Kainuu region action plan

7.11.2021

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Reference information

Table 1 Kainuu action plan reference information

Project Acronym	INNO PROVEMENT
Project Title	Translating Industry 4.0 to improved SME policy instruments targeting innovation
Index Number	PGI05280
Activity	Interregional Policy Learning
Partner	Regional Council of Kainuu, PP8
Deliverable title	Action Plan for the integration of Industry 4.0 into the Kainuu RIS3.
Version	Version 10
Status	Draft
Authors	Responsible: Jouni Ponnikas Project team alphabetically: Chaniotou N., Leinonen M., Moilanen K.

1 Introduction

Industry 4.0 is 'the comprehensive transformation of the whole sphere of industrial production through the merging of digital technology and the internet with conventional industry'[1]. It is a term applied to a group of rapid transformations in the design, manufacture, operation and service of manufacturing systems and products. The 4.0 designation signifies that this is the world's fourth industrial revolution, the successor to three earlier industrial revolutions (Table 2) that "caused quantum leaps in productivity and changed the lives of people throughout the world[2]".

Table 2 Industrial revolutions[3]

	Time periods	**Technologies and capabilities**
First	1784-mid 19th century	Water- and steam-powered mechanical manufacturing
Second	Late 19th century -1970s	Electric-powered mass production based on the division of labour (assembly line)
Third	1970s-Today	Electronics and information technology drives new levels of automation of complex tasks
Fourth	Today-	Sensor technology, interconnectivity and data analysis allow mass customisation, integration of value chains and greater efficiency

Industry 4.0 is crucial for the re-industrialisation of the EU because it reduces production costs, increases effectiveness of product delivery, and allows customisation of products. For example, the first generation 3D-printed homes, already realised in New York, shows production costs reduced by 50%, while for constructing flats totalling 1900m2, it required 8 mandays. Automated solutions applied, merged 20 different professional skills in total[4]. To be able to be part of such ventures, Industry 4.0 implies opportunities and demands on SMEs[5].

In March 2016, EC's Strategic Policy Forum on Digital Entrepreneurship delivered its final policy recommendations, urging action on what it considers the most critical needs of European businesses. This includes the need for cyber-security, high-performing infrastructures, a Single Market for European data,

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1 , p2.

2 , pp2-3.

3 , p3.

4 and

5 Ibid., above, page 2: "...new innovation models for local production systems and the increase in reshoring. ... More specifically, such location decisions can relate to the adaptation of a reshoring strategy, which involves bringing back the manufacturing activity (or part of it) from a foreign market to a home market" (p35).

DILETTA Pegoraro, D., PROPRIS, L.de, and Ch. A. (2020). De-globalisation, value chains and reshoring; in Propris and Bailey eds., 2020. "9.5 Some evidence of de-globalisation: In this section we piece together evidence on de-globalisation by looking at three trends: 1) recent trends in FDI3 in terms of volume, geography, sector and operations; 2) the current reorganisation of GVC into shorter and more compact value chains; and 3) current firms' strategies to reshore production functions back to the home economy". P171. See page 187 for a summary for the forms of re-shoring and the steps.

actions to reskill our workforce, and building up innovative ecosystems to take advantage of the digital revolution ( ). The objective of the set of measures presented was to support and link up national initiatives for the digitisation of industry and related services across all sectors and to boost investment through strategic partnerships and networks. Concrete measures were proposed to speed up the development of common standards in priority areas, such as 5G communication networks or cybersecurity, and to modernise public services (European Commission 2016b).

In relation to the digitisation of industry, suggestions included inter alia: coordination between national and regional initiatives on digitising industry; focus on EU public-private partnerships; establish, operate and maintain a pan-EU network of digital innovation hubs (centres of excellence in technology); set up of large-scale pilot projects to strengthen the internet of things (IoT), advanced manufacturing and technologies in smart cities and homes, connected cars or mobile health services; adopt future-proof legislation that will support the free flow of data and clarify ownership of data generated by sensors and smart devices; an EU skills agenda that will help give people the skills needed for jobs in the digital age; priority standards to boost digital innovation (by (i) focusing on five priority areas, when asking industry and standardisation bodies to work on standards. These areas are: 5G, cloud computing, internet of things, data technologies and cybersecurity and (ii) co-financing the testing and experimentation of technologies to accelerate standards setting including in relevant public-private partnerships. This will ensure timely delivery of standards to spur innovation and business growth; digital public services including the development of cross-border e-health services such as e-prescriptions and patient summaries.

These recommendations, while essential, require time to be absorbed and especially benefit smaller and medium sized companies. Both early and later research indicate challenges the adoption of I4.0 poses to such types of firms.

