THE PRACTICAL IMPACT OF DIGITAL MANUFACTURING:
RESULTS FROM RECENT INTERNATIONAL EXPERIENCE

FINAL REPORT  |  SEPTEMBER 2018

A study for Innovate UK by Policy Links, Institute for Manufacturing (IfM), University of Cambridge

Contributors:
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Institute for Manufacturing (IfM), University of Cambridge
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- Conducts research across the full range of manufacturing issues, from understanding markets and technologies, through product and process design, production and supply chain design and operation, through-life service, to economics and policy.
- Conducts practical, problem-based, education to develop leaders and managers for industry.

Policy Links, IfM Education and Consultancy Services (IfM ECS)
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Contributors
The contributors to the report are Carlos López-Gómez, Head of Policy Links, IfM ECS; Duncan McFarlane, Head of the Distributed Information & Automation Laboratory; Eóin O’Sullivan, Director of the Centre for Science, Technology & Innovation Policy (CSTI); and Chander Velu, Head of the Business Model Innovation Research Group.

Acknowledgements
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Cambridge, UK | September, 2018
SELECTED WORK ON INDUSTRIAL DIGITALISATION / INDUSTRY 4.0
POLICY LINKS AND CENTRE FOR SCIENCE, TECHNOLOGY & INNOVATION POLICY (CSTI)

2018

- Study on Digitalisation of the Manufacturing Sector and the Policy Implications for Ireland – Department of Business, Enterprise and Innovation (DBEI)
- Expert paper for “Industry 2027 – Risks and Opportunities for Brazil in the face of disruptive innovations” – Brazil’s National Confederation of Industry (CNI) – [Link](#)
- ‘Supporting Technological Transformation in Indonesia’ – Asian Development Bank (ADB) – [Link](#)

2017

- ‘Review of International Policy Approaches to Value Chain Capability Development’ – UK Department for Business, Energy & Industrial Strategy (BEIS)
AIMS OF THE PROJECT

Background
Innovate UK is seeking to further enhance the evidence base on the potential gains that might be achieved through digital adoption.

Most estimates of the impact of digital applications in manufacturing produced to date have focused on *expected* rather than *observed* impact, primarily on the basis of crude macroeconomic extrapolations and survey data.

The Made Smarter Review estimates that UK industry could achieve a **25% increase in productivity through digital adoption by 2025**.

Opportunities exist to further enhance the evidence base on the practical potential of digital manufacturing by reviewing findings emerging from recent digital adoption efforts and studies from around the world.

Aims
To collect and analyse evidence on potential improvements derived from the adoption of digital technologies in the manufacturing sector, and discuss potential implications for the UK.
STRANDS OF WORK

The study encompassed three strands of work:

1. Sources of evidence and data gathering
   - Identification & review of sources of evidence
   - Gathering of indicators (impact of digital adoption)
   - Classification of raw data

2. Structuring & analysis of evidence base
   - Structuring of data using appropriate frameworks
   - Characterisation of international policy approaches and initiatives
   - Summary of findings and discussion of implications for UK industry

3. Workshop with selected stakeholders
   - Discussion of results
   - Capturing views from UK stakeholders
   - Discussion of implications for the UK

Evidence on practical impact of digital adoption in manufacturing
NOTES ON APPROACH
SCOPE OF THE PROJECT

Typical elements of national digital manufacturing initiatives

Technology R&D
Solution development
System integration
Adoption support (including training)

Démonstrators

Scope of this project
Firm-level impact / benefit

NOTE: Impact reported is a result of the combination of activities
VARIETY OF NATIONAL INITIATIVES (NON-EXHAUSTIVE)

**Type 1 (e.g. US, Australia, Canada)**
Research to improve functionality of application / next-generation → Pilot testing in ‘model factories’ / pilot lines → Pilot application in selected firms

**Type 2 (e.g. Japan)**
Private sector consortia / working groups identify common issues → Work with developer ("platformer") to produce solution → Adoption by firms working group and wider consortia

**Type 3 (e.g. Singapore, Korea)**
Development of suite of applications made available by RTO or Innovation Centre → Firms select relevant applications → Firms have access to grants to support application → Adoption support to firms including training

**Type 4 (e.g. Spain)**
Funding agency → Firm receives funding → Technology acquisition (typically off-the-shelf / open market/ pre-selected private vendors) → Adoption by firm

**Type 5 (e.g. Italy)**
Tax break → Capital equipment acquisition by firm → Adoption by firm
NOTES ON APPROACH / LIMITATIONS

SAMPLING
- Data informing the study was obtained from a limited number of countries (the primary focus was the cases reported by national Digital Manufacturing initiatives in countries including: China, France, Germany, Korea, Japan, Singapore, US).
- The initiatives surveyed largely focus on deployment of applications in firms (high-level TRLs), not development of new applications (lower TRLs).
- Results primarily from applications in SMEs.
- Estimations of impact are mostly self-reported by firms.
- Some results might have been obtained in controlled environments.

IMPACT MEASUREMENT
- Digitalisation efforts might involve activities in different operational and strategic aspects of a firm’s operation – not all the benefits are necessarily due to technology.
- In general, estimates assume that business models remain the same.
- Further analyses are required to account for time lags (between adoption and achievement of impact).
- Some digital applications reshape industrial organisation/value chains; impact might be very different if that happens.

NATIONAL DIFFERENCES
- Results are context dependent: difficult to use estimates for one country as the basis for estimations for a different one (different countries, different sectors).
RESULTS

Indicators of the practical impact of digital manufacturing were obtained from three main sources:

a) STRATEGIES & STUDIES FROM NATIONAL INITIATIVES
b) USE CASES (FIRM-LEVEL ADOPTION)
c) POLICY & ACADEMIC LITERATURE
This section presents estimations of the impact of digital adoption found in major national initiatives around the world.

