The Future of Manufacturing
Implications for Science, Technology & Innovation Policy

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Future of Manufacturing
Technology & Industrial Policy Context
UK Policy Context

Industrial [Sector] Strategies & ‘Great Technologies’
Centre for Science, Technology & Innovation Policy
An engineering contribution to STI policy

“What makes some national innovation systems more effective than others at translating science & engineering research knowledge into new technologies, industries & economic wealth?”
Centre for Science, Technology & Innovation Policy
An engineering contribution to STI policy

• More careful characterisation of technologies, manufacturing systems, industrial structures (and their linkages)
• More careful characterisation of technology readiness cycles, technology transitions & industrial change
International Benchmarking
Foresight, Trends & R&D
Future of Manufacturing
Why manufacturing matters (to policy makers)
Why Manufacturing Matters
A key policy theme in all countries

"Advanced Manufacturing is of fundamental importance to the economic strength and national security of the United States.

Advanced manufacturing provides high-quality jobs.

It is an important source of exports.

It is a key source of technological innovation."

Why Manufacturing Matters
The Interdependence of Manufacturing & Innovation

"In today's emerging technology sectors, R&D, design, and production appear to be harder to separate...

...it may well be that only those countries that can build powerful links between laboratory research and new manufacturing will be able to derive full benefit from their innovative capabilities."

Suzanne Berger, MIT
Why Manufacturing Matters
A Source of High Quality Jobs

“Start-ups are wonderful, but can’t by themselves increase technology employment...

Equally important is what comes after mythical moment of creation in the garage... the phase where companies scale up... work out design details, how to make things affordably, build factories...

”

Andy Grove, Former CEO Intel Corporation
Production for high wage economies
Retaining manufacturing jobs at home...

• **Balance economies of scale/scope:**
  Satisfying customer-specific requirements while minimizing production quantities

• **Exploit economies of planning:**
  Optimising processes using complex, capital-intensive planning methods and hybrid/integrated tools and systems

Relevant research domains

• Hybrid production
• Individualised production
• Virtual production
• Self-optimising production

Klocke, F. (2009). *Production technology in high-wage countries*
Future High Value Manufacturing
Why does Science & Technology policy matter for manufacturing jobs and innovation?

Process Innovation & High Quality Jobs
R&D underpinning manufacturing in high wage economies

Emerging Technology Innovation & Future Jobs
R&D for ‘manufacturability’ of high value emerging technologies

Hybrid machine tool systems

Regenerative medicine scale-up
Future of Manufacturing
S&T Policies Underpinning High Value Manufacturing
Future of Manufacturing
Where is the value in high value manufacturing?

Figure 2.3: The ‘smile curve’ representation of the manufacturing value chain

- Value added in each stage for a hypothetical product
- 21st century value chain
- 1970s value chain

Stage:
- Pre-fabrication services
- Fabrication
- Post-fabrication services

Source: Baldwin and Evenett (2012)
Value Capture from Manufacturing

The ‘Smile Curve’... Really?
Value Capture from Manufacturing

The ‘Smile Curve’... It’s a cartoon!

- Where’s the evidence?
- Every sector? Subsector?
- Different measures of ‘value’: Profits or jobs?
- High value production ‘lost in aggregation’
Future of Manufacturing
CSTI Project Examples
CSTI Project

Future Technologies for High Value Production

Aerospace

How is national economic value distributed within sub-sectors, market segments, subsystems...?

Value Added

R&D | Design | Supply mgmt | Production | Distribution | Services
CSTI Project

Future Technologies for High Value Production

High value subsystems:
- Aero-structures: (1) wings & winglets (2) fuselage, (3) vertical stabiliser...
- Propulsion systems: (1) high pressure chamber blades; (2) fans;...
CSTI Project

Future Technologies for High Value Production

Capability challenge for single aisle aircraft wings:
- High through-rate advanced composite manufacturing

Key competencies
- advanced autoclaves
- multi-layer hybrid processing
- tailored resin chemistry...
CSTI Project
Pathways to Manufacturing
with Dr Ronan Daly, IfM, Science & Technology of Manufacturing

Anticipating the industrialisation challenges of emerging technologies

How can analysis of ‘manufacturability’ risk factors inform:

- R&D agency initiatives and investments;
- Experimental design of university science and engineering research projects?

Example ‘manufacturability’ risk factors:

- Required advances in metrology/characterisation tools
- Availability of critical materials
- Novel production technology capabilities
- Regulatory requirements / emerging standards
- Supply chain maturity/stability
Thank You

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**High Value:** Underpinned by hard-to-replicate Technical and/or operational competencies

**STI Policy:**

- Can we create right innovation environment
  - mix of R&D strengths, technical/operational competencies, and infrastructure –
  
  to underpin high value (manufacturing) activities?