For example, SMEs often do not see the clear benefits from I4.0 -i.e. benefits are not convincingly high[6], they are hesitant because of the costs I4.0 implies -in some cases it was found that costs increased instead of decreased[7], they are also hesitant about the organisational and contextual changes, costs and risks they imply: "Building a complex value network that can produce and distribute products in a flexible fashion means business leaders must accept to change and partner with other companies – not only suppliers and distributors of a product, but technology companies and infrastructure suppliers such as telecoms and internet service providers"[8]. It has also been remarked that Industry 4.0 has been presented to SMEs more often as a technological rather than an operational solution: "This technological primacy has contributed to creating a climate of mistrust and concern amongst businesses, especially amongst small and medium-sized firms which cannot fully understand the potentials that such technologies present to them. Therefore, it is crucial to shift the debate on I4.0 from the mere technological aspects to a more systemic vision"[9]. Therefore,

[6] Digital Transformation Scoreboard, p20.

[7] Digital Transformation Scoreboard, p20.

[8] , p5.

[9] Corò, G. and Volpe, M. (2020). Driving factors in Industry 4.0 adoption, an investigation of SMEs. In Propris and Bailey eds., 2020. Page 135: "These doubts also arose from the way in which I4.0 was presented to companies with a strong emphasis placed on the adoption of, for instance, robotics, sensoring and relatively high-cost technologies, which small businesses have

to capture all the potential value that digital transformation can add, it is necessary for a business to be able to broaden its horizons and look beyond technological considerations[10].

2 General Information

2.1 Kainuu region

Kainuu is one of the 19 regions of Finland. It has an area of 22,687 km², and 72 506 inhabitants (31.12.2019), 1,3 % of Finland. It is located 568km from Helsinki and 181 km from Oulu ( ). It is classified as a NUTS3 region, FI1D4. Kainuu's share of Finland's population is 1,3 %. Share of employees is a bit lower, 1,2 %. Share of GDP is 1,0 % (2,3 billion €, 2017)[11].

Kainuu borders the regions of North Ostrobothnia, North Savo and North Karelia. In the east, it also borders Russia. Boreal forest makes up most of the Kainuu, with forested area about 95% of the region's total ( ).

The region is administratively organised into eight (8) municipalities: Kajaani (capital area), Paltamo, Puolanka, Suomussalmi, Hyrynsalmi, Ristijärvi, Sotkamo and Kuhmo, Figure 2.

[12]Kainuu has 27 194 employees (31.12.2017) of which 8,9 % are employed in agriculture and mining (Finland 3,1 %), 15,5 % in processing (Finland 20,8 %) and 75 % in services in both areas. Processing is on average clearly more productive than services, but variety between industries is significant. Of all employed people in Kainuu 9,9 % are entrepreneurs, exact same number as in Finland on average. The highest level of entrepreneurs is in agriculture (half of employed are entrepreneurs), whereas in manufacturing industry only 5 % are entrepreneurs. In construction the share is 14 % and in services between 3-28 % (lowest in health and social services, highest in other services).

Growth of investments was during 2010-2017 125,1 % in Finland and 112,3 % in Kainuu nominally. Level of investments was 587 million € in 2017 and it was 1,1 % of Finland´s investments, a bit lower than share of population.

GDP per capita was in 2017, 31 167 €. Nominal GDP per capita has grown in Finland 17 % during 2010-17 and in Kainuu 25 %. In this sense, Kainuu was catching up, since Kainuu per capita is considerably lower than in the rest of Finland, so the situation has gotten better during last decade.

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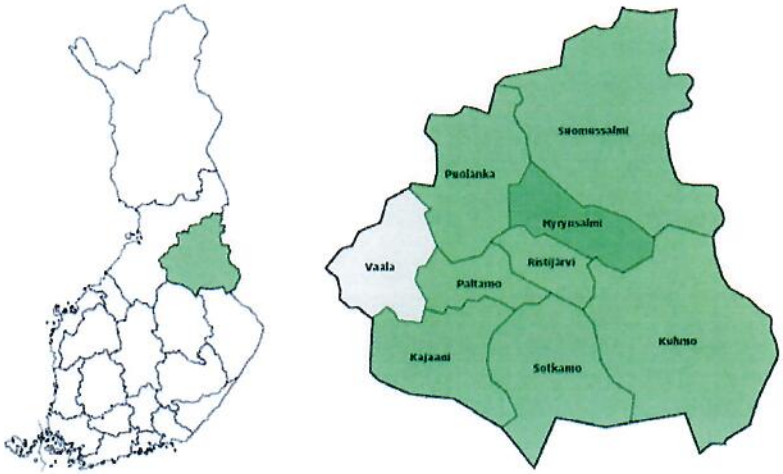
struggled to recognize as relevant for them, given the business model that has characterized their competitive advantage for years."

[10] Corò, G. and Volpe, M. (2020). Driving factors in Industry 4.0 adoption, an investigation of SMEs. Page 151. In Propris and Bailey eds., 2020.

[11] Source for these inputs from the research made for the revision of the Kainuu RIS3, Spring 2020; inputs by Jari Kaivo-Ajo.