These include:

- Targets established by the initiatives (expected impact)
- Impact estimated by policy studies (expected impact)
- Results obtained by firms supported by the initiatives (observed impact)
SELECTED INDICATORS ON IMPACT OF DIGITALISATION (SUMMARY)

<table>
<thead>
<tr>
<th>Expected impact</th>
<th>JP</th>
<th>AU</th>
<th>CA</th>
<th>AT</th>
<th>ES</th>
</tr>
</thead>
<tbody>
<tr>
<td>National productivity</td>
<td>Over 2% Labour productivity gains in manufacturing industries [38]</td>
<td>-</td>
<td>-</td>
<td>20% Productivity gains for the next 5 years [33]</td>
<td>-</td>
</tr>
<tr>
<td>Manufacturing efficiency (factory-level)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>€5-10 billion Efficiency potential 2015-2025 [32]</td>
<td>-</td>
</tr>
<tr>
<td>Jobs</td>
<td>-</td>
<td>-</td>
<td>50,000 (2017-2027) [9]</td>
<td>-</td>
<td>1.25 million In the next 5 yrs [21, 22]</td>
</tr>
<tr>
<td>Manufacturing output</td>
<td>-</td>
<td>25%-35% (Above trend by 2026) [10]</td>
<td>-</td>
<td>-</td>
<td>€35 billion Accumulated growth 2017-2020 [21]</td>
</tr>
<tr>
<td>Cost reduction</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2.9% Per year, for the next five years [33]</td>
<td>-</td>
</tr>
<tr>
<td>Other</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2.6% Average turnover increase per year [33] €6-14 billion Sales potential by 2025 [32]</td>
<td>-</td>
</tr>
</tbody>
</table>

JP: Japan; AU: Australia; CA: Canada; AT: Austria; ES: Spain.
## SELECTED INDICATORS ON IMPACT OF DIGITALISATION (SUMMARY)

<table>
<thead>
<tr>
<th>Expected Impact</th>
<th>KR</th>
<th>DE</th>
<th>US</th>
<th>SG</th>
</tr>
</thead>
<tbody>
<tr>
<td>National productivity</td>
<td>-</td>
<td>30%</td>
<td>-</td>
<td>30%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Annual productivity gains [18]</td>
<td></td>
<td>(labour productivity by 2024) [24]</td>
</tr>
<tr>
<td>Manufacturing efficiency</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>30-40%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(local companies expected output increment) [27]</td>
</tr>
<tr>
<td>Value added</td>
<td>-</td>
<td>€425 billion</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cumulative value added, 2016-2020 [18]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jobs</td>
<td>-</td>
<td>390,000</td>
<td>-</td>
<td>22,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>From 2015-2025 [19]</td>
<td></td>
<td>(From 2017-2024) [24,26]</td>
</tr>
<tr>
<td>Manufacturing output</td>
<td>2%</td>
<td>-</td>
<td>-</td>
<td>S$36b</td>
</tr>
<tr>
<td></td>
<td>Potential growth of output in major industries &quot;when opportunities given by I4.0 are suitable utilised&quot; [28]</td>
<td></td>
<td></td>
<td>(From 2017-2024) [24]</td>
</tr>
<tr>
<td>Cost reduction</td>
<td>-</td>
<td>2.6%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Annually, 2016-2020 [18]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>30,000</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Smart Factories for SMEs by 2025</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Observed Impact</th>
<th>KR</th>
<th>DE</th>
<th>US</th>
<th>SG</th>
</tr>
</thead>
<tbody>
<tr>
<td>National productivity</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Manufacturing efficiency</td>
<td>30%</td>
<td>-</td>
<td>20%</td>
<td>30%</td>
</tr>
<tr>
<td></td>
<td>Result from 2,800 digital applications primarily in SMEs [28]</td>
<td></td>
<td>(primarily SME results) [4,5]</td>
<td>(local companies improved efficiency) [26]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15-20%</td>
</tr>
<tr>
<td>Cost reduction</td>
<td>15% [28]</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Other</td>
<td>45% reduction in ratio of defective products</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>16% reduction in delivery time [28]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**KR**: Korea; **DE**: Germany; **US**: United States; **SG**: Singapore.
Variety of quantitative impact measures:
- Productivity, value added, jobs
- But also sales growth, cost reduction, delivery compliance
- And adoption

Also, significant attention to qualitative measures
- Competitiveness, business confidence, etc.

Important distinction between national-level ‘productivity’ and firm-level ‘manufacturing efficiency / output’
STRATEGIES & STUDIES FROM NATIONAL INITIATIVES

Budget comparisons
<table>
<thead>
<tr>
<th>Country</th>
<th>GDP (UK=100)</th>
<th>Initiative</th>
<th>Source of funding</th>
<th>Funding levels</th>
<th>Funding as % of GDP (per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Korea</td>
<td>58.4</td>
<td>The Korea Smart Factory Initiative</td>
<td>Public (MOTIE)</td>
<td>$189.3 million from 2017 to 2020 [19].</td>
<td>0.003</td>
</tr>
<tr>
<td>Germany</td>
<td>140.2</td>
<td>Plattform Industrie 4.0</td>
<td>Government (Ministry of Economic Affairs and Ministry of Education and Research)</td>
<td>€200 million in funding allocated by BMBF and BMWI complemented by industry contributions (2011-2020) [15].</td>
<td>0.0006</td>
</tr>
<tr>
<td>United States</td>
<td>739.4</td>
<td>Digital Manufacturing and Design Innovation (DMDII) [Part of the Manufacturing USA Institutes]</td>
<td>Co-Funding public-private</td>
<td>5-year cooperative agreement, $70 million federal funding and over $180 million matching funding from partners [36].</td>
<td>0.0002</td>
</tr>
<tr>
<td>Japan</td>
<td>185.8</td>
<td>Connected Industries</td>
<td>Public (METI)</td>
<td>$171.6 million included in the FY 2018 budget of the Ministry of Economy, Trade and Industry to promote Connected Industries [40].</td>
<td>0.0076</td>
</tr>
<tr>
<td>Japan</td>
<td></td>
<td>Robot Revolution Initiative (RRI)</td>
<td>Public and private sectors</td>
<td>¥ 100 billion investment expected in robots during the period 2015-2020 [39].</td>
<td></td>
</tr>
<tr>
<td>Singapore</td>
<td>12.4</td>
<td>Automation support package</td>
<td>Government</td>
<td>$400 million over the next three years [25].</td>
<td>0.0668</td>
</tr>
<tr>
<td>Singapore</td>
<td></td>
<td>(FoM) Initiavei4.0 strategy</td>
<td>Government (EDB, a-Star, MoT, NEA, MoH, MoHA)</td>
<td>S$450 million to support National Robotics Programme over next 3 years [25].</td>
<td></td>
</tr>
<tr>
<td>Singapore</td>
<td></td>
<td>‘Model Factory’ initiative</td>
<td>Public-private partnership</td>
<td>Model Factory@SIMTech: Up to S$60 million joint lab [25].</td>
<td></td>
</tr>
<tr>
<td>Country</td>
<td>GDP (UK=100)</td>
<td>Initiative</td>
<td>Source of funding</td>
<td>Funding levels</td>
<td>Funding as % of GDP (per year)</td>
</tr>
<tr>
<td>---------</td>
<td>--------------</td>
<td>------------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Australia</td>
<td>50.5</td>
<td>Industry’s Growth Centers Initiative</td>
<td>Australian Government (Department of Industry, Innovation and Science)</td>
<td>The Industry Growth Centres Initiative has funding of A$232.0 million over six years from 2017-18 [37].</td>
<td>0.0022</td>
</tr>
<tr>
<td>Canada</td>
<td>63.0</td>
<td>Innovation Superclusters Initiative</td>
<td>Private and Public</td>
<td>C$950 mi to support business-led innovation between 2017-2022 [8].</td>
<td>0.0073</td>
</tr>
<tr>
<td>Austria</td>
<td>15.9</td>
<td>Platform Industry 4.0</td>
<td>Basic Seed funding provided by 6 founding members and membership fees (50% from the Austrian Ministry of Transport, Innovation and Technology; remaining 50% provided by the other members) [13].</td>
<td>Founding members contribution: €300,000 per year for 3 years; €200,000 provided by the membership fees (forecast for 2017) [13].</td>
<td>0.0253</td>
</tr>
<tr>
<td>Austria</td>
<td></td>
<td>Production of the Future (Research)</td>
<td>Government (Federal Ministry of Transport, Innovation and Technology)</td>
<td>Over €450 million (2011-2015). Production of the Future provides €25 millions every year in funding for research projects [12, 14].</td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>50.0</td>
<td>Industria Conectada</td>
<td>Government (30-50% for SMEs, 20-40% for Large) [21].</td>
<td>€100 million in 2016 [22].</td>
<td>0.009</td>
</tr>
</tbody>
</table>
RESULTS

