

THE PRACTICAL IMPACT OF DIGITAL MANUFACTURING:

RESULTS FROM RECENT INTERNATIONAL EXPERIENCE

INTERIM REPORT | SEPTEMBER 2018

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

Contributors:

Carlos López-Gómez, Head of Policy Links, IfM ECS

Duncan McFarlane, Head of the Distributed Information & Automation Laboratory

Eoin O'Sullivan, Director of the Centre for Science, Technology & Innovation Policy (CSTI)

Chander Velu, Head of the Business Model Innovation Research Group

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

This document has been produced without formal Innovate UK editing. The views expressed here do not imply the expression of any opinion on the part of Innovate UK. Mention of firm names or commercial products does not constitute an endorsement by the authors or Innovate UK.

This material is in copyright. Subject to statutory exception and to the provision of relevant collective licensing agreements, no reproduction of any part may take place without the written permission of IfM Education and Consultancy Services (IfM ECS).

Institute for Manufacturing (IfM), University of Cambridge

The Institute for Manufacturing (IfM) is part of the Department of Engineering at the University of Cambridge. Comprising some 240 people (excluding taught course students), it:

- 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)

IfM ECS is owned by the University of Cambridge. It transfers new ideas and approaches developed by researchers at the Institute for Manufacturing (IfM) to industry and government through a programme of education and consultancy services. Profits are gifted to the University of Cambridge to fund future research activities. Policy Links is part of IfM ECS and is the knowledge transfer unit of the Centre for Science, Technology & Innovation Policy (CSTI). Policy Links works closely with UK and international policy practitioners to develop more effective industrial innovation policies.

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; **Eoin O'Sullivan**, Director of the Centre for Science, Technology & Innovation Policy (CSTI); and **Chander Velu**, Head of the Business Model Innovation Research Group.

Acknowledgements

The authors acknowledge research assistance by **Zoi Roupakia**, **Clara Aranda** and **Jennifer Castaneda**. The project team also acknowledge valuable insights from industry, academia and government representatives consulted during the project, in particular during the workshop organised in Birmingham on 6 September 2018.

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)
- **Book Chapter: ‘Manufacturing R&D Policies for the Next Production Revolution: An International Review of Emerging Research Priorities and Policy Approaches’** – Organisation for Economic Co-operation and Development (OECD) – [Link](#)
- **‘Emerging Trends in Global Advanced Manufacturing’** – United Nations Industrial Development Organization (UNIDO) – [Link](#)
- **Contribution to the ‘Readiness for the Future of Production Report 2018’** – World Economic Forum’s – [Link](#)



UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION



OECD

BETTER POLICIES FOR BETTER LIVES



ASIAN DEVELOPMENT BANK

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

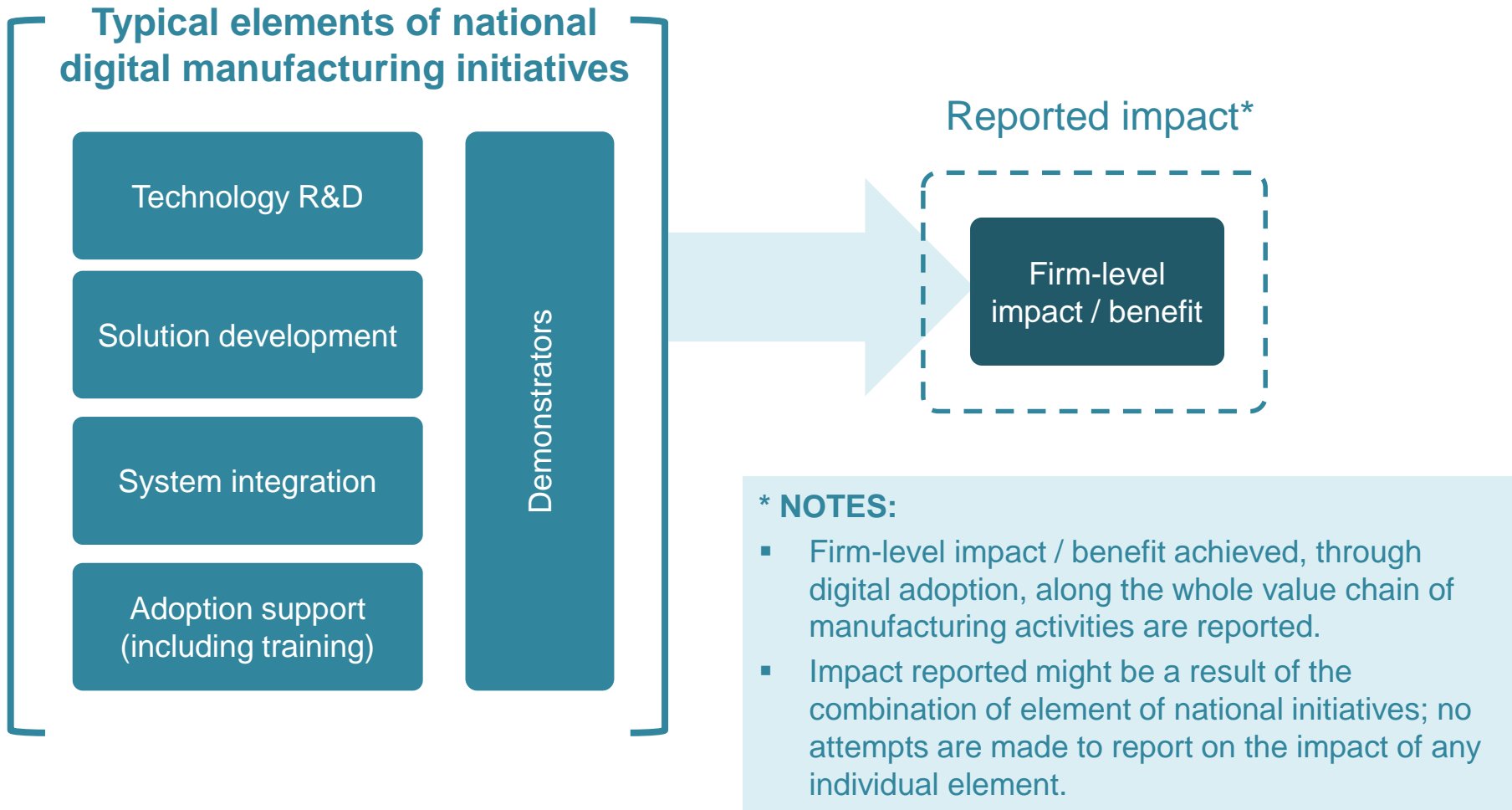
- Discussion of results
- Capturing views from UK stakeholders
- Discussion of implications for the UK

Evidence on practical impact of digital adoption in manufacturing



NOTES ON APPROACH

SCOPE OF THE PROJECT



VARIETY OF NATIONAL INITIATIVES (NON-EXHAUSTIVE)

Development-
focused

Adoption-
focused

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 reported were obtained primarily from applications in Small and medium-sized enterprises (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 achieved can necessarily be attributed to technology.
- In general, estimates assume that business models remains the same.
- Further analyses are required to account for potential time lags (between adoption and achievement of impact).
- Some digital applications could reshape industrial organisation and value chains; their impact might be very different if that happens.

NATIONAL DIFFERENCES

- Results are context dependent: care must be taken in using results from one country as the basis for estimations of impact in 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



STRATEGIES & STUDIES FROM NATIONAL INITIATIVES

This section presents estimations of the impact of digital adoption found in major national government-supported 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)

Data presented in this section was taken from original national sources. No attempt has been made to evaluate accuracy or methodological approaches. Typically, estimations are produced by government agencies or are taken from studies commissioned to private consultancies.

SELECTED INDICATORS ON IMPACT OF DIGITALISATION (SUMMARY)

	AUSTRALIA	AUSTRIA	CANADA	GERMANY	SPAIN	
Expected impact	National productivity	-	20% Productivity gains for the next 5 years [33]	-	30% Productivity gains of 'up to 30% by 2025' [18]	-
	Manufacturing efficiency (factory-level)	-	€-10 billion Efficiency potential 2015-2025 [32]	-	3.3% Annual efficiency gains, 2016-2020 [18]	-
	Value added	AU\$140-250 billion Contribution to GDP by 2025 [29]		C\$34 billion Contribution to GDP by 2025 [9]	€425 billion Cumulative value added, 2016-2020 [18]	€120 billion Accumulated growth 2017- 2025 [21,22]
	Jobs	-	-	50,000 (2017-2027) [9]	390,000 From 2015-2025 [19]	1.25 million In the next 5 yrs [21, 22]
	Manufacturing output	25%-35% (Above trend by 2026) [10]	-	-	-	€35 billion Accumulated growth 2017-2020 [21]
	Cost reduction	-	2.9% Per year, for the next five years [33]	-	2.6% Annually, 2016-2020 [18]	-
	Other	-	2.6% Average turnover increase per year [33] €-14 billion Sales potential by 2025 [32]	-	-	-

Note: Data taken from original national sources. No attempts have been made to evaluate accuracy or methodological approaches.

SELECTED INDICATORS ON IMPACT OF DIGITALISATION (SUMMARY)

	JAPAN	KOREA	SINGAPORE	US	
Expected impact	National productivity	Over 2% Labour productivity gains in manufacturing industries [38]	-	30% Boost in labour productivity by 2024 [24]	-
	Manufacturing efficiency	-	-	30-40% (local companies expected output increment) [27]	-
	Value added	\$270 billion Value added by advanced manufacturing by 2020 [30]	-	-	-
	Jobs	-	-	22,000 (From 2017- 2024) [24,26]	-
	Manufacturing output	-	2% Potential growth of output in major industries "when opportunities given by I4.0 are suitable utilised" [28]	S\$36b (From 2017-2024) [24]	-
	Cost reduction	-	-	-	-
	Other	-	30,000 'Smart Factories' for SMEs by 2025	-	-
Observed impact	National productivity	-	-	-	
	Manufacturing efficiency	-	30% Result from 2,800 digital applications primarily in SMEs [28]	30% Improvements in efficiency achieved by local companies [26] 15-20% Increment in output observed by local companies [27]	20% (primarily SME results) [4,5]
	Cost reduction	-	15% Result from 2,800 digital applications primarily in SMEs [28]	-	-
	Other	-	45% reduction defective product ratio 16% reduction in delivery time Result from 2,800 digital applications primarily in SMEs [28]	-	-

Note: Data taken from original national sources. No attempts have been made to evaluate accuracy or methodological approaches.

OBSERVATIONS

The international review of national digital manufacturing initiatives identified a variety of indicators used to report the *expected* and *observed* impact driven by industrial digitalisation. While not reported here, qualitative measures such as *competitiveness*, *business confidence*, and *sustainability* are also often cited.

EXPECTED IMPACT

In terms in *expected impact* countries provide estimations of national-level indicators such as *productivity*, *value added* and *jobs*.

- **Productivity***: Estimates cited by the national governments of the potential impact of digitalising industry include productivity gains of up to **30% by 2025 in Germany** and **30% by 2024 in Singapore**. In **Japan**, the government estimates that growth in labor productivity in manufacturing could be increased by more than **2% annually**, citing as a key driver a expected doubling of robot use by 2020.
- **Value added**: The most common indicator used in the sample of countries surveyed, however, is **value added**. Estimates vary significantly, reflecting differences between the size of national economies.
- **Jobs**: Despite common perceptions about the potential negative impact of digitalisation on jobs, all estimations identified forecast that digitalising industry will lead to the creation of new jobs.

OBSERVED IMPACT

Fewer countries have reported data on *observed impact*, reported at the firm level.

- Interestingly, both **Singapore** and **Korea** report the same levels of improvements in manufacturing efficiency (**30%**) in the samples of firms analysed.
- The case of **Korea** is particularly interesting. Systematic efforts have been made to evaluate the firm-level impacts of digital adoption observed by the firms supported by a major national programme, the *Korea Smart Manufacturing Initiative*,
- Perhaps not surprisingly, **no estimations of observed national productivity growth** are presented in any of the countries surveyed.

* Caution should be taken to distinguish between *national-level 'productivity'* and *firm-level 'manufacturing efficiency'*.

OBSERVATIONS

Difference between expected and observed impact
Less governments doing it

The case of Korea appears particularly interesting

No national productivity as 'observed'



STRATEGIES & STUDIES FROM NATIONAL INITIATIVES

This section presents a brief comparison of the funding levels and sources of major national digital manufacturing initiatives.

SELECTED MANUFACTURING DIGITALISATION INITIATIVES – BUDGET COMPARISON (1/2)

Country	GDP (UK=100)	Initiative	Source of funding	Funding levels	Funding as % of GDP (per year)
Korea	58.4	The Korea Smart Factory Initiative	Public (MOTIE)	\$189.3 million from 2017 to 2020 [19].	0.003
Germany	140.2	Plattform Industrie 4.0	Government (Ministry of Economic Affairs and Ministry of Education and Research) Private contributions (50% SMEs, <50% Large)	€200 million in funding allocated by BMBF and BMWI complemented by industry contributions (2011-2020) [15].	0.0006
United States	739.4	Digital Manufacturing and Design Innovation (DMDII) [Part of the Manufacturing USA Institutes]	Co-Funding public-private	5-year cooperative agreement, \$70 million federal funding and over \$180 million matching funding from partners [36].	0.0002
Japan	185.8	Connected Industries	Public (METI)	\$ 171.6 million included in the FY 2018 budget of the Ministry of Economy, Trade and Industry to promote Connected Industries [40].	0.0076
		Robot Revolution Initiative(RRI)	Public and private sectors	¥ 100 billion investment expected in robots during the period 2015-2020 [39].	
Singapore	12.4	Automation support package	Government	\$400 million over the next three years [25].	0.0668
		(FoM) Initiative 4.0 strategy	Government (EDB, a-Star, MoT, NEA, MoH, MoHA)	S\$450 million to support National Robotics Programme over next 3 years [25].	
		'Model Factory' initiative	Public-private partnership	Model Factory@SIMTech: Up to S\$60 million joint lab [25].	