[12] Source for the economic inputs from the research made for the revision of the Kainuu RIS3, Spring 2020; inputs by Jari Kaivo-Ajo.

Figure 1 Kainuu in Finland and administrative structure.



Source: https://investinkainuu.com/working-with-us/about-kainuu/)

2.2 Contact details

Table 3 Contact details

Project partner information	
Partner organization	Kainuu region
Country	Finland
NUTS2 region	FI 1D
Contact person	Jouni Ponnikas
Position	Department of Regional Development
E- mail	jouni.ponnikas@kainuu.fi
Phone number	(+358) 40 5740804

3 Policy context

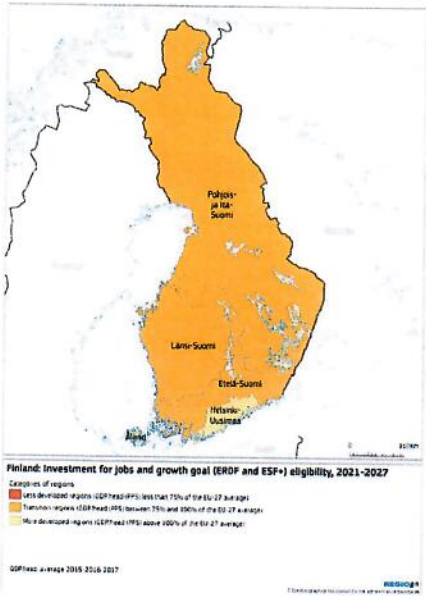
3.1 Policy instrument impact

Table 4 The action plan aims to impact

Project partner information		
Investment for Growth and Jobs programme, name of policy instrument here Kainuu RIS3 2021 - 2027		Yes
Type 1: Implementation of new projects Implementation of Industry 4.0 projects in the Kainuu SF 2014-2020. Provisions have been made to have implementation options open also for the new period of the SF through the Kainuu RIS3 2021-2027.	Yes	
Type 2: Change in the management of the policy instrument (governance) Integration of Industry 4.0 into the Kainuu RIS3.	Yes	
Type 3: Change in the strategic focus of the policy instrument	No	
Other improvements not corresponding to types 1-3 (please comment)	No	
European Territorial Cooperation programme		No
Other regional development policy instrument, name of policy instrument here		No

3.2 Policy instrument addressed

Sustainable growth and jobs 2014 - 2020 - Finland's structural funds programme', North-East Finland, Kainuu (CCI number: 2014FI16M2OP001[13]). Sustainable growth and jobs 2014 - 2020 - Finland's structural funds programme has 5 priority axes and 13 specific objectives (Total budget 2,598,922,190 €). Kainuu, NUTS3 has an ESIF budget ERDF 20 million€ (9€ support to SMEs, 11m€ production of new knowledge) and 12m€ ESF (6m€ for education and skills), (both from https://www.eura2014.fi/rrtiepa/?lang=en). INNO PROVEMENT's focus is relevant to ESIF's thematic objectives (TOs) TO1, TO3, and TO10. TO1: Investments promoting R&I activities; especially in growth companies and start-ups in chosen smart specialization fields; ~24% of programme is de dicated to TO1. TO1 is related to the small gaming cluster in Kainuu that can become part of Industry 4.0 service providers. 2) TO3: Improving the competitiveness of SMEs (~20% of the total OP allocations). The investments aim at diversifying business structures and increase the number of growing, innovative and internationally expanding companies, through, e.g. new business operations. TO3 is the main area relevant to the project relating to the metallurgical and wooden construction industries. TO10 is dedicated to Education and training, with 12% of the OP resources dedicated to investments in (among others) reinforcing the professional knowledge, innovative abilities and creative skills of the workforce. TO10 is relevant to the project because, as Industry 4.0 is not yet strongly disseminated in Kainuu, issues of skills and education will need to be part of the action plan.



3.3 Improvement needs of the policy instrument

Kainuu ESIF and RIS3 2018-2020, include the basics for addressing Industry 4.0: One of the 5 priorities of the Kainuu S3 is ICT and information systems, this includes digital transformation, which is the core idea of the industry 4.0. Under digital transformation advanced or high-performance computing, artificial intelligence, cognitive systems, augmented and virtual reality, etc are relevant subdomains. It should be mentioned that Industry 4.0 is highly relevant for the other S3 priorities, e. g. for wood industry with regards to advanced manufacturing systems.

However, as the *Policy instrument assessment report for Kainuu region, Finland*, revealed "As already stated above, Industry 4.0 is unfortunately not a sufficiently developed priority in the current RIS3 of Kainuu." (p29). Kainuu would need, in the future to address:

- Measures promoting Industry 4.0 uptake
- Measures supporting strategies for organisational adjustment and investments required for deploying Industry 4.0 by SMEs

[13] http://ec.europa.eu/regional_policy/en/atlas/programmes/2014-2020/finland/2014fi16m2op001 .