Indicators of the practical impact of digital manufacturing were obtained from three main sources:

a) STRATEGIES & STUDIES FROM NATIONAL INITIATIVES
b) USE CASES (FIRM-LEVEL ADOPTION)
c) POLICY & ACADEMIC LITERATURE
USE CASES IDENTIFIED & ANALYSED

1,038 individual cases identified in >70 national digital adoption initiatives from around the world

Assessment of relevance

212 cases selected for analysis
USE CASES IDENTIFIED & ANALYSED

Major initiatives reviewed

- France: Alliance Industrie du Futur
- Korea: Smart Factory Initiative
- Japan: Industrial Value Chains Initiative
- EU: I4MS initiative: ICT Innovation for Manufacturing SMEs
- EU Smart Anything Everywhere Initiative
- Singapore: Tech-Depot Initiative
- Germany: Plattform Industrie 4.0
- US: Industrial Internet Consortium
- US: America Makes
- Made in China 2025: National Intelligent Manufacturing Pilot Programme

Origin of cases
### Typical case structure

**COMPANY NAME / SOLUTION NAME**

#### Problem

#### Digital solution(s) used

#### Impact / benefit
- Tangible/intangibles
- Qualitative and quantitative

#### Etc.

Focus of this project: quantitative indicators
DATABASE STRUCTURE – LEVELS OF INFORMATION

1. Case study information: Initiative, link of data source, country and functional area

2. Implementation cost estimation for each application (grants and company contribution if data exist)

3. Estimated impact: list of all indicators of estimated benefit reported in the case studies
FINDINGS

Various types of applications & solutions

1. Various types of impact / business value benefit
   [WHAT IS ACHIEVED]

2. ‘Heatmap’ of relationships

3. [HOW IS IT ACHIEVED]
(1) BUSINESS VALUE
CLASSIFYING IMPACT ON BUSINESS VALUE

OBSERVED RESULTS: BUSINESS VALUE VIEWPOINT

**Increase revenue**
- Increase profit margin
- Increase sales of existing products
- Improve product performance / functionality
- Increase customer satisfaction
- Reduce time to market
- Reduce prototyping/testing/design time
- Reduce overall time to market (including development time)

**Reduce costs**

### Reduce input use
- Labour (time, effort)
- Material
- Energy
- Overall reduction of input use

### Increase outputs
- Improve production planning efficiency
- Improve factory safety
- Reduce prototyping/testing/design cost
- Increase process operating efficiency (process/ machine/ line/ factory)

### Increase manufacturing efficiency

### Increase factory efficiency

**Reduce working capital**
- Reduce inventory

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Policy Links, 2018
KEY FINDINGS

Business value areas where more cases reported improvements*:

- Increase in process efficiency (single, multiple process + whole factory efficiency): ~30% of instances
- Reduction of labour costs: ~16% of instances
- Reduction of defects and errors: ~10% of instances
- Reduction of energy costs: ~6% of instances
- Improved delivery & services performance: ~6% of instances

Business value areas with bigger benefit/improvement**†:

- Reduction of labour costs: >55%
- Reduction of defects and errors: >45%
- Reduction in material costs: >45%
- Increase in outputs: >30%
- Improved delivery & service performance: >30%

NOTES:
* Only cases with >5 instances are reported (total number of instances: ~420)
† Median

Policy Links, 2018
(2) APPLICATIONS & SOLUTIONS
## Usage of Applications & Solutions by Functional Area

<table>
<thead>
<tr>
<th>Manufacturing process</th>
<th>Enterprise management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process control and optimisation (including machine operation monitoring)</td>
<td>33.0%</td>
</tr>
<tr>
<td>Maintenance management</td>
<td>2.8%</td>
</tr>
<tr>
<td>Assembly</td>
<td>1.9%</td>
</tr>
<tr>
<td>Material pre/post processing</td>
<td></td>
</tr>
<tr>
<td>Material/product processing</td>
<td>9.0%</td>
</tr>
<tr>
<td>Testing, inspection, validation</td>
<td>2.4%</td>
</tr>
<tr>
<td>Input &amp; waste management</td>
<td>1.4%</td>
</tr>
<tr>
<td>Packaging &amp; shipping</td>
<td>0.9%</td>
</tr>
<tr>
<td>Material ...</td>
<td></td>
</tr>
<tr>
<td>Process quality management</td>
<td>7.1%</td>
</tr>
<tr>
<td>Production planning and control</td>
<td>9.4%</td>
</tr>
<tr>
<td>Demand forecasting, inventory and delivery management</td>
<td>5.2%</td>
</tr>
<tr>
<td>Staff and Workflow management</td>
<td>2.8%</td>
</tr>
<tr>
<td>Product and service quality management...</td>
<td></td>
</tr>
<tr>
<td>Supply chain management</td>
<td>1.4%</td>
</tr>
<tr>
<td>Business operations</td>
<td>1.4%</td>
</tr>
<tr>
<td>Product lifecycle management</td>
<td></td>
</tr>
<tr>
<td>Operations infrastructure</td>
<td></td>
</tr>
<tr>
<td>Manufacturing Infrastructure</td>
<td></td>
</tr>
<tr>
<td>Operations management</td>
<td></td>
</tr>
<tr>
<td>Manufacturing product &amp; process design</td>
<td></td>
</tr>
</tbody>
</table>