SELECTED MANUFACTURING DIGITALISATION INITIATIVES – BUDGET COMPARISON (2/2)

Country	GDP (UK=100)	Initiative	Source of funding	Funding levels	Funding as % of GDP (per year)
Australia	50.5	Industry's Growth Centers Initiative	Australian Government (Department of Industry, Innovation and Science)	The Industry Growth Centres Initiative has funding of A\$232.0 million over six years from 2017-18 [37].	0.0022
Canada	63.0	Innovation Superclusters Initiative	Private and Public	C\$950 mi to support business-led innovation between 2017-2022 [8].	0.0073
Austria	15.9	Platform Industry 4.0	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].	Founding members contribution: €300,000 per year for 3 years; €200,000 provided by the membership fees (forecast for 2017) [13].	0.0253
		Production of the Future (Research)	Government (Federal Ministry of Transport, Innovation and Technology)	Over €450 million (2011-2015). <i>Production of the Future</i> provides €25 millions every year in funding for research projects [12, 14].	
Spain	50.0	Industria Conectada	Government (30-50% for SMEs, 20-40% for Large) [21].	€100 million in 2016 [22].	0.009



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

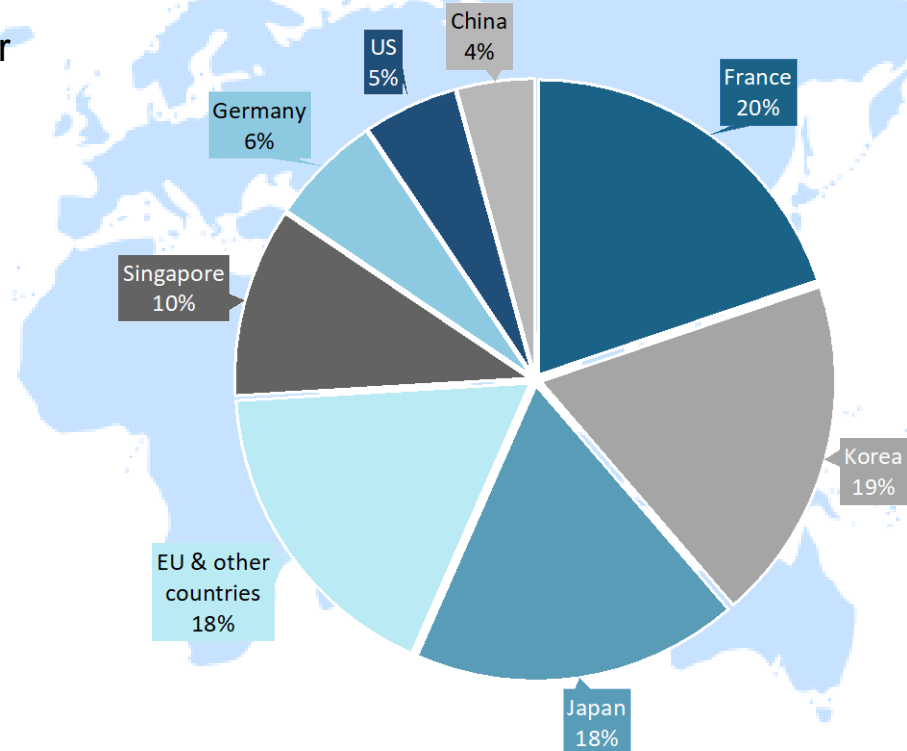
**212 cases
selected for
analysis**

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



USE CASES

Cyber physical production and logistics systems with common interface

Aragón Industria 4.0
Portal de Apoyo al despliegue de la Industria 4.0 en las empresas de Aragón

원연우
스마트공장으로 생산 혁신과 관리 혁신을 이룩하다

대표 기준년: 설립 1983년 9월
인원: 시군 가외 64명 13

1,900억 원 (2016년 매출)
주요 실적: 화강품 용기
1,337명 (2016년 매출)
2016년 2월 ~9월 매출: 50,000,000원
71,000,000원 (2016년 매출)
121,000,000원 (2016년 매출)

세계 10대 화강품 브랜드가 선택한 기업, 연우

연우는 국내 최초로 화강품용 디스펜스 필름을 개발하여 뛰어난 기술 경쟁력과 디자인 역량을 바탕으로 글로벌 시장에서 인정받고 있다.

연우는 국내 최초로 화강품용 디스펜스 필름을 개발하여 뛰어난 기술 경쟁력과 디자인 역량을 바탕으로 글로벌 시장에서 인정받고 있다. 디스펜스 필름은 용기용 필름에 장착되는 것으로 장식의 내용이 비출 수 있도록 정밀하게 설계된 제품이다. 그 고품질 및 기능성 화강품용 필름을 개발한 연우가, 1983년 회사 설립 당시 연우는 화강품 용기 추가공급 업체였다. 그러다 해외에서 제작되고 있던 필름 용기를 직접 만들기로 하고 기술개발에 몰두했다. 그렇게 1년 반이 지나고 수많은 실패를 거듭한 끝에 필름 용기 국산화에 최초로 성공했다. 그리고 현재 필름용 용기 국내 시장의 36%를 점유하고 있다. 하지만 모든 일들이 그리 순조롭지 않았던 일이었다. 초기에는 제품을 불량이 많아 납품 후 취소한 적도 있었다. 그러나 포기하지 않고 지속적으로 노력한 결과 오늘날의 성과로 이어졌다.

'우리가 받아야 할 시장은 무한하고, 훌륭한 직원들 덕분에 아이디어도 넘쳐납니다.'

기존엔 대표의 말이다. 그는 현재의 성과에 머물지 않고 더 큰 단계로의 도약을 위해 직원들이 더욱 편하게 일하면서도 생산성을 높일 수 있는 관리 혁신을 도모했다. 그 첫걸음이 바로 '스마트공장'의 구축이었다.

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

Initiative	Number of case	Link	Country of initiative	Country/ Province of application	Case/ Company/ Organization	Functional area	Title	Application
Korea Smart Factory Foundation- Best Practices		https://www.smart-factory.kr/buzInfo/popup/bestExamDet23_ail.do?idx=15_02	Korea		Daekwang Cast Iron Co., Ltd.	Process control and optimisation (including machine operation monitoring)		Manufacturing execution system - Point of Production (MES-POP) - Real time quality data management and process control

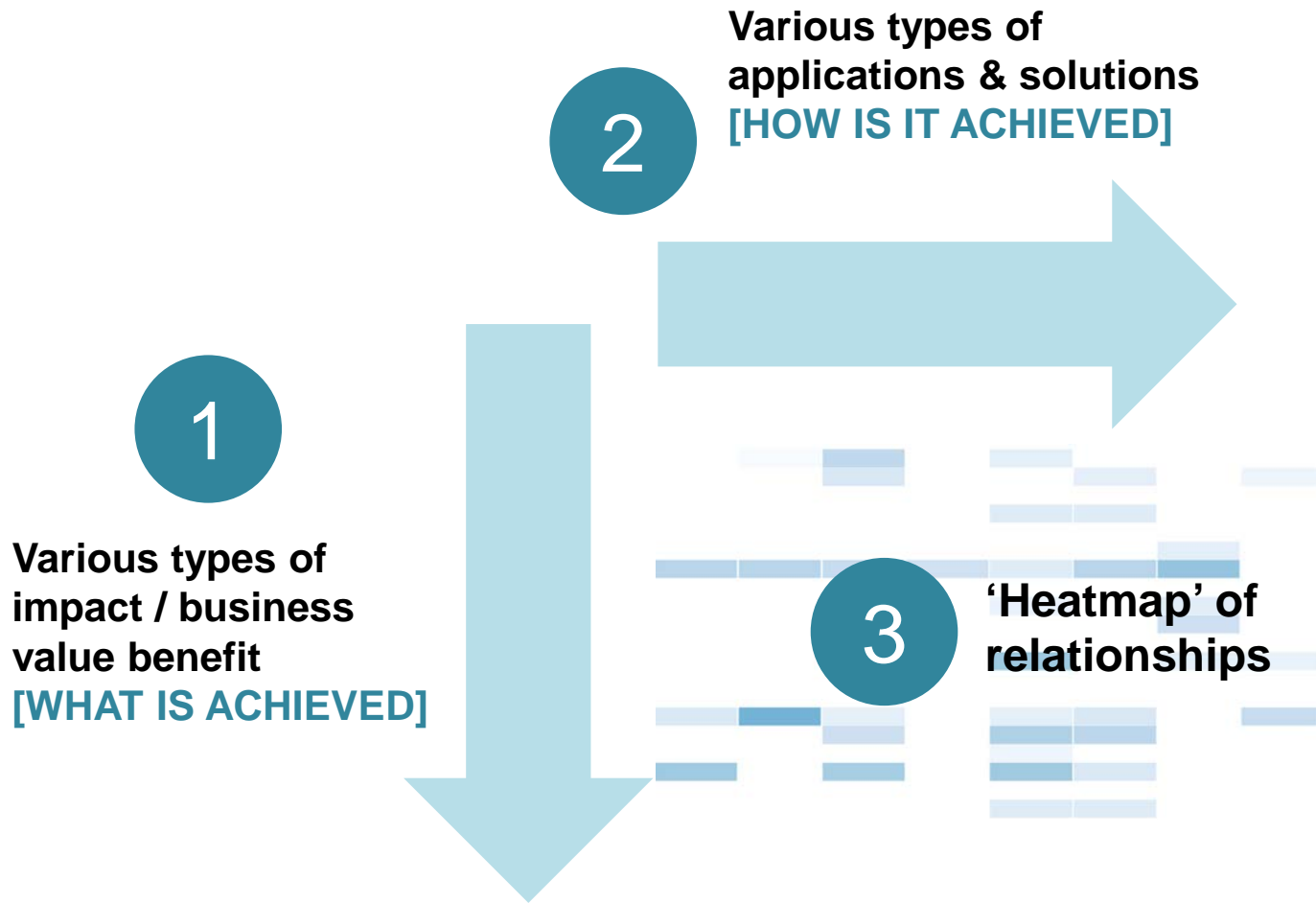


Initiative	Number of case	Link	Country of initiative	Country/ Province of application	Case/ Company/ Organization	Functional area	Title	Implementation cost estimation (€K)		Technology		Sectors	Estimated impact										
								Grants contribution	Company contribution	With_PC or table-top/ touchable interface	Example			IoT (Cyber- CAD/ Simulation/ Machine- OPC/ CPS) / Benefits: cloud based simulation/ Mobile (i)Cloud/ SaaS (Cloud-based/ PaaS/ IaaS) / ICT Technology	Cloud computing	Cloud connectivity	PLM (PLM)	Dissemination system (ERP for accounts process)	Robotic Machine Learning (RML), Feed Forwarding	Visual data/ dashboard	All (deep learning, machine learning, deep analysis/ Big data/ dashboard)		
Initiative	Number of case	Link	Country of initiative	Country/ Province of application	Case/ Company/ Organization	Functional area	Title	Application	Grants contribution	Company contribution	With_PC or table-top/ touchable interface	Example	IoT (Cyber- CAD/ Simulation/ Machine- OPC/ CPS) / Benefits: cloud based simulation/ Mobile (i)Cloud/ SaaS (Cloud-based/ PaaS/ IaaS) / ICT Technology	Cloud computing	Cloud connectivity	PLM (PLM)	Dissemination system (ERP for accounts process)	Robotic Machine Learning (RML), Feed Forwarding	Visual data/ dashboard	All (deep learning, machine learning, deep analysis/ Big data/ dashboard)	Sectors applied	Potential Sector application	Estimated impact
2017 Smart Factory	20	https://www.smart-factory.kr/buzInfo/popup/bestExamDet23_ail.do?idx=15_02	Korea	Daegu/ Gyeongsang	Daegu/ Gyeongsang/ Daegu A. Peckon Co. Ltd.	Machine operation monitoring	Manufacturing execution system - Point of Production (MES-POP)	Manufacturing execution system - Point of Production (MES-POP)	100	80		Example	IoT (Cyber- CAD/ Simulation/ Machine- OPC/ CPS) / Benefits: cloud based simulation/ Mobile (i)Cloud/ SaaS (Cloud-based/ PaaS/ IaaS) / ICT Technology	Cloud computing	Cloud connectivity	PLM (PLM)	Dissemination system (ERP for accounts process)	Robotic Machine Learning (RML), Feed Forwarding	Visual data/ dashboard	All (deep learning, machine learning, deep analysis/ Big data/ dashboard)	Manufacturing	Manufacturing	100%
2018 Smart Factory	21	https://www.smart-factory.kr/buzInfo/popup/bestExamDet23_ail.do?idx=15_02	Korea	Daegu/ Gyeongsang	Daegu/ Gyeongsang/ Daegu A. Peckon Co. Ltd.	Process quality improvement/ Process control and optimization	Computerized Production Control (CPC)	Computerized Production Control (CPC)	30	20	15	*	IoT (Cyber- CAD/ Simulation/ Machine- OPC/ CPS) / Benefits: cloud based simulation/ Mobile (i)Cloud/ SaaS (Cloud-based/ PaaS/ IaaS) / ICT Technology	Cloud computing	Cloud connectivity	PLM (PLM)	Dissemination system (ERP for accounts process)	Robotic Machine Learning (RML), Feed Forwarding	Visual data/ dashboard	All (deep learning, machine learning, deep analysis/ Big data/ dashboard)	Manufacturing	Manufacturing	100%
2019 Smart Factory	22	https://www.smart-factory.kr/buzInfo/popup/bestExamDet23_ail.do?idx=15_02	Korea	Daegu/ Gyeongsang	Daegu/ Gyeongsang/ Daegu A. Peckon Co. Ltd.	Machine operation monitoring	Manufacturing execution system - MES-POP	Manufacturing execution system - MES-POP	30	20	15	*	IoT (Cyber- CAD/ Simulation/ Machine- OPC/ CPS) / Benefits: cloud based simulation/ Mobile (i)Cloud/ SaaS (Cloud-based/ PaaS/ IaaS) / ICT Technology	Cloud computing	Cloud connectivity	PLM (PLM)	Dissemination system (ERP for accounts process)	Robotic Machine Learning (RML), Feed Forwarding	Visual data/ dashboard	All (deep learning, machine learning, deep analysis/ Big data/ dashboard)	Manufacturing	Manufacturing	100%
2020 Smart Factory	23	https://www.smart-factory.kr/buzInfo/popup/bestExamDet23_ail.do?idx=15_02	Korea	Daegu/ Gyeongsang	Daegu/ Gyeongsang/ Daegu A. Peckon Co. Ltd.	Machine operation monitoring	MES-POP system	MES-POP system	50	30	15	*	IoT (Cyber- CAD/ Simulation/ Machine- OPC/ CPS) / Benefits: cloud based simulation/ Mobile (i)Cloud/ SaaS (Cloud-based/ PaaS/ IaaS) / ICT Technology	Cloud computing	Cloud connectivity	PLM (PLM)	Dissemination system (ERP for accounts process)	Robotic Machine Learning (RML), Feed Forwarding	Visual data/ dashboard	All (deep learning, machine learning, deep analysis/ Big data/ dashboard)	Manufacturing	Manufacturing	100%
2021 Smart Factory	24	https://www.smart-factory.kr/buzInfo/popup/bestExamDet23_ail.do?idx=15_02	Korea	Daegu/ Gyeongsang	Daegu/ Gyeongsang/ Daegu A. Peckon Co. Ltd.	Machine operation monitoring	MES-POP system	MES-POP system	25	15	10	*	IoT (Cyber- CAD/ Simulation/ Machine- OPC/ CPS) / Benefits: cloud based simulation/ Mobile (i)Cloud/ SaaS (Cloud-based/ PaaS/ IaaS) / ICT Technology	Cloud computing	Cloud connectivity	PLM (PLM)	Dissemination system (ERP for accounts process)	Robotic Machine Learning (RML), Feed Forwarding	Visual data/ dashboard	All (deep learning, machine learning, deep analysis/ Big data/ dashboard)	Manufacturing	Manufacturing	100%
2022 Smart Factory	25	https://www.smart-factory.kr/buzInfo/popup/bestExamDet23_ail.do?idx=15_02	Korea	Daegu/ Gyeongsang	Daegu/ Gyeongsang/ Daegu A. Peckon Co. Ltd.	Machine operation monitoring	MES-POP system	MES-POP system	25	15	10	*	IoT (Cyber- CAD/ Simulation/ Machine- OPC/ CPS) / Benefits: cloud based simulation/ Mobile (i)Cloud/ SaaS (Cloud-based/ PaaS/ IaaS) / ICT Technology	Cloud computing	Cloud connectivity	PLM (PLM)	Dissemination system (ERP for accounts process)	Robotic Machine Learning (RML), Feed Forwarding	Visual data/ dashboard	All (deep learning, machine learning, deep analysis/ Big data/ dashboard)	Manufacturing	Manufacturing	100%
2023 Smart Factory	26	https://www.smart-factory.kr/buzInfo/popup/bestExamDet23_ail.do?idx=15_02	Korea	Daegu/ Gyeongsang	Daegu/ Gyeongsang/ Daegu A. Peckon Co. Ltd.	Machine operation monitoring	MES-POP system	MES-POP system	25	15	10	*	IoT (Cyber- CAD/ Simulation/ Machine- OPC/ CPS) / Benefits: cloud based simulation/ Mobile (i)Cloud/ SaaS (Cloud-based/ PaaS/ IaaS) / ICT Technology	Cloud computing	Cloud connectivity	PLM (PLM)	Dissemination system (ERP for accounts process)	Robotic Machine Learning (RML), Feed Forwarding	Visual data/ dashboard	All (deep learning, machine learning, deep analysis/ Big data/ dashboard)	Manufacturing	Manufacturing	100%