- Measures supporting scaling up to business intermediaries' skills to promote Industry 4.0 dissemination solutions.
- Measures supporting access of Industry 4.0 innovations accessing markets.

3.4 Self-defined indicator

Initial self-defined indicator:

- Number of Industry 4.0 projects, at budget 350 000€ each. Target value: 3 projects, 1 050 000€.

As a result of the Policy instrument assessment report for Kainuu region, Finland, of the thematic document on SMEs and Industry 4.0, the good practice transfer (Industry 4.0, PP1; COMPETE 2000 PP6), and the feasibility study, additional indicators were identified, relevant to the action plan and to the revised. Kainuu RIS3:

- A detailed model for applying I 4.0 to traditional industries including data analytics, and focusing on a digital transformation perspective.
- Qualification in education & skills-training, for creating & maintaining a pool of Industry 4.0 experts and qualified personnel.
- Number of initiatives scaling up to business intermediaries' skills to promote Industry 4.0 dissemination solutions.
- Number of projects supporting Industry 4.0 innovations accessing markets.

4 Background

4.1 The INNO PROVEMENT project

Industry 4.0 (I4.0) affects production processes, business models and innovation activities of companies throughout Europe. Failing to turn production or service provision adapted to I4.0 results in losing clients and markets, and also the potential for accessing markets. Partners' experience suggests that policy instruments (PIs) targeted to SME innovation often struggle to support I4.0 related projects efficiently.

The INNO PROVEMENT project aims at improving policies targeting innovation activities and adapt them to requirements set by I4.0. This overall objective will increase the share and number of SMEs successfully applying for and implementing I4.0 related innovation projects in the partners' regions and countries. The improvements of the addressed policy instruments will take place primarily at the level of their management. Such improvements are expected to be changes in the whole life cycle of fund management: design and setup of calls, project selection, contracting, monitoring methods including checks, financial settlement.

Partners have identified 7 thematic issues during project preparation related to innovation projects belonging to I4.0, which they share as joint concern and at which they see opportunities for improvement through the identification and sharing of good practices. Improving policy instruments in these thematic issues are defined as sub-objectives of the INNO PROVEMENT project. The 7 thematic issues: 1) Innovation in software development (defining innovation, judging the innovation content): what can be accepted as real innovation and what belongs to the regular development activity of the applicant/beneficiary (cf. Frascati and Oslo manual); 2) Effective use of public money to support industrial R&D under the I4.0 (analysing I4.0 projects with similar outputs but with significantly different costs); 3) Introducing I4.0 to traditional industries; 4) Definition of I4.0 public policy initiatives; 5) Adjusting calls to I4.0 requirements including scope, eligible activities, eligible costs; 6) Market price assessment methodologies (process and metrics to establish standard costs) along the life cycle of funded projects (call design, project selection, contracting, monitoring, financial settlement); 7) Definition of an I4.0 maturity evaluation matrix for projects (with factors like human capital, technological cooperation, etc.).

The Regional Council of Kainuu is INNO PROVEMENT Partner 8 (PP8) and responsible for the coordination of the 3rd thematic unit of the project, *Introducing Industry 4.0 to traditional industries*.

4.2 Policy instrument, Kainuu report

The objective of the Policy Instrument report was to outline the state of play of Industry 4.0 policies / relayed industries and digitalisation performance in each one of the INNO PROVEMENT regions. It was implemented during the period October 2018 – March 2019. The Digital Economy and Society Index (DESI)[14] and Digital

[14] . DESI is a composite index that summarises relevant indicators on Europe's general digital performance and tracks the evolution of EU member states in digital competitiveness.

Transformation Scoreboard (DTS)[15] indexes were also used.

To implement the field work, PP8 reviewed the relevant national and regional policies, regionally funded projects, and interviewed about 30 businesses. Issues in focus included getting insights into (1) correlating the overall awareness of the business in Industry 4.0 with their opinions on the role of public sector support; (2) understanding the perspective of businesses as users or potnetial producers of Industry 4.0 solutions; (3) understanding the overall forward and backward linkages of businesses in the supply chain in which they operate and eventually correlating it to businesses' Industry 4.0 awareness; and (4) confirm the overall level of ICT utilisation of a business as a starting point for future Industry 4.0 applications.

The main findings can be summarised as follows:

- the Finnish DESI index is high, however However, the DESI[16] 2018 report notes also: "...currently, and despite the overall strong position and the policy support for digitisation, there remain significant disparities among businesses. According to the Finnish Innovation Survey, the importance of digitalisation for enterprises' business activity is much more strongly acknowledged in services than in manufacturing firms: 41% of services firms consider one form or another of digitalisation key to the firm operations, compared to 25.4% of manufacturing firms"[17], [18].
- Kainuu businesses' awareness of Industry 4.0 is very low. Traditional industries and SMEs need the most tailored Industry 4.0 programmes and projects.
- Implemented Industry 4.0 projects relate to development of technologies and innovations more than uptake of comprehensive. Industry 4.0 solutions.
- Qualified business intermediaries for the uptake of the I 4.0 are lagging and their competences need to be reinforced.
- In Finland, there is no distinct Industry 4.0 policy. Rather, Industry 4.0 is part of Finland's overall Industrial, Innovation and Digitisation policies. Digitisation, especially through Artificial Intelligence (AI) initiatives is a policy in its own right involving the uptake & production of AI solutions. Digitisation has been a priority in Finland since the 1990s, and today's performance is especially encouraging. In December 2017 Finland launched a national artificial intelligence (AI) strategy19 aiming at turning Finland into a leading country in the application of artificial intelligence. In June 2018, a first report on the AI strategy implementation was published[20].