**Policy Links, 2018**

Note: Manufacturing taxonomy adapted from Integrated Manufacturing Technology. 21st Century Manufacturing Taxonomy: [IMTI, 2003].
(3) ‘HEATMAPS’
HEATMAPS

Heatmap 1: Prevalence of applications
Tells us how often an application led to an impact on a particular type of business value

Heatmap 2: Relevance of applications
Tells us how big the impact of an application was for each type of business value
HEATMAPS (EXAMPLE: LABOUR COSTS)

Heatmap 1: Prevalence of applications

Digital applications and solutions [HOW IS IT ACHIEVED]

<table>
<thead>
<tr>
<th>Sources of business value [WHAT IS ACHIEVED]</th>
<th>Manufacturing product &amp; process design and development</th>
<th>Manufacturing process</th>
<th>Manufacturing infrastructure</th>
<th>Enterprise management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase revenue</td>
<td>Product design &amp; definition</td>
<td>Product development</td>
<td>Process design &amp; definition</td>
<td>Process quality management</td>
</tr>
<tr>
<td>Reduce costs</td>
<td>Product design &amp; definition</td>
<td>Product development</td>
<td>Process design &amp; definition</td>
<td>Process quality management</td>
</tr>
</tbody>
</table>

Policy Links, 2018
## Heatmaps

### Heatmap 1: Prevalence of applications

#### Most common applications:
- Process control & optimisation
- Process quality management
- Product design & definition

#### Sources of business value [WHAT IS ACHIEVED]

<table>
<thead>
<tr>
<th>Increase revenue</th>
<th>Reduce time to market</th>
<th>Reduce costs</th>
<th>Reduce working capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase profit margins</td>
<td>Reduce time to market (including development time)</td>
<td>Reduce input use (energy, raw materials)</td>
<td>Reduce inventory</td>
</tr>
<tr>
<td>Improve product performance / functionality</td>
<td>Reduce input use</td>
<td>Increase outputs</td>
<td>Reduce equipment commissioning and tooling</td>
</tr>
<tr>
<td>Increase customer satisfaction</td>
<td>Reduce input use</td>
<td>Improve production planning efficiency</td>
<td>Reduce working capital</td>
</tr>
<tr>
<td>Reduce prototyping/testing/design time</td>
<td>Improve production planning efficiency</td>
<td>Reduce process operating efficiency (process/machine/line/factory)</td>
<td>Reduce working capital</td>
</tr>
<tr>
<td>Increase overall time to market (including development time)</td>
<td>Reduce process operating efficiency (process/machine/line/factory)</td>
<td>Reduce process operating efficiency (process/machine/line/factory)</td>
<td>Reduce working capital</td>
</tr>
</tbody>
</table>

#### Digital applications and solutions [HOW IS IT ACHIEVED]

<table>
<thead>
<tr>
<th>Manufacturing product &amp; process design and development</th>
<th>Manufacturing process</th>
<th>Manufacturing infrastructure</th>
<th>Enterprise management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product design &amp; definition</td>
<td>Product development</td>
<td>Process design &amp; definition</td>
<td>Process design &amp; definition</td>
</tr>
<tr>
<td>Process quality management</td>
<td>Process quality and design</td>
<td>Material PreProcessing</td>
<td>Material PreProcessing</td>
</tr>
<tr>
<td>Material / Process</td>
<td>Material / Process</td>
<td>Process control and optimisation</td>
<td>Process control and optimisation</td>
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<tr>
<td>Process control and optimisation</td>
<td>Process control and optimisation</td>
<td>Operation Management</td>
<td>Operation Management</td>
</tr>
<tr>
<td>Process control and optimisation</td>
<td>Process control and optimisation</td>
<td>Production Planning and Control</td>
<td>Production Planning and Control</td>
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<tr>
<td>Process control and optimisation</td>
<td>Process control and optimisation</td>
<td>Staff and Workforce Management</td>
<td>Staff and Workforce Management</td>
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<tr>
<td>Process control and optimisation</td>
<td>Process control and optimisation</td>
<td>Demand Forecasting / Inventory and Delivery Management</td>
<td>Demand Forecasting / Inventory and Delivery Management</td>
</tr>
</tbody>
</table>

#### Policy Links, 2018
**HEATMAPS**

**Heatmap 2: Relevance of applications**

<table>
<thead>
<tr>
<th>Digital applications and solutions [HOW IS IT ACHIEVED]</th>
<th>Manufacturing product &amp; process design and development</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Product design &amp; definition</strong></td>
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<tr>
<td><strong>Product development</strong></td>
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<td></td>
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<tr>
<td><strong>Process design &amp; definition</strong></td>
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<tr>
<td><strong>Process quality management</strong></td>
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<tr>
<td><strong>Input &amp; waste management</strong></td>
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<tr>
<td><strong>Material/product processing</strong></td>
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<tr>
<td><strong>Assembly</strong></td>
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<tr>
<td><strong>Testing, inspection, validation</strong></td>
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<tr>
<td><strong>Packaging &amp; shipping</strong></td>
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<tr>
<td><strong>Maintenance management</strong></td>
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<tr>
<td><strong>Process control and optimisation</strong></td>
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<tr>
<td><strong>Operations infrastructure</strong></td>
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<tr>
<td><strong>Product and service quality management</strong></td>
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<tr>
<td><strong>Supply chain management</strong></td>
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<tr>
<td><strong>Production planning and control</strong></td>
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<tr>
<td><strong>Resource management</strong></td>
<td></td>
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</tr>
<tr>
<td><strong>Business operations</strong></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Sources of business value [WHAT IS ACHIEVED]**

- **Increase revenue**
  - Increase profit margins
  - Increase sales of existing products
  - Increase customer satisfaction
- **Reduce costs**
  - Reduce time to market
  - Reduce overall time to market (including development time)
  - Reduce labour (time, effort)
  - Reduce energy
  - Reduce overall reduction of input use
  - Increase output
- **Increase manufacturing efficiency**
  - Improve production efficiency
  - Improve factory safety
  - Reduce prototyping/testing/design time
  - Reduce prototyping/testing/design cost
  - Reduce process operating efficiency (process/machine/line/factory)
  - Reduce defects and errors
  - Reduce maintenance cost
  - Reduce delivery and service performance
  - Reduce equipment commissioning and tooling
  - Reduce working capital
  - Reduce inventory

