Manufacturing, Scale-up
and Clean Energy

Berkeley – March 2015

Prof. Mike Gregory
Outline

- Changing structures in manufacturing
- Mapping research to value chains
- Emergence and Scale-up
- Tackling the whole manufacturing system
- Implications for clean energy
Changing Patterns of Industry

- Companies increasingly focus on particular stages of value chain

- Stages in the value chain may have different ‘owners’.
- Interfaces and interdependencies poorly understood.
- Implications for industrial competitiveness
R&D - Plastic Logic

- ‘Power of electronics with pervasiveness of printing’
- Enables new product concepts including displays & sensors.
- Potential to create new industry via radical change in economics of production
Production - GKN

- 40% of world market for constant velocity joints
- Leadership enabled by production capability linked to advanced design
- Close integration with customers
- Local production facilities worldwide
Service - Xerox

- Pioneered service based business models
- Service offering now includes business improvement
- Re-manufacturing a growing strength
- Example of product-service systems
So what can research do…?

- How can research help keep industrial systems healthy, efficient, competitive and evolving?

- Ensure take up of new knowledge
- Marshal research across value chain
- Support & capture “emerging industries”
Identify **Societal / Market Needs** & define system requirements & barriers

Integrate Fundamental Knowledge into **Enabling Technology**

Develop Useful Insights from **Fundamental Knowledge**

(E O'Sullivan: Adapted from NSF ERC Strategy Framework)
Linking research to industrial needs

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<thead>
<tr>
<th>INDUSTRY</th>
<th>R&amp;D</th>
<th>Design</th>
<th>Supply Mgt</th>
<th>Production</th>
<th>Routes-to-market</th>
<th>After-sales services</th>
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<td>MANUFACTURING RESEARCH SYSTEM</td>
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**PLASTIC LOGIC**

**XEROX**
Industrial Innovation and Research Fields

**Industrial Systems-Market/Society Interface**
- Innovation Systems & Design
- Service Enterprise Systems
- Industrial Economics
- Industrial policy

**Industrial Innovation Systems**
- Innovation Systems & Design Eng
- Operations Systems research
- Logistics & Distribution
- Value chain research
- Product-service systems
- Industrial Organizational Systems

**Decision Systems Engineering**
- Reconfigurable Manufacturing Systems
- System Design & Simulation Engineering
- Product Development Innovation
- Visualizing & virtual prototyping systems
- Sensors and Sensing Systems
- Control Systems

**Physical Production Engineering**
- Advanced Manufacturing
- Manufacturing Machines & Equipment
- Materials Process & Performance Control
- Fabrication & Processing Technology
- Advanced Processing & Packaging
- Production scale-up (emerging industries)

**Applied science & Technology**
- Materials science
- Device physics
- Applied chemistry
- Biotechnology
Research fields and their positioning

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Emergence map – CT Scanners

(Eoin O’Sullivan)
Misalignment & leakage

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Precursor | Embryonic | Nurture | Growth

Mature "emerged" market

(E. O’Sullivan)
Scale-up
New science ideas & technology opportunities into new industries, new jobs

**Navigation of industrial emergence**
(barriers, enablers, inhibitors) depends on understanding of industry-level factors, e.g.:

- Industrial design
- Manufacturing strategy
- Production scale-up
- Supply networks
- Investment
- Regulation & standards

(Eoin O’Sullivan)
Scale-up
Different value chain configuration for different emergence phase

(Eoin O’Sullivan)
Scale-up

Different research for different innovation needs
Different research for different phases of scale-up

(Eoin O’Sullivan)
Emerging Industries

Regenerative Medicine

Science lab-grown human tissue

(E O'Sullivan & L. Dodin)
Emerging Industries

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Seeding of stem cells on engineered structures

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GMP manufacturing & automation processes

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Emerging Industries

Regenerative Medicine

Seeding of stem cells on engineered structures

GMP manufacturing & automation processes

Advances in logistics & distribution technologies

Science lab-grown human tissue

Time

Level of Funding

(E O'Sullivan & L. Dodin)
Definitions of ‘Manufacturing’

People can mean very different things...

transformation of materials

plants or factories

machines and materials-handling equipment

business system

...extends from R&D, design, engineering, to production, finance, sales, marketing, after-sales service

The manufacturing sector... a wide range of industries, technologies and activities

industries, technologies and activities

factors of production

[The system extends from R&D, design, engineering, to production, finance, sales, marketing, after-sales service... extends beyond any single enterprise, across increasingly global supply chains and business networks.]

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[Definitions of ‘Manufacturing’]
Perspectives on ‘Manufacturing’ / ‘Production’
What we talk about when we talk about ‘manufacturing’...

• Factory-based activities

• Production function

• Material transformation & assembly/supply

• Product development & delivery

• Production capability
Integrated Conceptualisation of Manufacturing
A Systems Perspective

Factors of Production
- Knowledge
- Organisation
- Enterprise
- Energy
- Natural resources
- Low skilled labour
- High skilled labour
- Capital

Production
Integrated Conceptualisation of Manufacturing

A Systems Perspective

Factors of Production

- Knowledge
- High skilled labour
- R&D
- Design
- Supply Mgt.
- Organisation
- Enterprise

Production capability configuration

- Production
- Assembly
- Parts
- Material transformation
- Material
- Raw materials
- Natural resources
- Energy
- Low skilled labour
- Capital equip / tools
- Mechatronics
- Adaptive machines
- Factory equipment
- Capital equip / tools

Product/service

Product idea
So what about clean energy?

• Manufacturing has focussed on energy reduction
• Opportunities at process, system and network levels
• Good practice and load scheduling undervalued

SO...

• Low cost clean energy the goal
• Modern manufacturing offers integrating approach
• Identification and mapping of ‘ecosystems’ a first step
A manufacturing perspective

- Consider energy systems as manufacturing systems
- Seek to lower cost of ‘production’ processes
  - through process efficiency
  - and radical product design
- Consider system and network opportunities
- Explore cross sectoral learning
- Map and manage the manufacturing ‘ecosystem’