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

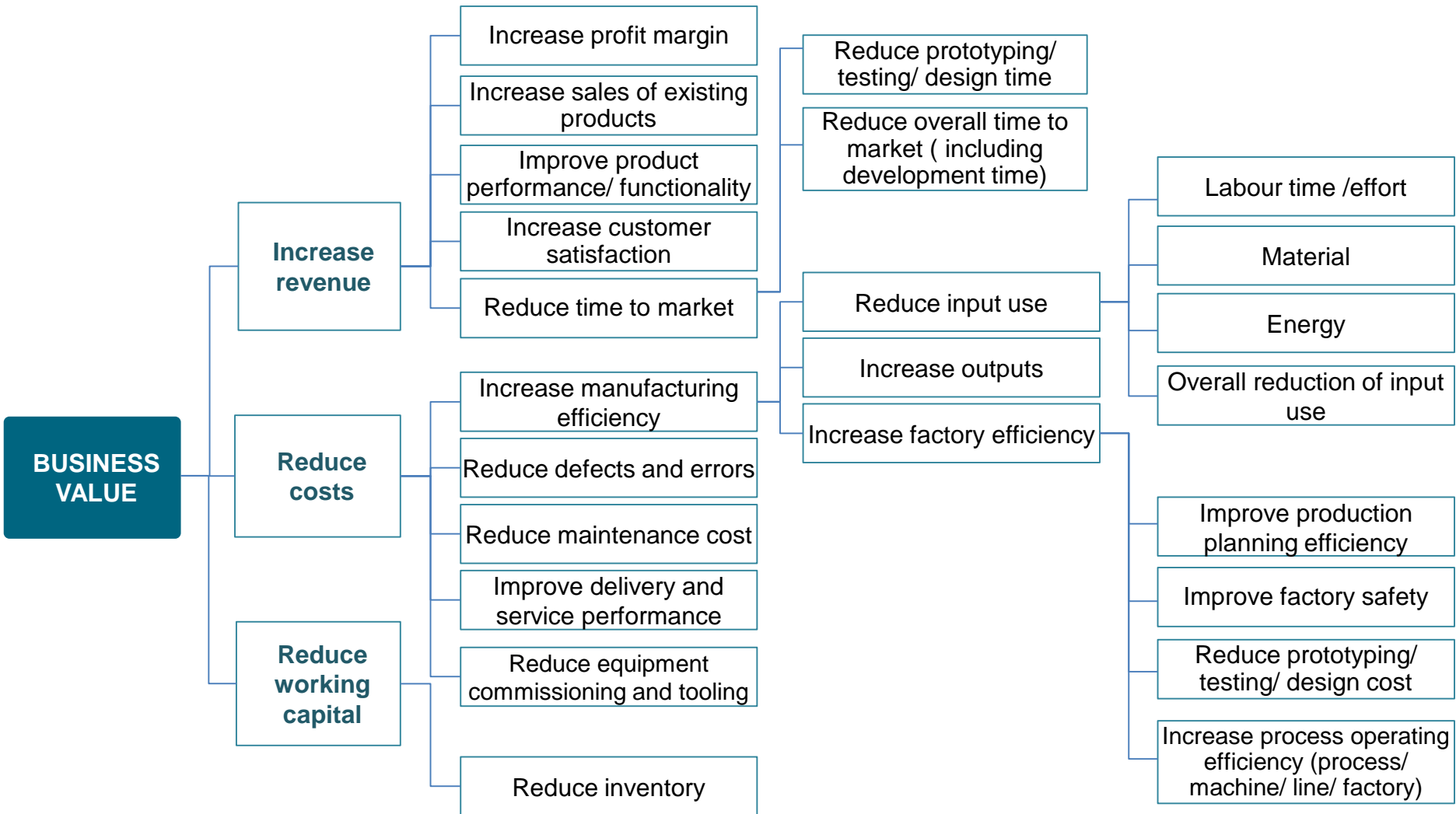
FINDINGS





(1) BUSINESS VALUE

CLASSIFYING IMPACT ON BUSINESS VALUE



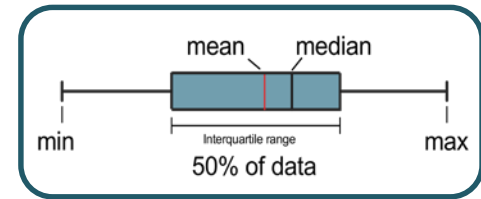
Adapted from: William P. King (2015). [Digital Manufacturing. Digital Manufacturing & Design Innovation Institute presentation](#)



CLASSIFYING DIGITAL APPLICATIONS & SOLUTIONS

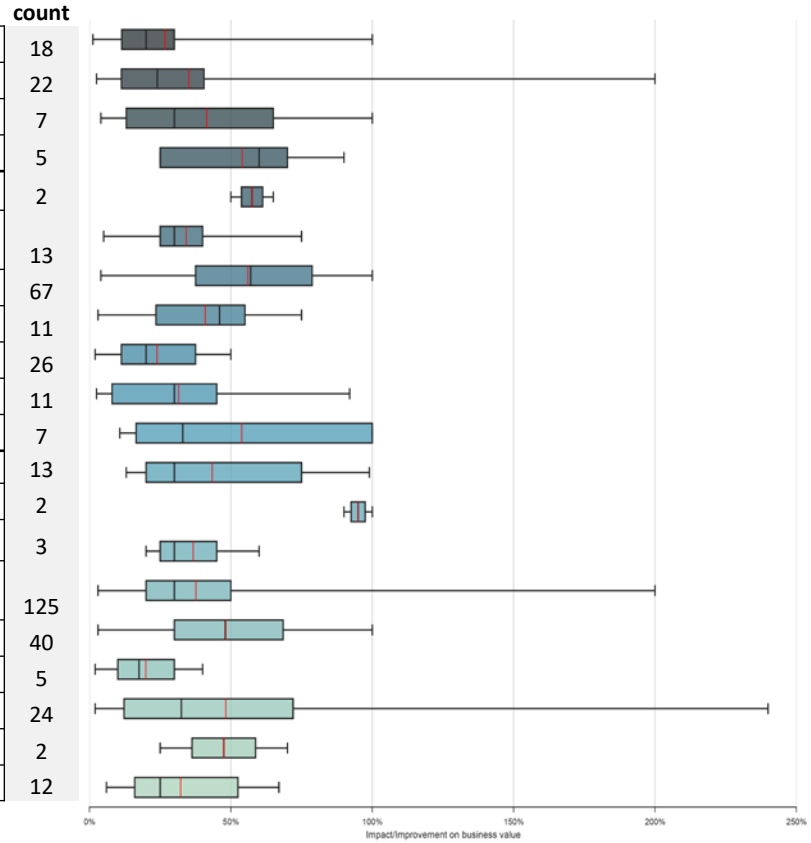
Manufacturing product & process design	Encompasses all of the functions and processes associated with conceiving and developing new (and improved) products and manufacturing processes, to the point of readiness for manufacturing execution.	
Manufacturing process	Encompasses all of the functions associated with translating product designs into finished goods.	
Manufacturing infrastructure	Encompasses all of the functions that support the creation of the product, both directly and indirectly.	
Enterprise management	Encompasses all of the functions associated with managing the operation of a manufacturing business entity.	
Manufacturing business & technology environment	Encompasses all of the issues and functions not addressed under the other four elements.	

OBSERVED RESULTS: BUSINESS VALUE VIEWPOINT



BUSINESS VALUE

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 costs	Reduce input use	Reduce overall time to market (including development time)			
		Labour (time, effort)			
		Material			
		Energy			
		Overall reduction of input use			
	Increase outputs				
	Increase manufacturing efficiency	Increase factory efficiency	Improve production planning efficiency		
			Improve factory safety		
			Reduce prototyping/testing/design cost		
			Increase process operating efficiency (process/ machine/ line/ factory)		
			Reduce defects and errors		
	Reduce maintenance cost				
	Improve delivery and service performance				
	Reduce equipment commissioning and tooling				
	Reduce working capital	Reduce inventory			



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:

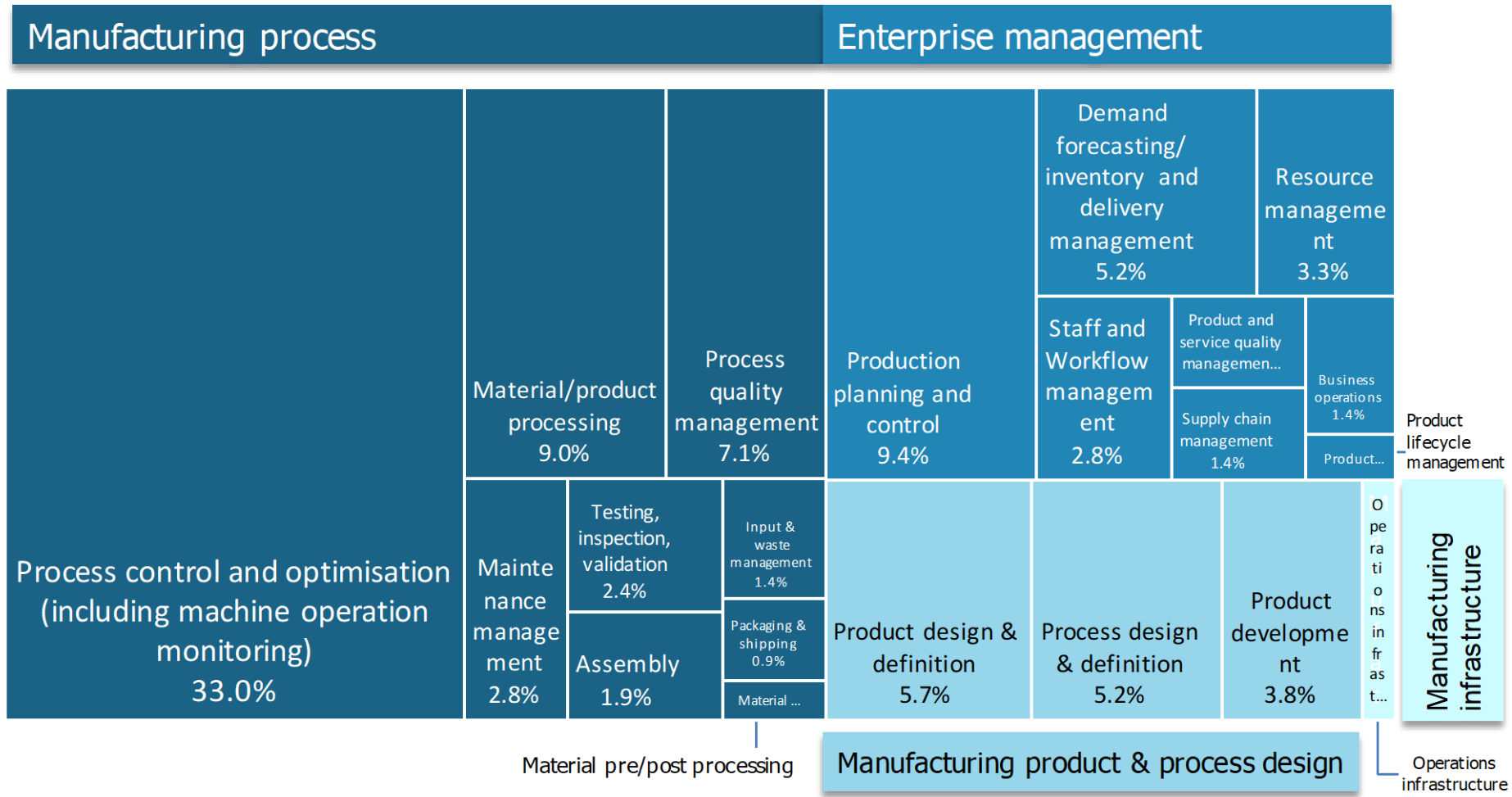
* Only cases with >5 instances are reported (total number of instances: ~420)

† Median




(2) APPLICATIONS & SOLUTIONS

USAGE OF APPLICATIONS & SOLUTIONS BY FUNCTIONAL AREA



Policy Links, 2018

Note: Manufacturing taxonomy adapted from Integrated Manufacturing Technology. 21st Century Manufacturing Taxonomy: [IMTI, 2003].