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Low  →  High
HEATMAPS (EXAMPLE: LABOUR COSTS)

Heatmap 2: Relevance of applications

Digital applications and solutions [HOW IS IT ACHIEVED]

<table>
<thead>
<tr>
<th>Sources of business value [WHAT IS ACHIEVED]</th>
<th>Manufacturing product &amp; process design and development</th>
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<th>Supply chain management</th>
<th>Production planning and control</th>
<th>Product lifecycle management</th>
<th>Staff and workflow management</th>
<th>Demand forecasting/Inventory and delivery management</th>
<th>Resource management</th>
<th>Business operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase revenue</td>
<td>Increase profit margin</td>
<td>Improve product performance / functionality</td>
<td>Reduce time to market</td>
<td>Reduce input use</td>
<td>Improve production planning efficiency</td>
<td>Improve factory safety</td>
<td>Reduce prototyping/testing/design time</td>
<td>Reduce overall time to market (including development time)</td>
<td>Reduce operational efficiency</td>
<td>Increase process operating efficiency</td>
<td>Process control and optimisation (including machine operation monitoring)</td>
<td>Reduce overall time to market (including development time)</td>
</tr>
<tr>
<td>Reduce costs</td>
<td>Increase customer satisfaction</td>
<td>Reduce time to market</td>
<td>Reduce input use</td>
<td>Overall reduction of input use</td>
<td>Reduce defects and errors</td>
<td>Reduce prototyping/testing/design cost</td>
<td>Reduce prototyping/testing/design time</td>
<td>Reduce overall time to market (including development time)</td>
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<td>Reduce overall time to market (including development time)</td>
</tr>
<tr>
<td>Reduce working capital</td>
<td>Increase manufacturing efficiency</td>
<td>Increase manufacturing efficiency</td>
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</tr>
</tbody>
</table>

Reduction of labour costs

Most common applications:
- Process control & optimisation
- Process quality management
- Product design & definition

Most impactful applications:
- Process design & definition
- Resource management
- Product design & definition

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### ‘DEEP DIVES’: APPLICATIONS THAT LED TO THE IMPACT IN TOP 5 BUSINESS VALUE AREAS

<table>
<thead>
<tr>
<th>Area</th>
<th>Key Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduction of labour costs</td>
<td>- Process design &amp; definition&lt;br&gt;- Resource management&lt;br&gt;- Product design &amp; definition</td>
</tr>
<tr>
<td>Reduction of defects and errors</td>
<td>- Product design &amp; definition&lt;br&gt;- Staff and workflow management&lt;br&gt;- Process design &amp; definition</td>
</tr>
<tr>
<td>Increase outputs</td>
<td>- Packaging &amp; shipping&lt;br&gt;- Process control and optimisation&lt;br&gt;- Assembly</td>
</tr>
<tr>
<td>Improved delivery &amp; service performance</td>
<td>- Staff and workflow management&lt;br&gt;- Product &amp; service quality management&lt;br&gt;- Production planning &amp; control</td>
</tr>
<tr>
<td>Reduction in material costs</td>
<td>- Process design &amp; definition&lt;br&gt;- Product development&lt;br&gt;- Process control and optimisation</td>
</tr>
</tbody>
</table>
ANALYSIS BY COUNTRIES
### ANALYSIS BY COUNTRIES

#### USE OF APPLICATIONS & SOLUTIONS ACROSS COUNTRIES

#### Digital applications and solutions

<table>
<thead>
<tr>
<th>Country</th>
<th>Manufacturing product &amp; process design and development</th>
<th>Manufacturing process</th>
<th>Enterprise management</th>
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<tbody>
<tr>
<td>Product design &amp; definition</td>
<td>Product design &amp; definition</td>
<td>Process design &amp; definition</td>
<td>Process quality mgmt</td>
</tr>
<tr>
<td>Process pre/post processing</td>
<td>Material pre/post processing</td>
<td>Input &amp; waste mgmt</td>
<td>Material &amp; product processing</td>
</tr>
<tr>
<td>Assembly</td>
<td>Testing &amp; inspection &amp; validation</td>
<td>Packaging &amp; shipping</td>
<td>Maintenance mgmt</td>
</tr>
<tr>
<td>Process control &amp; optimisation</td>
<td>Operations infrastructure</td>
<td>Product &amp; service quality mgmt</td>
<td>Supply chain mgmt</td>
</tr>
<tr>
<td>Production planning &amp; control</td>
<td>Product lifecycle mgmt</td>
<td>Staff &amp; workflow mgmt</td>
<td>Demand forecasting &amp; delivery mgmt</td>
</tr>
<tr>
<td>Resource mgmt</td>
<td>Business operations</td>
<td>Demand forecasting &amp; delivery mgmt</td>
<td>Business operations</td>
</tr>
</tbody>
</table>

- **France**
- **Korea**
- **Japan**
- **EU & other countries**
- **Singapore**
- **Germany**
- **US**
- **China**

Policy Links, 2018
<table>
<thead>
<tr>
<th>Country</th>
<th>Applications</th>
</tr>
</thead>
</table>
| France        | - Material/product processing  
                          - Process control and optimisation  
                          - Process design and definition |
| Korea         | - Process control and optimisation  
                          - Production planning and control  
                          - Process quality management       |
| Japan         | - Process control and optimisation  
                          - Production planning and control  
                          - Demand forecasting/inventory and delivery management  
                          - Staff and workflow management     |
| EU & other countries | - Product design and definition  
                          - Process design and definition  
                          - Process control and optimisation |
| Singapore     | - Demand forecasting/inventory and delivery management  
                          - Process quality management  
                          - Process control and optimisation |
| Germany       | - Process control and optimisation  
                          - Maintenance management  
                          - Product development*       |
| US            | - Product development  
                          - Process control and optimisation  
                          - Operations infrastructure     |
| China         | - Process control and optimisation  
                          - Production planning and control  
                          - Assembly                        |

*Same position as Material/product processing, Assembly, Product and service quality management, Production planning and control, Business operations
Indicators of the practical impact of digital manufacturing were obtained from three main sources:

a) STRATEGIES & REPORTS AND STUDIES FROM NATIONAL INITIATIVES
b) USE CASES (FIRM-LEVEL ADOPTION)
   c) POLICY & ACADEMIC LITERATURE
### SOME RESULTS FROM THE ACADEMIC LITERATURE