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[15] https://ec.europa.eu/growth/tools-databases/dem/index/publications/publications-relevant. DESI and the DTS share one common dimension, the 'Integration of Digital Technology', therefore the Digital Transformation Scoreboard 2018 uses the values provided by the DESI's dimension on technology integration (DESI 2017).

[16] https://ec.europa.eu/digital-single-market/en/desi.

[17] DESI ranking 2018, page 9 and OECD Reviews of Innovation Policy, Finland, 2017.

[18] It would be impotant to have better understanding of those firms that have adopted Industry 4.0 solutions already. An estimate is that these are larger businesses, confirmed members of mainstream, competitive, global value chains. One questions therefore would be, could this model be gradually transferred to SMEs?

[19] TEM (2017). Finland's Age of Artificial Intelligence Turning Finland into a leading country in the application of artificial intelligence, Objective and recommendations for measures.

[20] Publications of the Ministry of Economic Affairs and Employment 21/2018. Work in the age of artificial intelligence Four perspectives on the economy, employment, skills and ethics.

Finland's 2014-2020 Structural Funds[21] provide an excellent enabling framework for applying Industry 4.0 solutions. Investment priorities 2 (Investment priority 2. Supporting SMEs so that they can grow in the local, national and international markets and take part in innovative processes; page 43) and 3d (3d - Supporting SMEs so that they can be part of the growth in the local, national and international markets and innovative processes; page 46) provide excellent opportunities for the uptake of Industry 4.0, including comprehensive types of projects. This enabling approach has been reinforced in the current period of the SF 2021-2027[22].

In the Regional Development Programme of Kainuu, Industry 4.0 is assigned under the Smart Specialisation approach[23]. Ideally, Industry 4.0 should be up-taken by the prioritised industries of the smart specialisation strategy 1) measurement technology, gaming & simulators, and innovations in metal industry 2) process and environmental monitoring of bio-based economy, mining and innovations of forest, food and blue bio-based economy industries, 3) activity tourism on social and welfare sector and innovations in health and sports sector. Industry 4.0 solutions are described as cross-cutting themes through all chosen spearheads of the RIS3 strategy. In the Regional Action Plan of the Structural Funds and Rural & Agriculture Funding, Industry 4.0 is referred to in chapter 1.324.

The Policy Instrument report revealed that there is room for improvement of the RIS3, including Industry 4.0 policies & associated project funding criteria, for example: more targeted policies, addressing gaps (such as uptake processes of Industry 4.0) as well as strengthening strengths, for example production of solutions & technologies where Kainuu has competence, as well as associated research; also support for joint efforts and international innovation partnerships and projects.

Policy implications / recommendations include: measures promoting Industry 4.0 uptake; measures supporting strategies for organisational adjustment and investments required for deploying Industry 4.0 by SMEs; measures supporting scaling up to business intermediaries skills to promote Industry 4.0 dissemination solutions; measures supporting access of Industry 4.0 innovations accessing markets; measures supporting access of Industry 4.0 innovations accessing markets; measures promoting Industry 4.0 education, research, and new software development.

4.3 Thematic document 2: Introducing Industry 4.0 to traditional industries

The Regional Council of Kainuu is responsible for the thematic unit of the INNO PROVEMENT project dealing with 'Industry 4.0 & traditional industries SMEs'. The term 'traditional industries' relates to the technology

[21] 5 December 2014, version 1.2 of the programme 2014FI16M2OP001, Ref. Ares(2014)4083828 - 05/12/2014.

[22] Funding for the 2021–2027 programming period comes from three different funds: the European Regional Development Fund (ERDF), the European Social Fund (ESF+) and the Just Transition Fund (JTF). The objective of the EU's regional and structural policy is to even out disparities in regional development in Europe and to boost the growth and competitiveness of the Union's economy.

