materials in M&S’ clothing supply chain. The team will apply circular economy thinking to drive greater garment recovery and retained value. The outcomes of the project can be applied to textile and other industries.

The first REDRESS workshop took place on 2-3 October and was attended by a group of enthusiastic forward-looking thinkers from academia, business and other organisations. The group generated a wide range sustainable business model ideas for the project. The next challenge is to pick out the best ideas for the business pilots. To find out more about this project, contact lead researcher Dr Nancy Bocken (nmb02@cam.ac.uk).

2012 Results
- 4 million items
- Approx 1700 tonnes
- Fibre value of £5 million
- What next?
Tentative conclusions from UK experience

- Seek opportunities in efficiency aggressively, buy time, knowledge and credit for wider change. Seek the whole picture.

- Learning to experiment effectively and quickly to do things in seriously different ways.

- New ways of doing business can be found which are better for all.
Discussion & questions

http://www.ifm.eng.cam.ac.uk/
http://www.industrialsustainability.org/

Hangzhou, Summer 2013

Hangzhou, Winter 2013

Courtesy of Miying Yang