<table>
<thead>
<tr>
<th>Reference</th>
<th>Impact</th>
<th>Indicator</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kromann, L et al. (2016)</td>
<td>Automation of production processes was found to be positively and significantly correlated to productivity</td>
<td>Increased Labour productivity between 1997-2007 in the manufacturing sector due to investments in industrial robots.</td>
<td>35%</td>
</tr>
<tr>
<td>Brynjolfsson, E. et al. (2011)</td>
<td>Firms that adopt data-driven decision making (DDD) have a higher market value, mostly related to the IT Capital.</td>
<td>Adoption of &quot;data-driven decision making&quot; (DDD) increases firm's productivity</td>
<td>5-6%</td>
</tr>
<tr>
<td>Graetz, G. &amp; Michales, G. (2015)</td>
<td>An estimated 0.4 percentage points of annual GDP growth was added by robotics between 1993 and 2007</td>
<td>Annual GDP growth due to robotics</td>
<td>0.4 percentage points</td>
</tr>
<tr>
<td>Schuh, G. et al (Eds.) (2017).</td>
<td>Value creation potential of Industrie 4.0 between 100-150 billion euros over the next 5 years in Germany.</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Smart Service Welt Working Group/acatech (Eds.). (2015)</td>
<td>Generated additional value-added from Europe's digital single market up to 500 billion euros by 2020.</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>
DISCUSSION

- Strong focus on ‘Manufacturing Process’ applications & solutions within one enterprise
  - Few applications across multiple enterprises

- Choice of applications influenced by focus of Agency / Institution
  - But also by definition of ‘digitalisation’ adopted

- Some experts suggested influence of complexity on current levels of adoption
  - Some SMEs prefer simpler applications like visualisation for production planning and single-process optimisation solutions
  - Opportunity to distinguish between ‘new and old’ applications & solutions - and where the impact might come in the future
DISCUSSION

- **Difference between SMEs and large firms**
  
  “Larger companies have invested in digital solutions in the past, so they are expected to achieve less significant productivity improvements” [1]

- **And between sectors – in particular country context**
  
  “Sectors like shipbuilding, mechanical engineering, smart grids, etc. need to change whole infrastructures and supply chains… benefits in these sectors are likely to take place only after 2025.” [1]

- **Attention to collaborative platforms**
  
  Role of collaborative platforms (and large firms) in digital adoption along the supply chain

**DISCUSSION**

- **Open Questions**
  - Where can the UK can genuinely get ahead of competitors?
  - Will many benefits disappear if everyone makes the same improvements?
  - What is the relationship between productivity and measures of international competitiveness (market shares, etc.)?
Structure for future evidence collection: The suggested approach could be used to structure emerging evidence – as more data is generated internationally.

Insights into factors/practices facilitating adoption: While not the focus of the project, some international effective practices identified (use cases; cost/ROI; training support).

Reference for policy evaluation: Estimations of expected benefit obtained across different applications can provide useful information for policy evaluation.
REFERENCES

[3] UILABS (ND) DMDII.
[17] BMWi (2018) What does Industry 4.0 mean for Germany?
[40] METI (2017), FY2018 Initial Budget and FY2017 Supplementary Budget.
Carlos López-Gómez
cel44@cam.ac.uk

Ella Whellams
erd30@cam.ac.uk

Institute for Manufacturing (IfM)
Department of Engineering
17 Charles Babbage Road
Cambridge, CB3 0FS
United Kingdom
APPENDIX 1: VARIABLES REPORTED BY CASE STUDIES

a) Example indicators across different types of business value
### A) Example Indicators in Each Business Value Type

| Increase revenue | Increase profit margin | • Increased turnover  
| | | • Improvement of the profit margin  
| | | • Improved operating margin  
| | Increase sales of existing products | • Increase sales of spare parts  
| | | • Exports growth  
| | | • Increased sales/ Sales growth  
| | Improve product performance / functionality | • Improvement of combustion efficiency  
| | | • Reduction of boiler's size (Product improvement)  
| | | • Increased life of stamping die  
| | Increase customer satisfaction | • Increased customer service level  
| | | • Decreased number of complaints  
| | | • Reduction of claims  
| | Reduce prototyping/testing/design time | • Reduction of wind tunnel and physical testing  
| | | • Reduced simulation  
| | Reduce overall time to market (including development time) | • Reduction of time to market  
| | | • Reduction of development time  
| | | • Reduction of testing effort  

---

[University of Cambridge: Department of Engineering] [IfM: Education and Consultancy Services]
### A) EXAMPLE INDICATORS IN EACH BUSINESS VALUE TYPE

<table>
<thead>
<tr>
<th>Cost Reduction</th>
<th>Indicators</th>
</tr>
</thead>
</table>
| Labour (time, effort) | - Reduced manpower time for documentation  
- Reduced manpower  
- Save time & effort |
| Material | - Reduction in material use  
- Reduction of scrap rate  
- Reduced use of (supplementary) materials |
| Energy | - Reduced electricity costs  
- Reduced energy use/consumption  
- Reduction of gas consumption  
- Reduction of resources consumption (energy, water and detergent)  
- Decreased product cost  
- Reduction of resources |

<table>
<thead>
<tr>
<th>Input Use Reduction</th>
<th>Indicators</th>
</tr>
</thead>
</table>
| Overall reduction of input use | - Increase daily production  
- Increased production capacity  
- Improved throughput of production line |

<table>
<thead>
<tr>
<th>Output Increase</th>
<th>Indicators</th>
</tr>
</thead>
</table>
| Improve production planning efficiency | - Improved project resource allocation and utilisation  
- Accuracy of production plan  
- Reduced production (planning) cycles |
| Improve factory safety | - Decrease of industrial accident rate  
- Reduction of alarm rate |
| Reduce prototyping/testing/design cost | - Decrease of testing cost  
- Decrease of design cost  
- Decrease of prototyping cost |
| Increase process operating efficiency (process/ machine/ line/ factory) | - Reduced machine stopped time (idle)  
- Increased facility operation rate  
- Reduction of time spent in operating machine |
### A) EXAMPLE INDICATORS IN EACH BUSINESS VALUE TYPE

| Reduce costs | Reduce defects and errors | • Reduction of defect rate  
• Reduction of human related errors  
• Reduction of process failure rate |
|--------------|----------------------------|--------------------------------------------------------------------------|
|              | Reduce maintenance cost    | • Reduced maintenance cost  
• Decreased cost of renewing insurance premiums |
|              | Improve delivery and service performance | • Increase delivery & pick-ups per trip  
• Improved delivery lead time  
• Increased on-time delivery |
|              | Reduce equipment commissioning and tooling | • Reduction of commissioning and retooling of production systems  
• Reduction of commissioning time |
| Reduce working capital | Reduce inventory | • Reduction in inventory and inventory management  
• Reduced intermediate stock  
• Reduction of WIP inventory |
## B) EXAMPLE APPLICATIONS PER CATEGORY