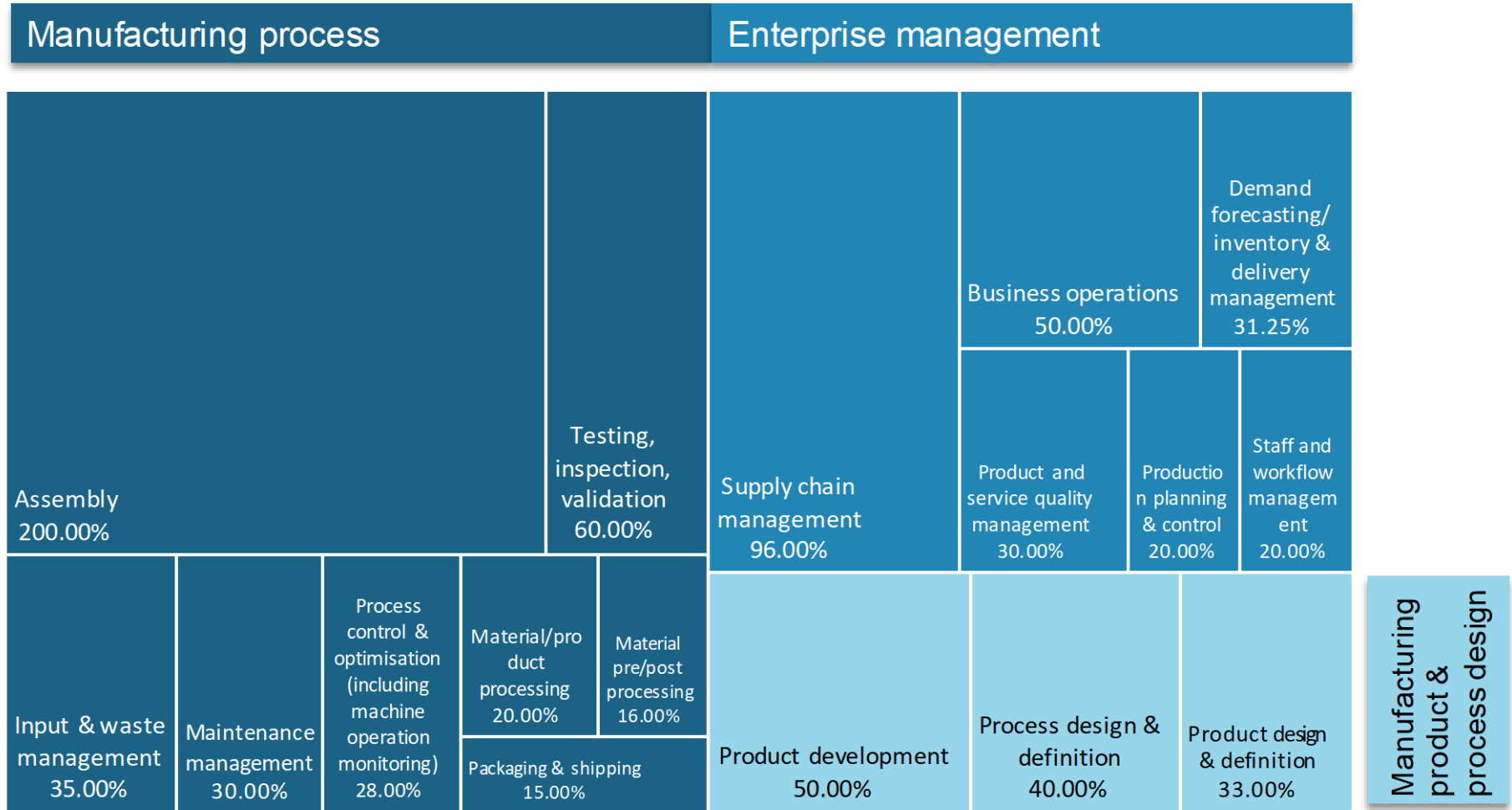
TOP APPLICATIONS & SOLUTIONS LEADING TO INCREASE OF PROCESS EFFICIENCY



COLUMN GRAPH

IMPACT ACHIEVED BY FIRMS ADOPTING DIGITAL APPLICATIONS & SOLUTIONS

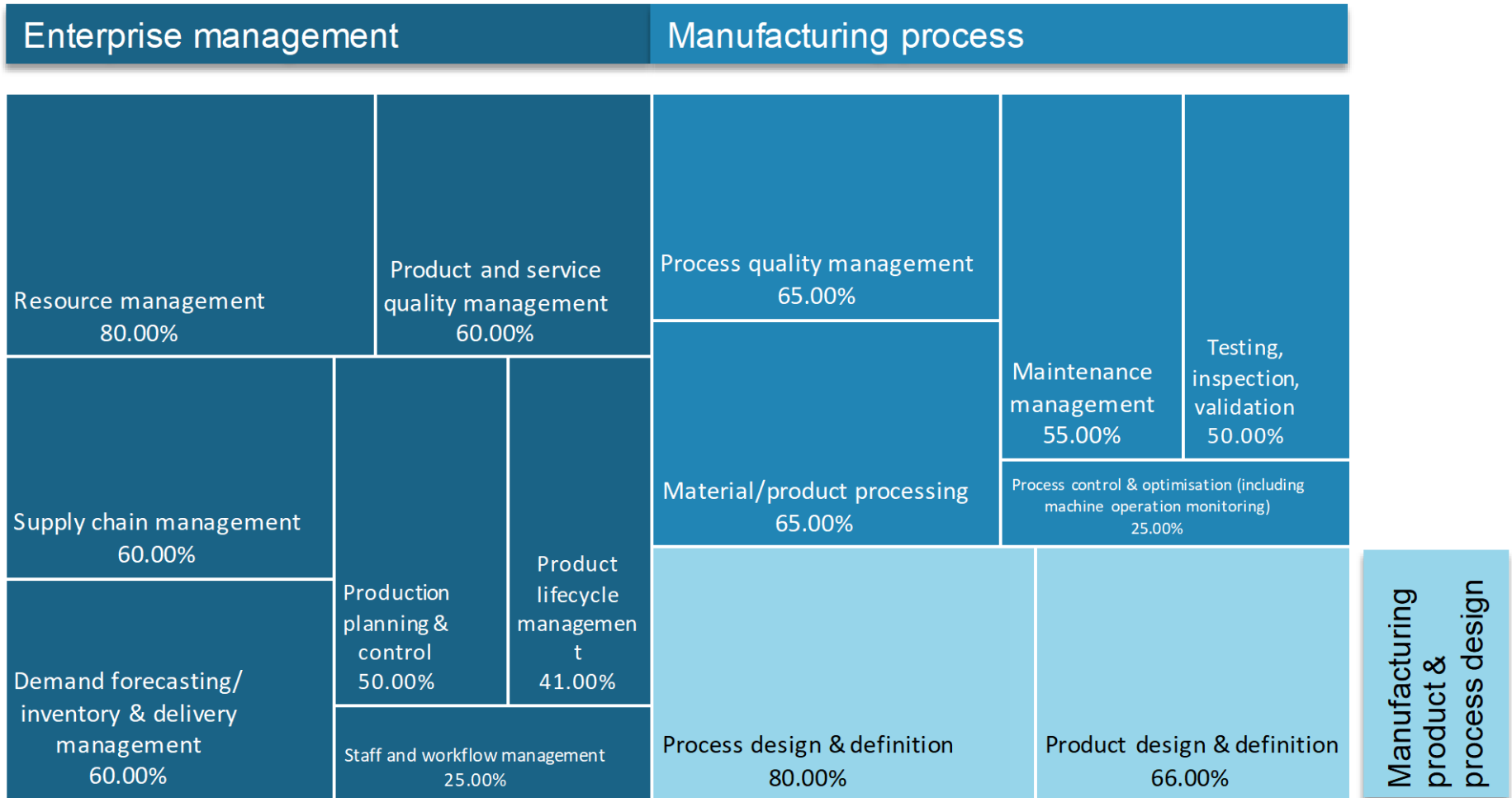
BUSINESS VALUE VARIABLE: INCREASE OF PROCESS OPERATING EFFICIENCY*



* Including process/ machine/ line/ factory process efficiency

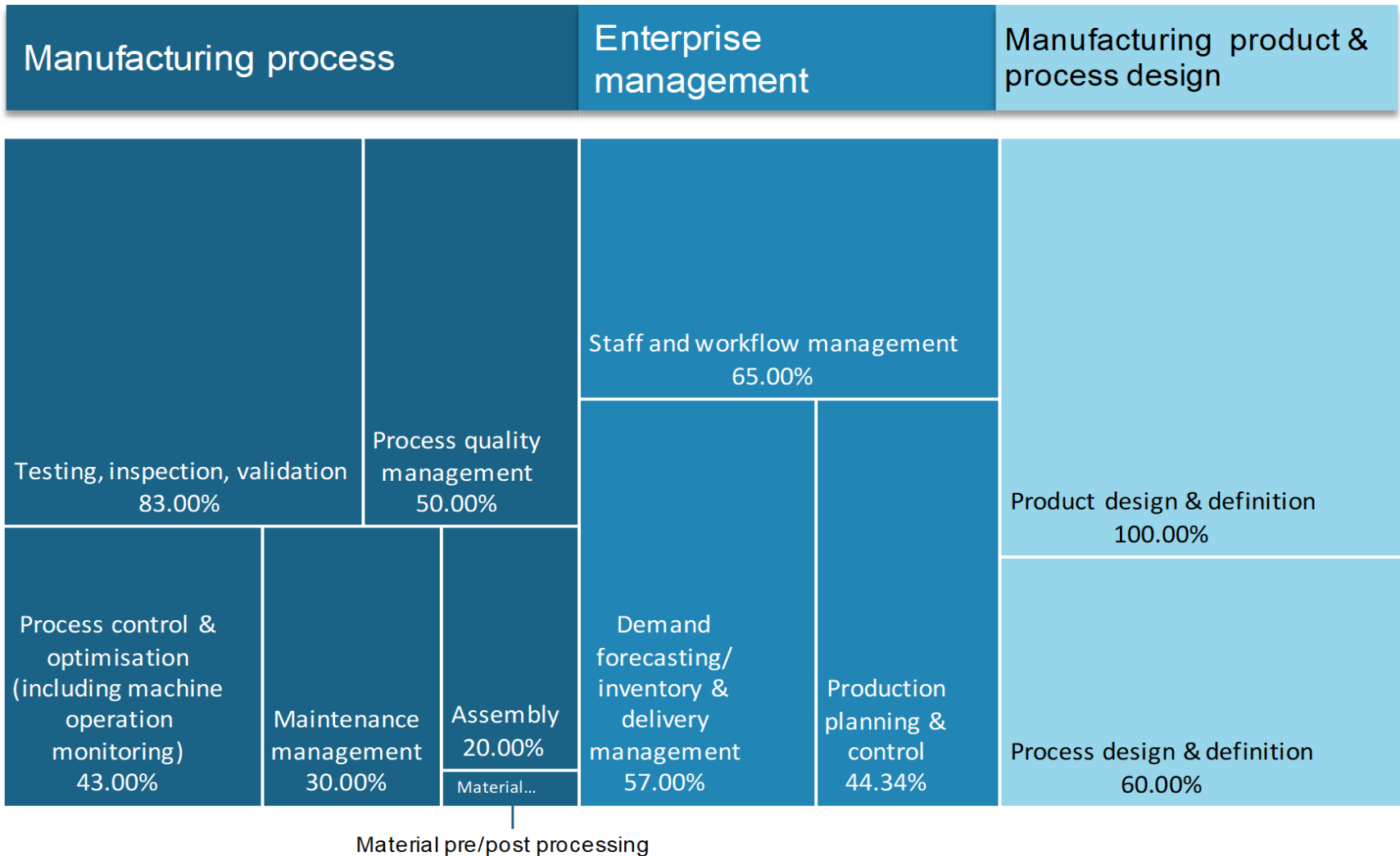
IMPACT ACHIEVED BY FIRMS ADOPTING DIGITAL APPLICATIONS & SOLUTIONS

BUSINESS VALUE VARIABLE: REDUCTION OF LABOUR COSTS



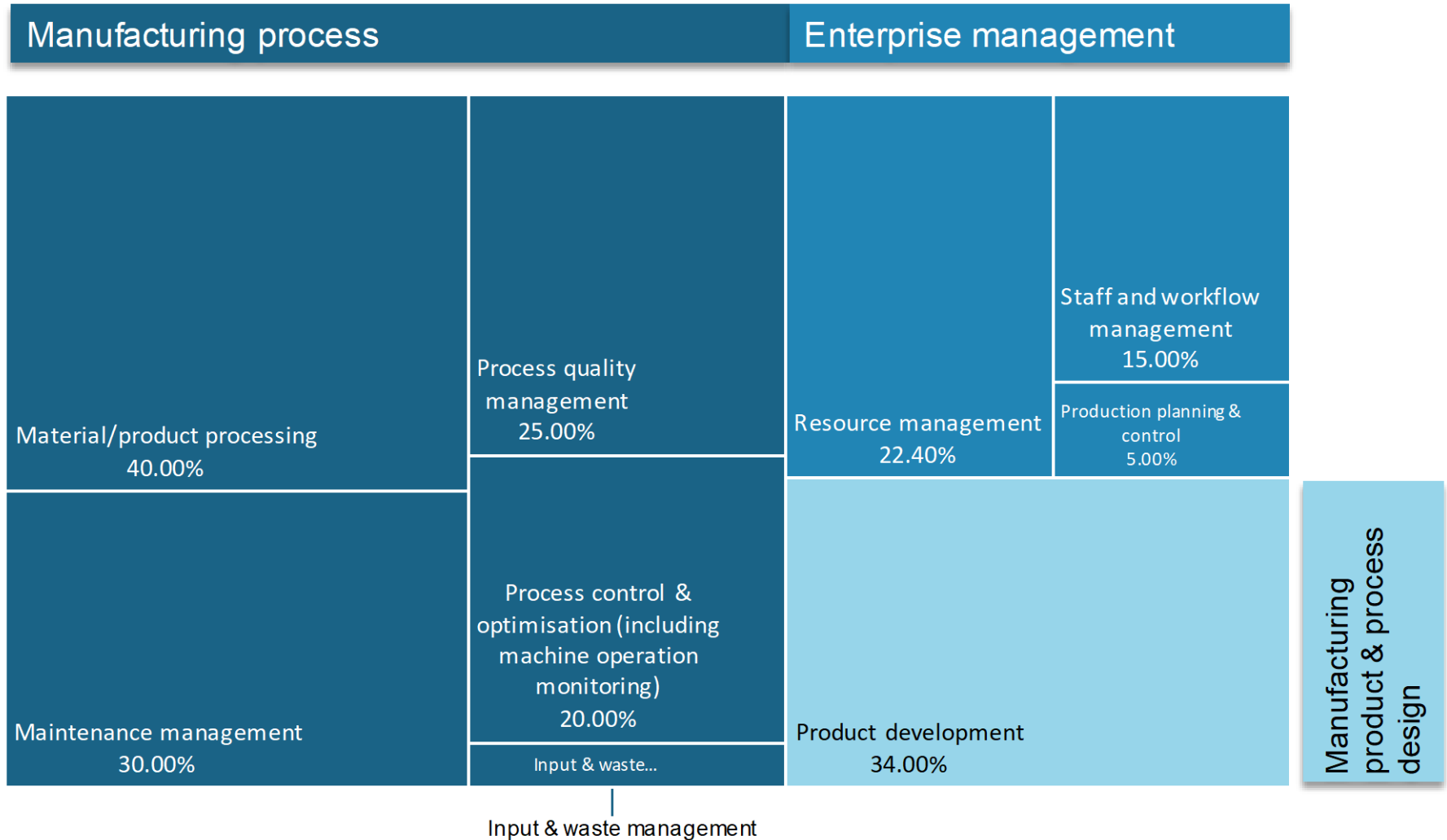
IMPACT ACHIEVED BY FIRMS ADOPTING DIGITAL APPLICATIONS & SOLUTIONS

BUSINESS VALUE VARIABLE: REDUCTION OF DEFECTS AND ERRORS