[23] Kainuu Regional Development Programme, Page 29, Figure 9: Smart specialisation in Kainuu region 2018-20121

[24] Regional Action Plan of the Stuctural Funds, Page 13, Figure 2: Smart specialisation in Kainuu region 2018-2021.

and knowledge intensity of the main business activities[25], and includes from medium tech to low-tech industries. The thematic document ( ) was prepared during May 2019-July 2019. It contributed to better understand and visualise the transformative character of Industry 4.0 as well as gain insights into the benefits and barriers of traditional SMEs in respect to Industry 4.0. Industry 4.0 eventually results in the digital transformation of a business. "In addition, it both enables and requires end-to-end engineering across the entire value chain." (, page 5). The challenge for a small or medium traditional business is to visualise itself being member of such a value chain. The challenge for the innovation system is to have the capacity to provide tailored services for businesses to overcome structural barriers towards digital transformation, and the challenge for policy makers is to be in a position to introduce and support the right type of projects.

The literature review identified a possible way to merge these three aspects: to classify and quantify the benefits of Industry 4.0 for a business. The most important benefits include savings (inventory costs, manufacturing costs, logistics costs, complexity costs (additive manufacturing, product customisation, ...), and internet-based management systems. In addition, I 4.0 creates its market (In addition, a new market towards productising components for Industry 4.0 applications is fast developing. The benefits of Industry 4.0 have been classified and quantified by various researchers. One good reference is the summary proposed by Table 5.

Table 5 Evaluation of potential benefits of Industry 4.0 for SMEs[26]

Type of activities & associated costs	**Total value**
Inventory cost	*-30% to - 40%*
Manufacturing costs	*-10% to -20%*
Logistics costs	*-10% to -20%*
Complexity costs (additive manufacturing, product customisation, ...)	*-60% to -70%*
Quality costs (product customisation, personalised medicine, ...)	*-10% to – 20%*
Maintenance costs	*-20% to -30%*

The recommendations of the thematic document emphasise the importance of linking Industry 4.0 applications to the business rational of traditional SMEs. One way to achieve this, would be to take into account the cost structure of traditional SMEs. For example, how important are complexity and quality costs to the overall costs of a traditional SME? How important is product customisation as revenue generator for the SME? Does the SME see linking to new types of demand as a relevant investment? Does the opportunity or, even, the anticipation of such an opportunity exist? What is the time span: short, medium or long-term? What are the types of backward and forward linkages of the most performing of the business' products (value chain mapping)? In such a case, it might be useful to find out, i.e. to specify & quantify, the immediate benefits of I4.0 uptake for SMEs. To estimate these benefits, we propose to relate the benefits listed in Table 5 to the cost structure of traditional SMEs, and then calculate the real value of I 4.0 uptake, and, finally, to decide the uptake of tailored I 4.0 solutions, Table 6.

[25] Based on NACE Rev. 2 3-digit level of technology classification, access:

[26] From and .

Table 6 Linking I4.0 benefits to business costs

Type of cost **1**	**Cost savings from 4.0** **2**	**Type of cost participation into the overall business costs** **3** 3= Type of cost /Total costs	**Cost savings value of I4.0 to an SME** **4** 4= 2 *3	**SME-prioritised digitisation investments** **5** Industry 4.0 uptake according to highest costs savings
Inventory costs	30% to 40%, average savings 35%	Inventory costs /total costs	-35%* column3	
Manufacturing costs	10% to 20% average savings 15%	Manufacturing costs / total costs	-15%* column3	
Logistical costs	-10% to 20% Average savings 15%	Logistical costs / total costs	-15% *column3	
Complexity costs (Additive manufacturing, product customisation design and application)	60% to 70% Average savings 65%	Complexity costs / total costs	-65% *column3	
Quality control costs (product customisation, personalised medicine)	10% to 20% Average savings 15%	Quality costs / total costs	-15% *column3	
Maintenance costs	20% to 30% Average savings 25%	Maintenance costs / total costs	-25%* column3	

What follows from Table 6, is that if, for example, inventory costs are very high in a business while complexity costs are negligible, then, a tailored approach to I4.0 uptake would prioritise the digital transformation of the inventory function. On the other hand, as value chain participation is a priortiy for Kainuu, it becomes clear that Industry 4.0 uptake is very important in value chain participation, i.e. complexity costs & quality costs.

An important part of Industry 4.0 uptake is, throughout the automated production and delivery processes, collecting, analysing, evaluating, and utilising data[27],[28]. It has been claimed that generating value at the different stages of the data value chain is at the centre of the future knowledge economy, Table 7. As in the

[27] As a disticnt domain, it is a result of the digital transformation of the economy and society as a whole. "The European data strategy aims at making the EU a leader in a data-driven society. Creating a single market for data will allow it to flow freely within the EU and across sectors for the benefit of businesses, researchers and public administrations.People, businesses and organisations should be empowered to make better decisions based on insights from non-personal data, which should be available to all".

[28]

case of Industry 4.0 (Table 5 Evaluation of potential benefits of Industry 4.0 for SMEs and Table 6 Linking I4.0 benefits to business costs) diffusing this approach which matches the generation of quantifiable, accessible value concepts to any type of business including SMEs, with investments in technology uptake & organisational adjustment, is maybe the way to go forward.