<table>
<thead>
<tr>
<th>Manufacturing product &amp; process design</th>
<th>Product design &amp; definition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Optimised sports car aerodynamics</td>
</tr>
<tr>
<td></td>
<td>• Cloud-based design of high-pressure vessels</td>
</tr>
<tr>
<td></td>
<td>• Cloud-based simulation of high-temperature concentric chimneys</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Product development</th>
<th>Product development</th>
</tr>
</thead>
<tbody>
<tr>
<td>• HPC-Cloud-based design of copper-alloy moulds</td>
<td>• Cloud-based optimisation of water turbines for power generation</td>
</tr>
<tr>
<td>• Simulation Computer Assisted Analysis (CAD) and Product Lifecycle management (PLM)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Process design &amp; definition</th>
<th>Process design &amp; definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Additive manufacturing for improving gearbox production</td>
<td>• HPC-Cloud-based simulation of steel casting</td>
</tr>
<tr>
<td>• Plant Simulation: Optimization of Steel Structure Manufacturing</td>
<td></td>
</tr>
</tbody>
</table>
## B) EXAMPLE APPLICATIONS PER CATEGORY

<table>
<thead>
<tr>
<th>Manufacturing process</th>
<th>Process quality management</th>
<th>Material pre/post processing</th>
<th>Input &amp; waste management</th>
<th>Material/product processing</th>
<th>Assembly</th>
<th>Testing, inspection, validation</th>
<th>Packaging &amp; shipping</th>
<th>Maintenance management</th>
<th>Process control and optimisation (including machine operation monitoring)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Process simulation through Numerical Simulation Software and 5-axis milling centre</td>
<td>• Production Management System (ERP) and Automation of Administrative Tasks</td>
<td>• Robotic mould finishing process</td>
<td>• Machine Standby Status Control</td>
<td>• Production Tool Optimisation (ROBOT Start PME Systems and a 6-axis welding)</td>
<td>• Automated Assembly Line</td>
<td>• Machine Operation Controller System</td>
<td>• Automated palletising, fleet management software and tool breakage control laser</td>
<td>• Numerically controlled robot with laser search application</td>
<td>• Yield Monitoring</td>
</tr>
<tr>
<td>• On-site quality control and integrated management of inspection</td>
<td>• Production of Administrative Tasks</td>
<td>• Optimised Energy Management</td>
<td>• Robotic integration for cutting, marking and welding tools</td>
<td>• Automated Process through integration of 2 robots and two 3-axis machining centres</td>
<td>• Automated Process through integration of 2 robots and two 3-axis machining centres</td>
<td>• Production management and inspection system</td>
<td>• More efficient bridge inspection by using autonomous micro aerial vehicles (MAVS)</td>
<td>• Predictive Maintenance</td>
<td>• Machine Automation Controller System</td>
</tr>
<tr>
<td>• Integration of Processes Systems by connecting a welding robot and flow machine for optimised aluminium cutting</td>
<td>• Could-type Energy Monitoring System</td>
<td>• Optimised Energy Management</td>
<td>• Integration of Processes Systems by connecting a welding robot and flow machine for optimised aluminium cutting</td>
<td>• Manufacturing with modular design principle - Flexible assembly line with integrated robotics</td>
<td>• Manufacturing with modular design principle - Flexible assembly line with integrated robotics</td>
<td>• More efficient bridge inspection by using autonomous micro aerial vehicles (MAVS)</td>
<td>• Automated palletising, fleet management software and tool breakage control laser</td>
<td>• Predictive Maintenance and Machine Operation Monitoring</td>
<td>• Production Process Optimization - Integrated Data Management System</td>
</tr>
</tbody>
</table>
## B) Example Applications Per Category

<table>
<thead>
<tr>
<th>Category</th>
<th>Operations infrastructure</th>
<th>Enterprise management</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Manufacturing infrastructure</strong></td>
<td>- Wireless network and IoT technology for video surveillance, physical access control, communications and temperature monitoring</td>
<td><strong>Product and service quality management</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Remote Real-time and On-demand Maintenance Services</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Automatic Order Processing integrated into CAD files automatically generated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Electronic Form Creation, Tracking and Report Generation</td>
</tr>
<tr>
<td><strong>Supply chain management</strong></td>
<td>- Integrating Supply Chain Information System</td>
<td><strong>Production planning and control</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Simulation, production and marketing optimization (from procurement to delivery to the customer, end-to-end integration)</td>
</tr>
<tr>
<td><strong>Production planning and control</strong></td>
<td>- Real-time visualisation of Production Information across different processes</td>
<td><strong>Product lifecycle management</strong></td>
</tr>
<tr>
<td></td>
<td>- Production Systems Data Aggregation and Optimisation of Visualisation and Analysis</td>
<td>- Product Lifecycle Management - Real-time drawing history management</td>
</tr>
<tr>
<td><strong>Supplier management</strong></td>
<td>- Digital Planning Board and Mobile Production Management</td>
<td></td>
</tr>
<tr>
<td><strong>Staff and Workflow management</strong></td>
<td>- Resource Optimisation - Manpower Scheduling</td>
<td><strong>Demand forecasting/inventory and delivery management</strong></td>
</tr>
<tr>
<td></td>
<td>- Management of Staff's workflow</td>
<td>- Last Mile Logistics Management</td>
</tr>
<tr>
<td></td>
<td>- Monitoring and analysis of machine operation and staff's productivity</td>
<td>- Collection &amp; Delivery Management System (CDMS)</td>
</tr>
<tr>
<td><strong>Resource management</strong></td>
<td></td>
<td>- Resource Optimisation - Inventory Planning</td>
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<td></td>
<td></td>
<td><strong>Resource management</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Project Resource Management System (PRMS)</td>
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<tr>
<td></td>
<td></td>
<td>- Resource Optimisation - Energy Efficient Monitoring and Analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- The Impact of IoT on Smart Farming and Water Usage Efficiency</td>
</tr>
<tr>
<td><strong>Business operations</strong></td>
<td></td>
<td><strong>Collaborative Data Management an Sharing between Suppliers and Customers</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Integrated Customer-Supplier Relationships through ERP and standardisation of CAD software</td>
</tr>
</tbody>
</table>
APPENDIX 2: OVERVIEW OF SELECTED INITIATIVES

- Korea
- Singapore
- US
CASE STUDY: KOREA

Industry 3.0

SM Foundation

Innovation Centres

Samsung

2,800 firm applications

Case studies for the project
KOREA – SMART MANUFACTURING INITIATIVE

Aim
“To develop smart manufacturing technologies and facilitating evolution to smart factories with key ICT technologies such as IoT, Big Data and Cloud Computing”

As part of Korea’s Creative Economy Initiative, Korean Ministry of Trade, Industry and Energy (MOTIE) launched the Manufacturing Industry Innovation 3.0 programme for the development of R&D roadmaps of technologies for the Industry 4.0. As part of this programme, MOTIE launched the Korea Smart Manufacturing Initiative to convert 10,000 small business into Small Factory Sites.
The Manufacturing Industry Innovation 3.0 strategy was defined as part of Korea’s Creative Economy Initiative.