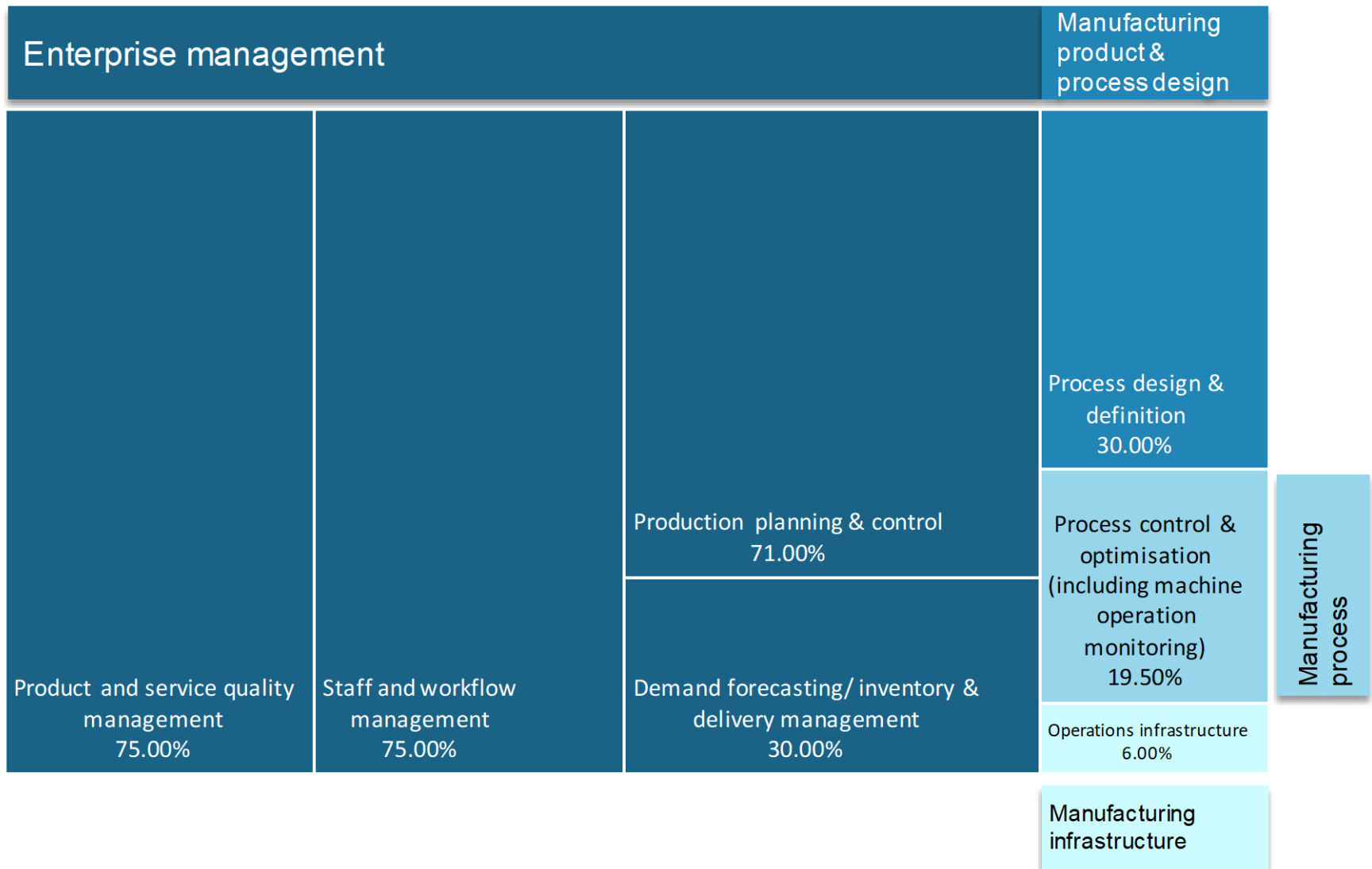
IMPACT ACHIEVED BY FIRMS ADOPTING DIGITAL APPLICATIONS & SOLUTIONS

BUSINESS VALUE VARIABLE: REDUCTION OF ENERGY COSTS



IMPACT ACHIEVED BY FIRMS ADOPTING DIGITAL APPLICATIONS & SOLUTIONS

BUSINESS VALUE VARIABLE: IMPROVEMENT OF DELIVERY & SERVICE PERFORMANCE





(3) 'HEATMAPS'

HEATMAPS

Heatmap 1: Prevalence of applications

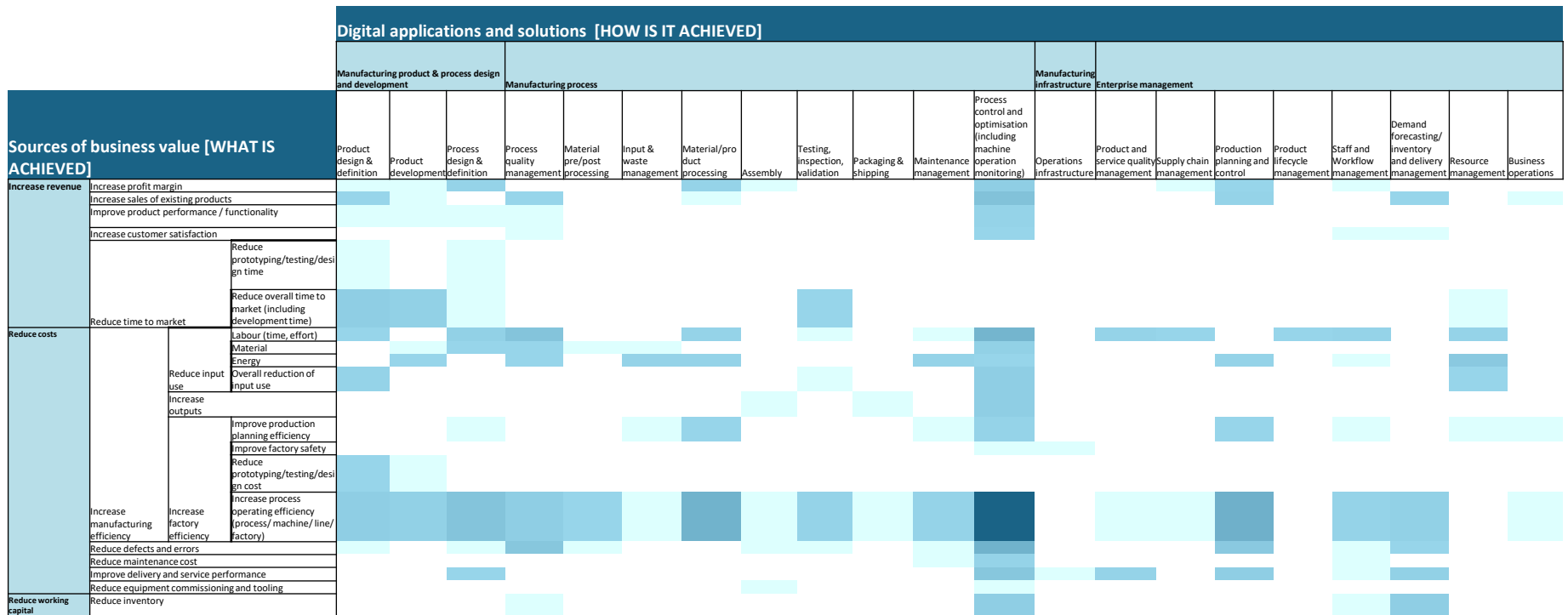
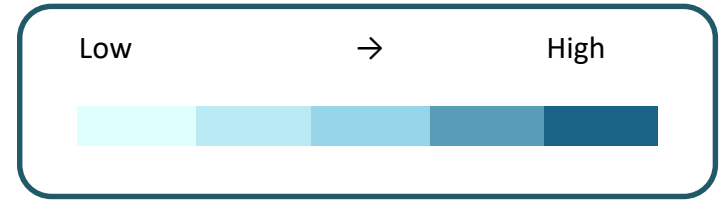
Tells us how often an application led to an impact on a particular type of business value

Heatmap 2: Relevance of applications

Tells us how big the impact of an application was for each type of business value