Table 7 Data analytics domains[29]

Data analytics domains	Value generation
Performance measurement[30].	
Decision making, iterative (evaluation and learning[31]).	
Predictive tool (utilisation of advance-prediction tools, so that data can be systematically processed into information to explain uncertainties, and thereby make more "informed" decisions[32]).	
Product and process quality tool: as the final outcome of the manufacturing process, product quality can provide much insight on machine condition via backward reasoning algorithms (product quality can provide feedback for system management, which can be used to improve production scheduling. Currently, such feedback loop does not exist and needs further research[33]).	
Management tool (management of operational processes and control[34]).	
Big data analytics is playing a critical role[35], e.g. digitalisation and data analytics applied to implement the Green Deal objectives.	

In conclusion, the findings identified in the 2nd INNO PROVEMENT thematic document (Industry 4.0 and traditional SMEs) confirm that: (i) it is necessary to integrate Industry 4.0 into the region's policies, includind the RIS3, (ii) it is necessary to adopt an integrated transformative approach based on digitalisation, tailored nevertheless to individual business' actual or forthcoming operations, taking care to maximise explicit benefits and growth generation for the business, and (iii) it is recommended to introduce Industry 4.0 initiatives to firms that are intermediate good sellers or buyers from and to other firms, i.e. already value chain members.

4.5 Good practice transfer

The Regional Council of Kainuu is importing two good practices, both related to policy integration of Industry 4.0, one from the lead partner region Hungary and one from Portugal. Both good practices are defined at national level. The below Table 9 summarises the good practices, their significance for Kainuu, and indicates

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29 Table compiled from

30 2017 .

31).

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34 Hammer M. et al. (2017). "The information flow among the production line, business management level, and supply chain management make the industrial management more transparent and organised".

35 Sharma and Pandey, (2020). "Eventually, it will reduce the cost by energy-saving, optimized maintenance scheduling and supply chain management".

what will be transferred. Both good practices adopt a comprehensive, transformative approach right from the start and do not stop at grass-roots digitisation.

Table 8 Summary of the Kainuu preferred good practices and relevance to the region

Good practice transferred	**Relevance to Kainuu and elements transferred**
Industry 4.0 initiatives (Hungary) -The I4.0 initiative was planned to coherently span in the SF Priority Axes: Axis 1 SME development; Axis 3 ICT (this focuses especially on digitisation); Axis 6 Training. - The Hungarian maturity assessment matrix (SME maturity model) - The Hungarian SME Industry 4.0 path. - The Night of Industry 4.0	-Industry 4.0 is a SF, national level initiative. - In comparison, in Kainuu the focus has been more on the production of I4.0 compatible technologies. It will be important to introduce I4.0 not only as production of technologies but also as uptake of technologies coherently. - The Hungarian maturity assessment matrix is very close to the one developed by VTT in Finland ApuaDigiin. It would be important to compare the approaches, results and improvement needs and learn from each other. - The Hungarian SME Industry 4.0 path is very close to the findings from the 2nd thematic document and provides a good base for implementation and synthesis. The GP needs to be further developed.
National Industry 4.0 policy (Portugal) -Distinct implementation initiative (COMPETE 2020) -Implementation is structured according to three components: *Qualifying i4.0* (creating a corpus of i4.0 qualified professionals and public administration, competent in promoting i4.0 to the economy); *Promoting i4.0* (7 cross cutting policy initiatives to effectively promote uptake of i4.0: Voucher / Diagnosis of opportunity, ID&T projects individual and copromotion, SME Qualification and Internationalisation, Productive Innovation and Entrepreneurship, Integrated and Autonomous Training, Action training, Collective Actions, and 4 more related to 'flagship' type of projects: Grade improvement of projects within the i4.0 framework, Incentive bonus for the projects in the i4.0, Specific budget for projects within the i4.0 Framework) and Achieving i4.0 (*Objective* - To promote the value and transfer of technology, such as industry 4.0, where digital transformation aims new products and processes. *Incentive bonus* - 10 pp for SMEs with eligible investments in the areas of Industry i4.0 (in certain conditions of dimension). *Grade improvement* (criterion A - project quality) for projects whose investments fit the objectives of i4). WHAT HAS HAPPENED: 7 calls for 'Training in Action' Objective – training oriented to strategies based on digital solutions, promoting efficient and interconnected production processes, creating new business models. Diagnostic / consultancy phase - assessment of SME industrial and technological maturity, identifying critical skills development needs. Training areas (examples) - digital organizational culture; artificial intelligence; robotics; cloud computing, big data.	-The comprehensive national level initiative (will be introduced at national level and maybe linked to related policies like Advanced Manufacturing and Artificial Intelligence). -Structured approach in formulating first a qualified (and accredited?) group of experts - Addressing I4.0 right from the start as a transformative rather than "just" a digitisation initiative. - National level I.40 budget - I4.0 flagship projects (promotion and continuous learning process).

Good practice transferred	Relevance to Kainuu and elements transferred
Quantification: 428 projects, 1 220 759 059€ investment (SF + private co-funding).	