Smart Factory Policy started in 2014 with the aim to develop 30,000 Smart Factories in the private sector by 2025. The Factories are supervised by the Korea Smart Factory Foundations.

In 2015, the Centre for Creative Economy and Innovation received $27 million and more than 150 Engineers from Samsung over a 2-year period to support the digital transformation of 600 SMEs.

The scope of the Smart Factory support is the integrated automation and digitalisation of production processes using IoT, AI and Big data.
The Ministry of Trade, Industry and Energy (MOTIE), the Korea Evaluation Institute of Industrial Technology, the Korea Smart Factory Foundation (KOSF) and the Korea Institute for Advancement of Technology have supported the Smart Manufacturing Innovation Centre to establish a Demo Factory integrating smart manufacturing technologies for testing solutions.

The Demo Factory includes a virtual manufacturing environment for the digital design and simulation of processes and, also, a physical environment that uses an IoT and cloud platforms connecting industrial robots, conveyers and assembly lines, packaging, logistics and data services.

The Smart Manufacturing Innovation Centre is working towards the standardisation of Demo Factories globally with the Industrial Internet Consortium.
CASE STUDY: US

Department of Defense

U+I Labs

Collaborating partners

Digital Manufacturing and Design Innovation Institute (DMDII)

National network for manufacturing innovation

Use cases

Case studies for the project
Aim

• “To transform American manufacturing competitiveness by accelerating the development and adoption of digital technology across the manufacturing enterprise”

DMDII is a collaboration between U+I Labs and the Department of Defense. Based on the Revitalize American Manufacturing and Manufacturing (RAMI) Act, the DMDII, together with 6 other institutes (also public-private partnerships), is part of the National Network for Manufacturing Innovation (or Manufacture USA) led by the Department of Commerce to provide resource and facilities to support universities and companies to develop solutions for industry-based problem.

Link to report

US–DMDII

- U+I Labs is an academic and industry collaboration for accelerating the technology development and bridging the gap between research and industrial solutions.

- DMDII was created to support the incorporation of digital technologies in production and design processes in the industry.

- DMDII is a platform for research innovation collaboration of entrepreneurs, academics, SMEs, large corporations, and government agencies.

- Technological solutions are developed in four areas: i) **Design, Product Development and Systems Engineering**, ii) **Future Factory**, iii) **Agile, Resilient Supply Chain**, and iv) **Cybersecurity in Manufacturing**.
US–DMDII’S *DIGITAL CAPABILITY CENTRE*

### DMDII – Demonstrator Space

- Central to the UI LABS facility is a 24,000 square-foot manufacturing floor that showcases the machines and technology from DMDII’s innovation centre.
- DMDII’s Manufacturing Floor is a demonstrator that offers a hands-on factory environment for showcasing products and services in action.
- The demonstrator space has capabilities to provide training for the *Factory of the Future*, test new software/hardware/techniques, shop-floor development environment process for the design of hardware and software, low-volume production runs (test processes), university and industrial workforce digital skills, and demonstration of product and software solutions to partners.

[https://www.uilabs.org/what-is-ui-labs/innovation-center/](https://www.uilabs.org/what-is-ui-labs/innovation-center/)
CASE STUDY: SINGAPORE

National initiative (RIE2020)

Future of Manufacturing (foM) initiative

MODEL FACTORIES

Network of model factories in a pilot production setup

TECH ACCESS

Access to advanced manufacturing equipment & facilities

TECH DEPOT

Suite of plug-and-play technologies that are easy to use

Use cases for analysis
Three key ‘thrusts’:

**TECH DEPOT**
Suite of plug-and-play technologies that are easy to use

**TECH ACCESS**
Access to advanced manufacturing equipment & facilities

**MODEL FACTORIES**
Network of model factories to co-innovate and test-bed advanced manufacturing technologies in a pilot production setup

[Link to report]
The newly launched Tech Depot is a centralised platform under the SME Portal aimed at improving SMEs’ access to technology and digital solutions.

By innovating and tapping on technology, SMEs can enhance their productivity and transform their businesses.

More than 25 technology solutions across a wide range of industries and business functions are currently featured at Tech Depot.

Discover solutions that can help address your business needs in the following areas:

- Customer Management
- Data Analytics
- Finance Management
- HR Management
- Inventory Management
- Machine Effectiveness
- Marketing & Content Management
- Project Management
- Quality Assurance
- Workflow Tracking & Management

https://www.smeportal.sg/content/tech-depot/en/home.html
In support of firms’ innovation efforts, Tech Access:

- Provides SMEs, access to A*STAR’s installed base of advanced manufacturing equipment/facilities as well as expertise; and
- Enables learning, experimenting, prototyping with the primary aim of eventual deployment of advanced technologies in the firms.

Tech Access can be provided in various combinations:

- Access to use of the equipment;
- User training; and
- Consultancy to optimise equipment effectiveness

From the experience gained, firms could then opt to scale and acquire such equipment to capture new business opportunities.
A Model Factory has been established at A*STAR's Singapore Institute of Manufacturing Technology (SIMTech).

A second model factory will be opened at A*STAR’s Advanced Remanufacturing and Technology Centre (ARTC) in 2018.

MCT is one of the key platforms, developed under A*STAR’s ‘Model Factories’ initiative – simulating production environments where companies can experiment and learn new manufacturing technologies.

These Model Factories allow SMEs to test new technologies with the help of public sector researchers before adopting into their factories.

A*STAR’S FUTURE OF MANUFACTURING INITIATIVE

- Centralised platform for SMEs aimed at improving access to technology and digital solutions.
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https://www.smeportal.sg/content/tech-depot/en/home.html