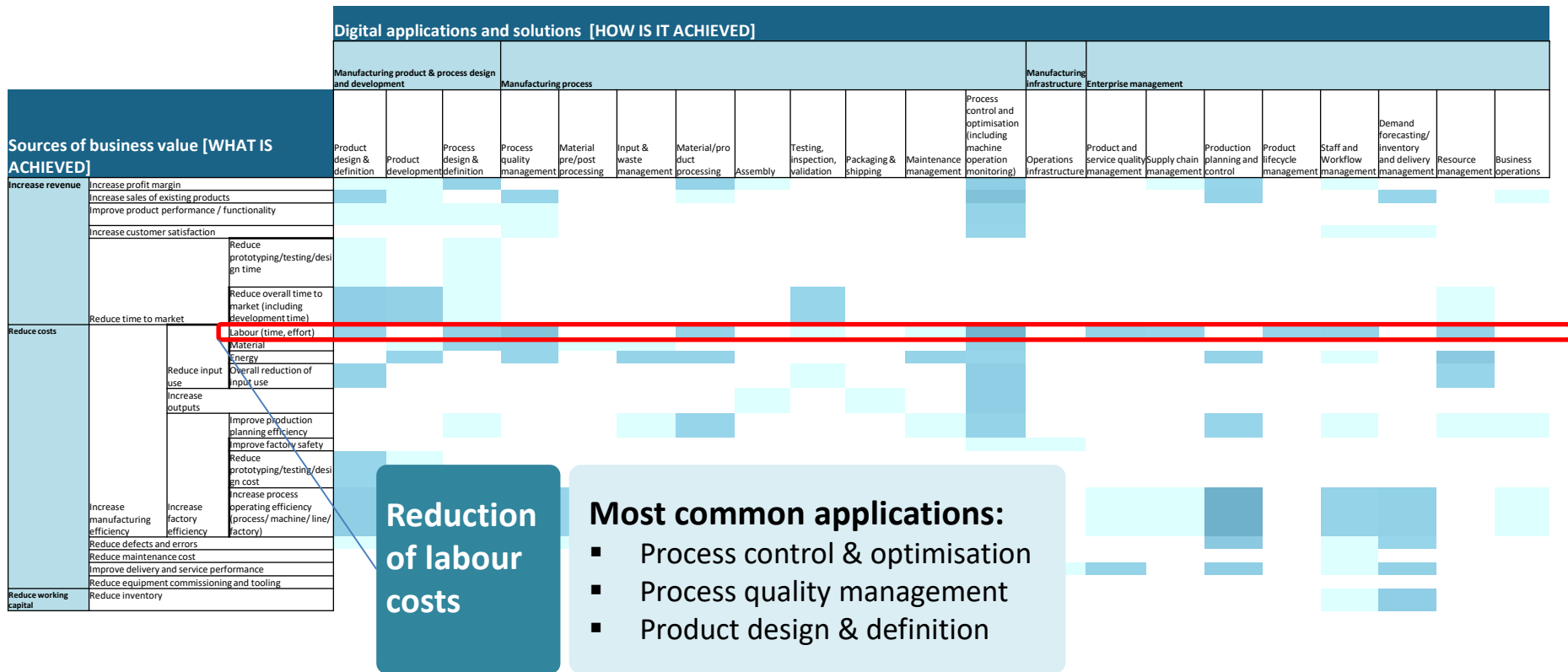
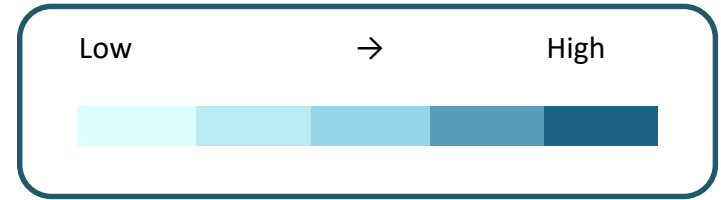
HEATMAPS (EXAMPLE: LABOUR COSTS)

Heatmap 1: Prevalence of applications



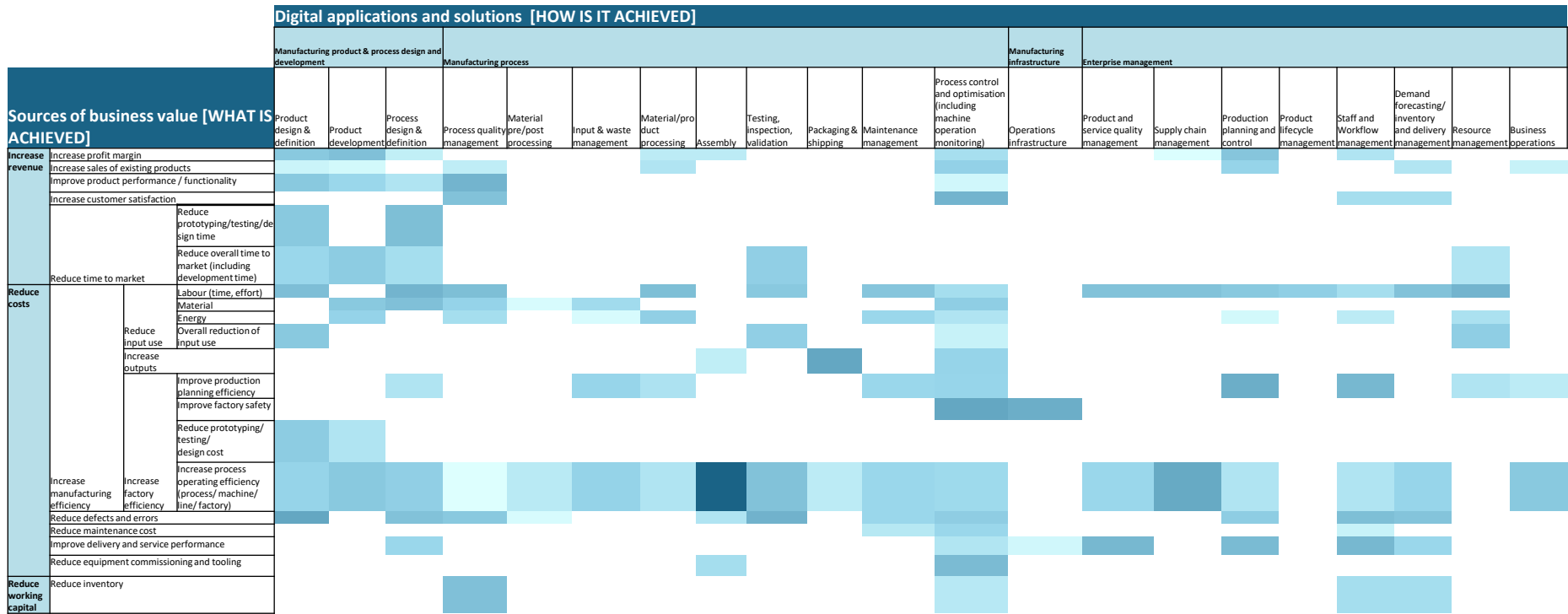
HEATMAPS

Heatmap 1: Prevalence of applications



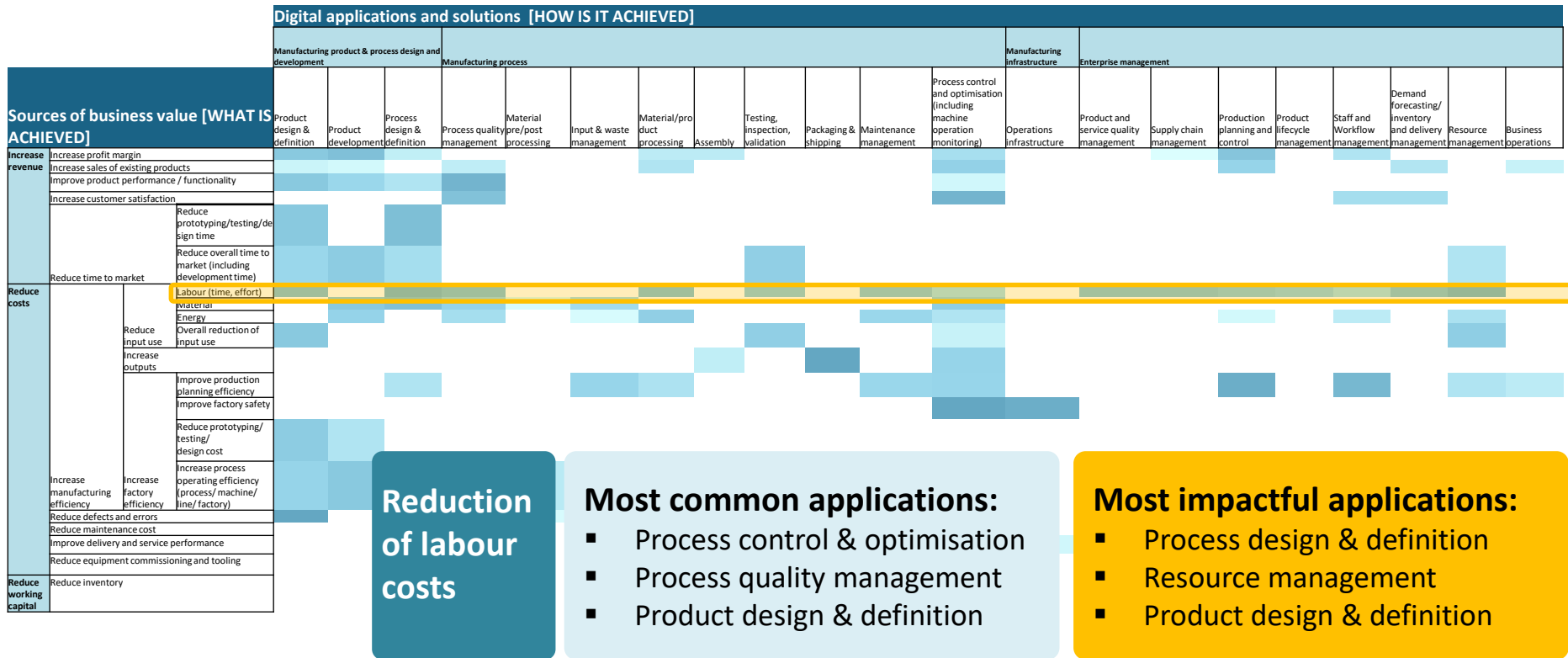
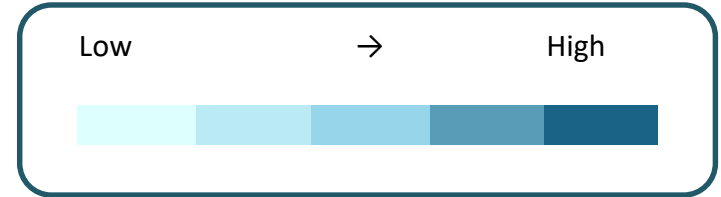
HEATMAPS

Heatmap 2: Relevance of applications



HEATMAPS (EXAMPLE: LABOUR COSTS)

Heatmap 2: Relevance of applications



'DEEP DIVES': APPLICATIONS THAT LED TO THE IMPACT IN TOP 5 BUSINESS VALUE AREAS

Reduction of labour costs

Key applications

- Process design & definition
- Resource management
- Product design & definition

Reduction of defects and errors

Key applications

- Product design & definition
- Staff and workflow management
- Process design & definition

Reduction in material costs

Key applications

- Process design & definition
- Product development
- Process control and optimisation

Increase outputs

Key applications

- Packaging & shipping
- Process control and optimisation
- Assembly

Improved delivery & service performance

Key applications

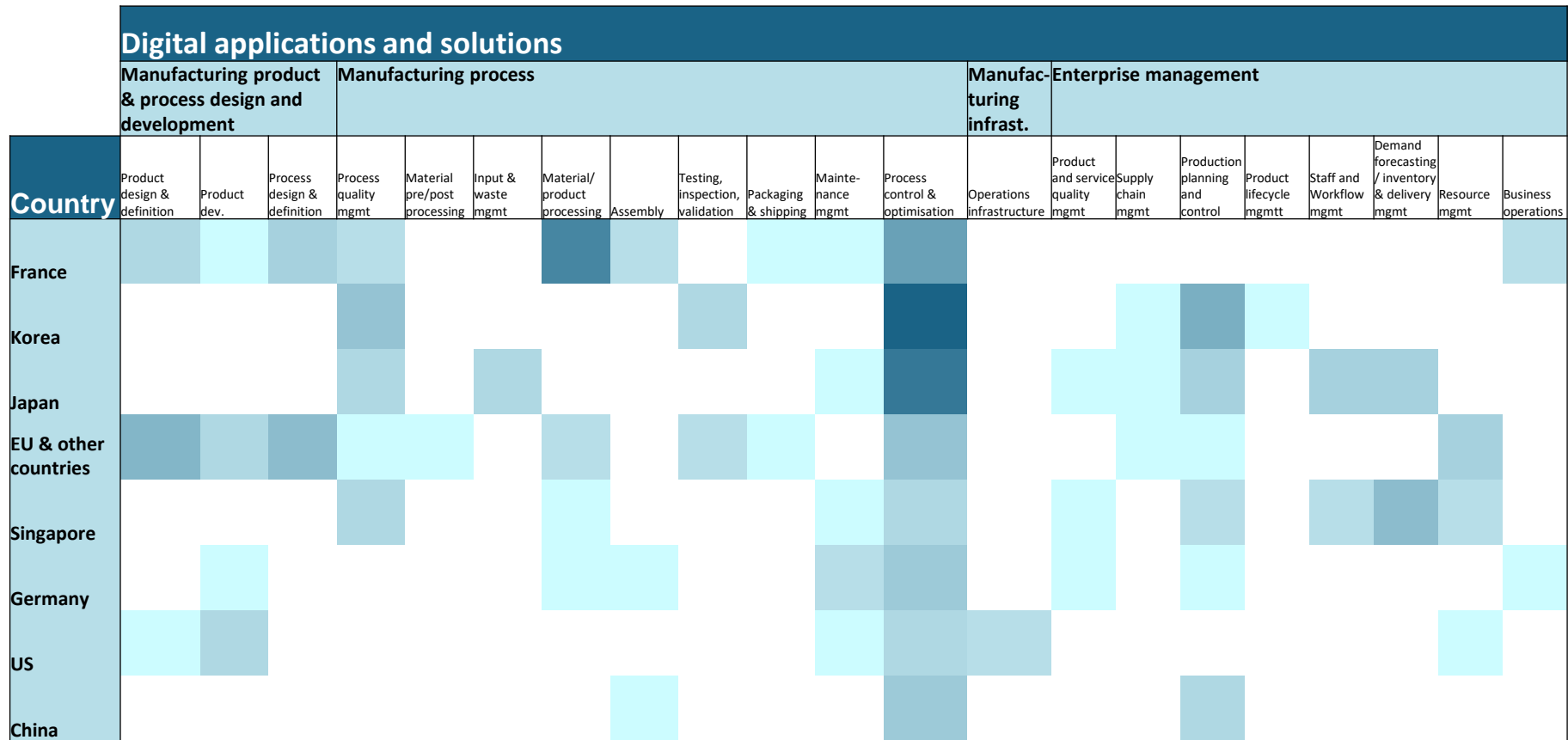
- Staff and workflow management
- Product & service quality management
- Production planning & control



ANALYSIS BY COUNTRIES

ANALYSIS BY COUNTRIES

USE OF APPLICATIONS & SOLUTIONS ACROSS COUNTRIES



Policy Links, 2018

'DEEP DIVES': COUNTRIES AND APPLICATIONS

HOW EACH COUNTRY ACHIEVED BENEFIT – KEY APPLICATIONS

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*

*Same position as Material/product processing, Assembly, Product and service quality management, Production planning and control, Business operations

US

- Product development
- Process control and optimisation
- Operations infrastructure

China

- Process control and optimisation
- Production planning and control
- Assembly

RESULTS

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

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



DISCUSSION AND CONCLUSIONS

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

[1] KIET (2017). The Influences & Challenges of the Fourth Industrial Revolution on Korean Major Industries. Korea Institute for Industrial Economics & Trade.

■ 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.)?

RELEVANCE

- **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

REFERENCES

- [1] DMDII (2015) [The Digital Manufacturing and Design Innovation Institute \(DMDII\)](#).
- [2] DMDII (2016) [Digital Manufacturing and Design Innovation Institute \(DMDII\)](#)
- [3] UILABS (ND) [DMDII](#).
- [4] UILABS (ND) [IMPACT. Omative systems is making standard machines smarter.](#)
- [5] UILABS (ND) [IMPACT. ROI for Illinois manufacturers: Two cases.](#)
- [6] DMDII (2017) [Strategic Investment Plan 2018.](#)
- [7] Scale AI (2018) [SCALE AI](#).
- [8] Government of Canada (2018) [Canada's new superclusters](#)
- [9] Canada's Digital Technology Supercluster (2017) [Business Plan. Canada wise, Global impact.](#)
- [10] AMGC (2017) [Advanced Manufacturing Growth Centre Sector Competitiveness Plan 2017.](#)
- [11] AMGC (2018) [Advanced Manufacturing. Building Resilience in Australian Manufacturing.](#)
- [12] FFG (ND) [Production of the Future – the Programme.](#)
- [13] [European Commission \(2017\) Austria: Plattform Industrie 4.0](#)
- [14] FFG (2015) [Production of the Future.](#)
- [15] European Commission (2017) [Germany: Industrie 4.0.](#)
- [16] Platform Industry 4.0 (2017) [Fortschrittsbericht.](#) BMWi
- [17] BMWi (2018) [What does Industry 4.0 mean for Germany?](#)
- [18] Mattauch, W. (2017) [Digitising European Industries - Member States Profile:Germany.](#)
- [19] Ezell, S (2018) [Why Manufacturing Digitalization Matters and How Countries Are Supporting It.](#) ITIF.
- [20] Platform Industry 4.0 (2017) [Progress Report.](#) BMWi
- [21] Ministerio de Economía, Industria y de Competitividad (2017) [Industria Conectada 4.0: Digital Innovation Hubs.](#)
- [22] Secretaría General de la Industria y de la Pyme (2018) [Estrategia Industria Conectada 4.0.](#)
- [23] A*STAR (2017) [Report on Future of Manufacturing Initiative](#)
- [24] EDB Singapore (2018) [Advanced Manufacturing: Singapore's smart factory future.](#)
- [25] Ministry of Finance (2016) ["Opportunities for all"](#) in Singapore Public Sector Outcomes Review.
- [26] SIMTech (2018) [Model Factory @SIMTech.](#)
- [27] EDB Singapore (2018) [Factories of tomorrow, today.](#)
- [28] KIET (2018) [제4차 산업혁명이 주력산업에 미치는 영향과 주요 과제](#)
- [29] McKinsey (2017) [Digital Australia: Seizing the opportunity from the Fourth Industrial Revolution.](#)
- [30] ITA- U.S. Department of Commerce (2017) [Japan – Advanced Manufacturing.](#)
- [31] Government of Canada (2018) [Advanced Manufacturing Supercluster.](#)
- [32] Sommer, R. (2016) [Association Industry 4.0 Austria – the Platform for Smart Production.](#) Industrie 4.0 Österreich.
- [33] PWC (2016) [Industry 4.0 – The Industrial Internet. Opportunities and challenges for the Austrian industrial sector.](#)
- [34] Ministry of Trade, Industry and Energy (2015) [A roadmap for smart manufacturing R&D to be announced.](#)
- [35] Ministry of Trade, Industry and Energy (2018) [Korea capitalizes on future industries for innovation growth.](#)
- [36] Molnar, M (2018) [Manufacturing USA and DMDII Program Update and Activities in PHM](#)
- [37] Australian Government (2018) [Industry, Innovation and Science: Regional Australia—A Stronger Economy Delivering Stronger Regions 2018–19](#)
- [38] The Headquarters for Japan's Economic Revitalization (2015) [New Robot Strategy.](#)
- [39] MET, MHLW and MEXT (2015) [Summary of the White Paper on Manufacturing Industries \(Monodzukuri\)](#)
- [40] METI (2017), [FY2018 Initial Budget and FY2017 Supplementary Budget](#)

CONTACT DETAILS

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		<ul style="list-style-type: none"> • Increased turnover • Improvement of the profit margin • Improved operating margin
	Increase sales of existing products		<ul style="list-style-type: none"> • Increase sales of spare parts • Exports growth • Increased sales/ Sales growth
	Improve product performance / functionality		<ul style="list-style-type: none"> • Improvement of combustion efficiency • Reduction of boiler's size (Product improvement) • Increased life of stamping die
	Increase customer satisfaction		<ul style="list-style-type: none"> • Increased customer service level • Decreased number of complaints • Reduction of claims
		Reduce prototyping/testing/design time	<ul style="list-style-type: none"> • Reduction of wind tunnel and physical testing • Reduced simulation
		Reduce overall time to market (including development time)	<ul style="list-style-type: none"> • Reduction of time to market • Reduction of development time • Reduction of testing effort
	Reduce time to market		

A) EXAMPLE INDICATORS IN EACH BUSINESS VALUE TYPE

Reduce costs		Labour (time, effort)	<ul style="list-style-type: none"> • Reduced manpower time for documentation • Reduced manpower • Save time & effort
		Material	<ul style="list-style-type: none"> • Reduction in material use • Reduction of scrap rate • Reduced use of (supplementary) materials
		Energy	<ul style="list-style-type: none"> • Reduced electricity costs • Reduced energy use/consumption • Reduction of gas consumption
			<ul style="list-style-type: none"> • Reduction of resources consumption (energy, water and detergent) • Decreased product cost • Reduction of resources
	Reduce input use	Overall reduction of input use	
		Increase outputs	<ul style="list-style-type: none"> • Increase daily production • Increased production capacity • Improved throughput of production line
		Improve production planning efficiency	<ul style="list-style-type: none"> • Improved project resource allocation and utilisation • Accuracy of production plan • Reduced production (planning) cycles
		Improve factory safety	<ul style="list-style-type: none"> • Decrease of industrial accident rate • Reduction of alarm rate
		Reduce prototyping/testing/design cost	<ul style="list-style-type: none"> • Decrease of testing cost • Decrease of design cost • Decrease of prototyping cost
	Increase manufacturing efficiency	Increase factory efficiency	Increase process operating efficiency (process/ machine/ line/ factory)

A) EXAMPLE INDICATORS IN EACH BUSINESS VALUE TYPE

Reduce costs	Reduce defects and errors	<ul style="list-style-type: none"> • Reduction of defect rate • Reduction of human related errors • Reduction of process failure rate
	Reduce maintenance cost	<ul style="list-style-type: none"> • Reduced maintenance cost • Decreased cost of renewing insurance premiums
	Improve delivery and service performance	<ul style="list-style-type: none"> • Increase delivery & pick-ups per trip • Improved delivery lead time • Increased on-time delivery
	Reduce equipment commissioning and tooling	<ul style="list-style-type: none"> • Reduction of commissioning and retooling of production systems • Reduction of commissioning time
Reduce working capital	Reduce inventory	<ul style="list-style-type: none"> • Reduction in inventory and inventory management • Reduced intermediate stock • Reduction of WIP inventory

B) EXAMPLE APPLICATIONS PER CATEGORY

Manufacturing product & process design	Product design & definition	<ul style="list-style-type: none"> • Optimised sports car aerodynamics • Cloud-based design of high-pressure vessels • Cloud-based simulation of high-temperature concentric chimneys
	Product development	<ul style="list-style-type: none"> • HPC-Cloud-based design of copper-alloy moulds • Cloud-based optimisation of water turbines for power generation • Simulation Computer Assisted Analysis (CAD) and Product Lifecycle management (PLM)
	Process design & definition	<ul style="list-style-type: none"> • Additive manufacturing for improving gearbox production • HPC-Cloud-based simulation of steel casting • Plant Simulation: Optimization of Steel Structure Manufacturing

B) EXAMPLE APPLICATIONS PER CATEGORY

Manufacturing process		<ul style="list-style-type: none"> • Process simulation through Numerical Simulation Software and 5-axis milling centre • Production Management System (ERP) and Automation of Administrative Tasks
	Process quality management	<ul style="list-style-type: none"> • On-site quality control and integrated management of inspection
	Material pre/post processing	<ul style="list-style-type: none"> • Robotic mould finishing process
	Input & waste management	<ul style="list-style-type: none"> • Machine Standby Status Control • Optimised Energy Management • Cloud-type Energy Monitoring System
	Material/product processing	<ul style="list-style-type: none"> • Production Tool Optimisation (ROBOT Start PME Systems and a 6-axis welding) • Robotic integration for cutting, marking and welding tools • Integration of Processes Systems by connecting a welding robot and flow machine for optimised aluminium cutting
	Assembly	<ul style="list-style-type: none"> • Automated Assembly Line • Automated Process through integration of 2 robots and two 3-axis machining centres • Manufacturing with modular design principle - Flexible assembly line with integrated robotics
	Testing, inspection, validation	<ul style="list-style-type: none"> • Vision Inspection Automation • Production management and inspection system • More efficient bridge inspection by using autonomous micro aerial vehicles (MAVS)
	Packaging & shipping	<ul style="list-style-type: none"> • Automated palletising, fleet management software and tool breakage control laser
	Maintenance management	<ul style="list-style-type: none"> • Numerically controlled robot with laser search application • Predictive Maintenance • Predictive Maintenance and Machine Operation Monitoring
	Process control and optimisation (including machine operation monitoring)	<ul style="list-style-type: none"> • Yield Monitoring • Machine Automation Controller System • Production Process Optimization - Integrated Data Management System

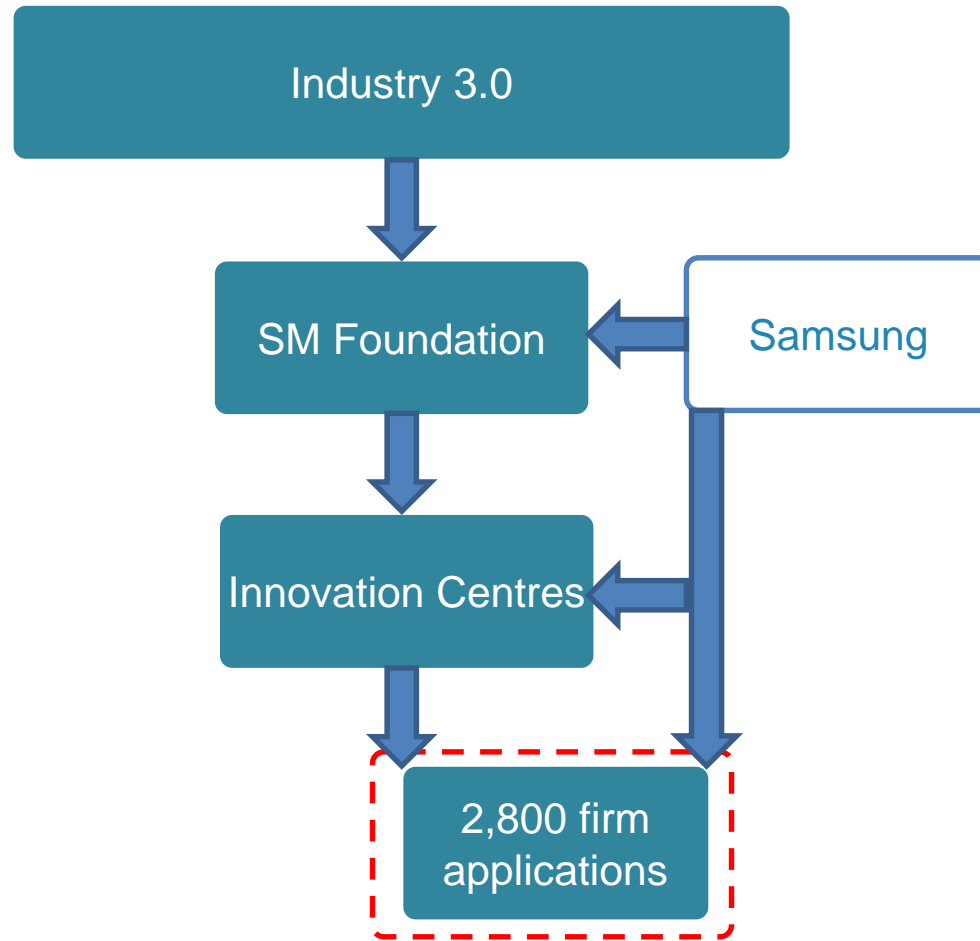
B) EXAMPLE APPLICATIONS PER CATEGORY

Manufacturing infrastructure	Operations infrastructure	<ul style="list-style-type: none"> • Wireless network and IoT technology for video surveillance, physical access control, communications and temperature monitoring
Enterprise management	Product and service quality management	<ul style="list-style-type: none"> • Remote Real-time and On-demand Maintenance Services • Automatic Order Processing integrated with CAD files automatically generated • Electronic Form Creation, Tracking and Report Generation
	Supply chain management	<ul style="list-style-type: none"> • Integrating Supply Chain Information System • Simulation, production and marketing optimization (from procurement to delivery to the customer, end-to-end integration)
	Production planning and control	<ul style="list-style-type: none"> • Real-time visualisation of Production Information across different processes • Production Systems Data Aggregation and Optimisation of Visualisation and Analysis • Digital Planning Board and Mobile Production Management
	Product lifecycle management	<ul style="list-style-type: none"> • Product Lifecycle Management - Real-time drawing history management
	Staff and Workflow management	<ul style="list-style-type: none"> • Resource Optimisation - Manpower Scheduling • Management of Staff's workflow • Monitoring and analysis of machine operation and staff's productivity
	Demand forecasting/ inventory and delivery management	<ul style="list-style-type: none"> • Last Mile Logistics Management • Collection & Delivery Management System (CDMS) • Resource Optimisation - Inventory Planning
	Resource management	<ul style="list-style-type: none"> • Project Resource Management System (PRMS) • Resource Optimisation - Energy Efficient Monitoring and Analysis • The Impact of IoT on Smart Farming and Water Usage Efficiency
	Business operations	<ul style="list-style-type: none"> • Collaborative Data Management and Sharing between Suppliers and Customers • Integrated Customer-Supplier Relationships through ERP and standardisation of CAD software

APPENDIX 2: OVERVIEW OF SELECTED INITIATIVES

- Korea
- Singapore
- US

CASE STUDY: KOREA



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**.



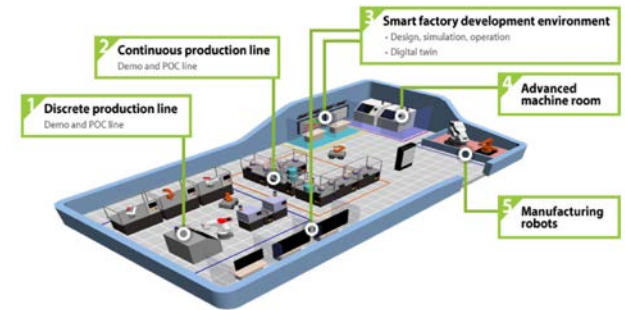
KOREA-SMART FACTORY

- 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.



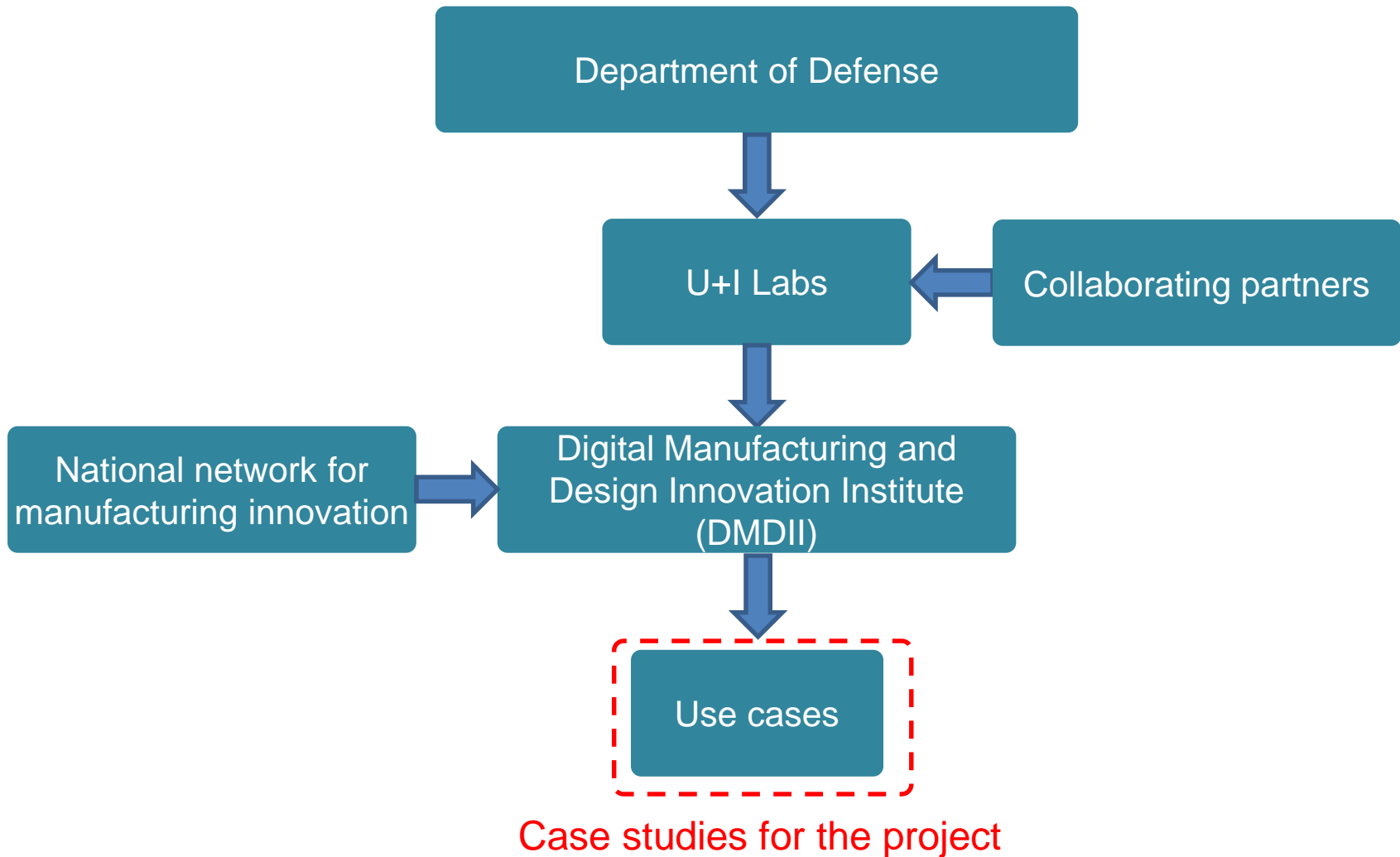
KOREA-SMART FACTORY

Demo Factory



- 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.

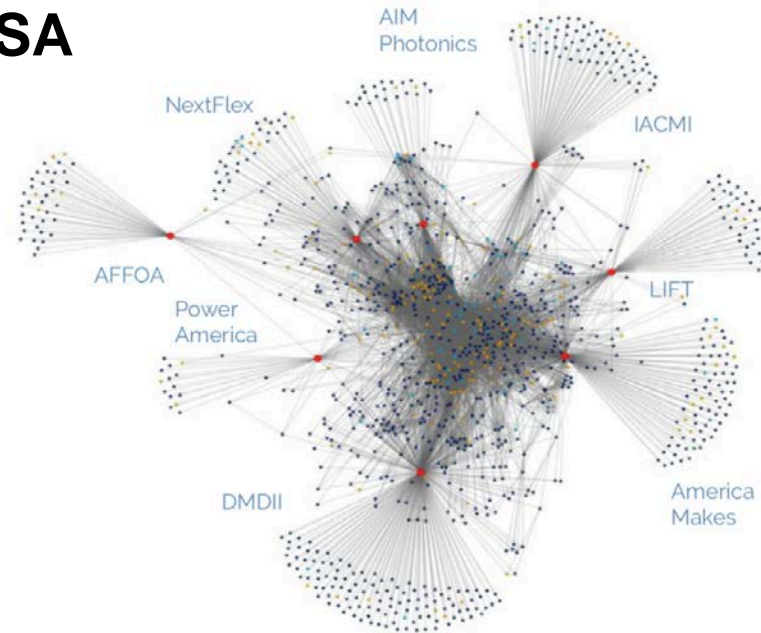
CASE STUDY: US



US – MANUFACTURE USA

Aim

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



9,424

Relationships between organizations

1,174

Organizations involved with the program

753

Organizations with formal membership

203

Organizations have relationships with multiple institutes

120

Organizations are members of more than one institute

Link to report

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.

US-DMDII

- U+I Labs is a 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 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.**



DMDII

DIGITAL MANUFACTURING AND
DESIGN INNOVATION INSTITUTE

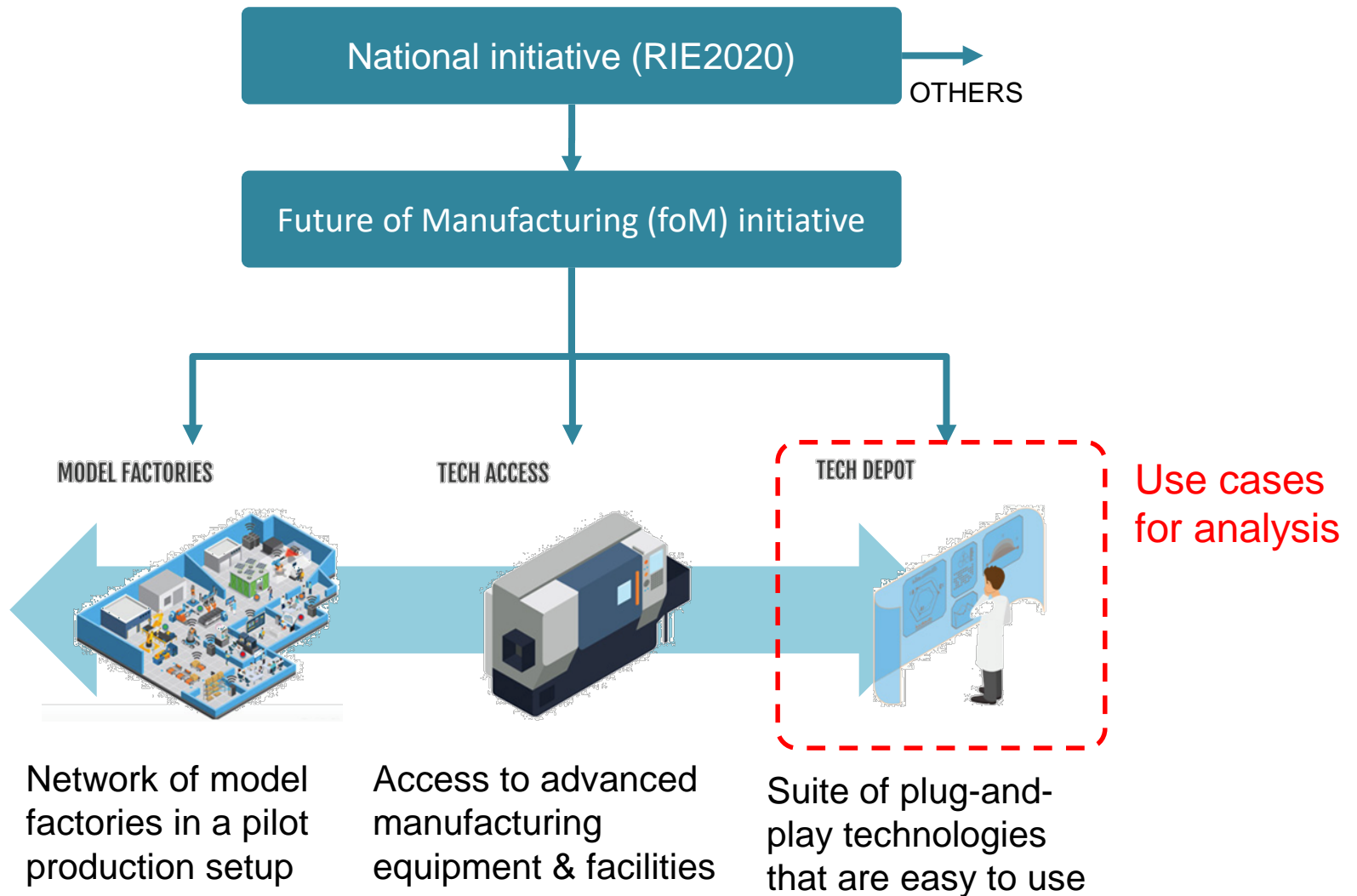
US-DMDII'S *DIGITAL CAPABILITY CENTRE*

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 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.



CASE STUDY: SINGAPORE



SINGAPORE – DIGITAL TECHNOLOGY DEPLOYMENT

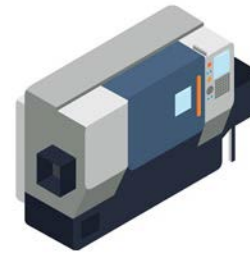
Three key ‘thrusts’:

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](#)

SINGAPORE – A*STAR’S FUTURE OF MANUFACTURING INITIATIVE

TechDepot.

- 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:



<https://www.smeportal.sg/content/tech-depot/en/home.html>

SINGAPORE – A*STAR’S FUTURE OF MANUFACTURING INITIATIVE

Tech Access

In support of firms’ innovation efforts, Tech Access:

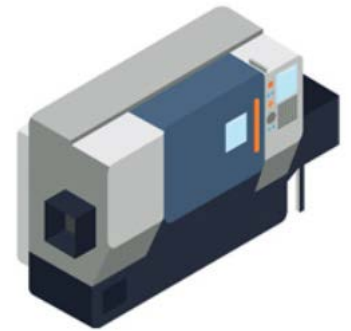
- Provides SMEs, access to A*STAR’s installed base of advanced manufacturing equipment/facilities as well as expertise; and
- Enables learning, experimenting, prototyping with the primary aim of eventual deployment of advanced technologies in the firms.

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.

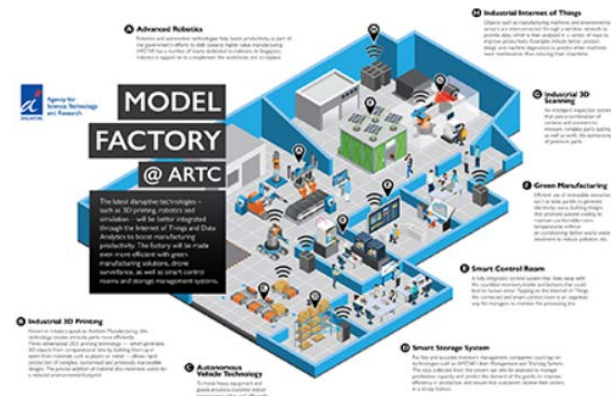
TECH ACCESS



SINGAPORE – A*STAR'S FUTURE OF MANUFACTURING INITIATIVE

Model Factory

- 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.



<https://www.a-star.edu.sg/News-and-Events/A-STAR-INNOVATE/Index/Embracing-transformation-Factories-of-the-Future>



TechDepot. A*STAR'S FUTURE OF MANUFACTURING INITIATIVE

- Centralised platform for SMEs aimed at improving access to technology and digital solutions.
- 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>