5 Feasibility Study[36]

5.1 Objectives and process

The purpose of the feasibility study is to identify, prioritise, document, and recommend to the Regional Council of Kainuu activities to be included into the Kainuu regional action plan and the revised RIS3 addressing Industry 4.0 strategies and projects in the region, including applications of and reinforcing the knowledge base of data analytics.

The feasibility study was done by VTT, the Technical Research Centre of Finland, between August 2020-January 2021.

5.2 Findings

The questionnaire was implemented with Questback. Invitations were shared by RCK. Personal invitations via the members of the Regional Stakeholder Group were sent too. The questionnaire was open from the 5th to 31st October 2020. We got 18 responses, mainly from SMEs:

- According to the questionnaire the most urgent operational costs to be managed were manufacturing (5 immediately and 8 near future), quality, assets management and logistic. No complexity costs appeared.
- When considering which functionalities are supported with digital solutions the lowest scores are service sales, logistics and sales. The low score in service sales may indicate that there are **few added value services in the offering**. Purchase and logistics indicate that the **collaboration with supply-chain could be enhanced**.
- Exploitation of digital solutions used in business. The lowest scores (Web shop, mobile payment, digital marketplace and electronic appointment system) can be explained with the nature of business, the questionnaire was targeted for manufacturing companies where these are not relevant in the customer interface.
- Current COVID-19 pandemic has probably boosted on-line meetings. Data security, cloud services and e-invoice are widely used. **Integration with information systems** like Enterprise Resource Planning (ERP), Customer Relationship Management (CRM) and Electronic Data Interchange (EDI) between organisations is falling behind.

[36] VTT; Leila Saari, Jukka Kääriäinen, (2021). INNO PROVEMENT feasibility study in Kainuu. Accepted by VTT: Toni Ahonen, 25.1.2021.

- The most exploited technologies were data analytics, data visualisation, Internet of Things (IoT) and big data. It is interesting that sensor networks and cloud computing fall behind IoT as they usually are part of the IoT solution.
- The most common topics to be introduced in the future are big data, artificial intelligence (AI), data-analytics, high performance computing (HPC), real-time machine vision and robot process automation (RPA).
- Further, the most unknown technologies were Natural language processing (NLP), chat bot, high performance computing (HPC), block chains, real-time machine vision, 5G and robot process automation (RPA).
- The integration of information systems is not on good level in most of the companies as seven (of eighteen) indicate that: The ICT infrastructure is fragmented and in-house. Order, product and production data exist in separate systems. Data is combined (mainly) manually. In five companies the status is even worse as: There are no dedicated ICT tools for processing order, product and production data, but office tools, e.g., spreadsheet and word processing are used.
- The automation of manufacturing is on low level as nine respondents indicate that: Company has no automation solutions. Humans take care of the agility. Machine tool settings can be changed manually. Six companies have partial automation systems: Company has partially automated production (manufacturing) cells, CNC machines and/or dedicated robotic systems, which have limited flexibility.

5.3 Recommendations

The recommendations include:

I. Types of comprehensive Industry 4.0 uptake projects to prioritise in Kainuu (for example: Reduction of manual work for example in pre-bid, i.e., when entering the customer bid into the ERP for bid-counting. Increasing integration with information systems and minimising the manual work from own business processes increases the efficiency of internal processes, enabling sovietisation (value-added services) through gathering data from products during their life cycle. Adapting business model to be able to benefit from the four stages of data analytics, starting from integration into the decision-making process (descriptive analytics, diagnostic analytics, predictive analytics, prescriptive analytics).

II. Industry 4.0 technologies research is reasonable for Kainuu to invest further (for example: Research (post graduate level) should provide estimation models for the return of digital investments and the handprint of digitalisation (in manufacturing industry). For the manufacturing SMEs in Kainuu the technologies related to data gathering, pre-processing, harmonising, saving and sharing are relevant. The recommendations of GAIA-X and IDS should be observed and considered.)

III. Industry 4.0 technologies education related to forthcoming demand for jobs (for example: A research, development and teaching environment boosting the utilisation of digital and virtual solutions of industrial production processes should be established in Kainuu; The training and education aiming to produce skilled staff for local industry should include the latest I4.0 enabling skills and competencies in their training programmes.

IV. Qualified business services that ensuring in the long run the reinforcement of Industry 4.0 uptake and joint development (for example: Engage skilled resources at business services. The person(s) should have knowledge on digital technologies, experiences of digitalisation in manufacturing companies and understanding on I4.0 opportunities in Kainuu in addition to social and business skills; Help companies to get external funding for their development needs; Follow the preparation of EDIHs and try to settle a local service point).

V. Recommended networks, national and otherwise, for Kainuu Industry 4.0 to liaise with (for example, the actors and their natural roles should be identified and the motivation for the interaction designed; Value network analysis would be a good tool to sketch the interaction.

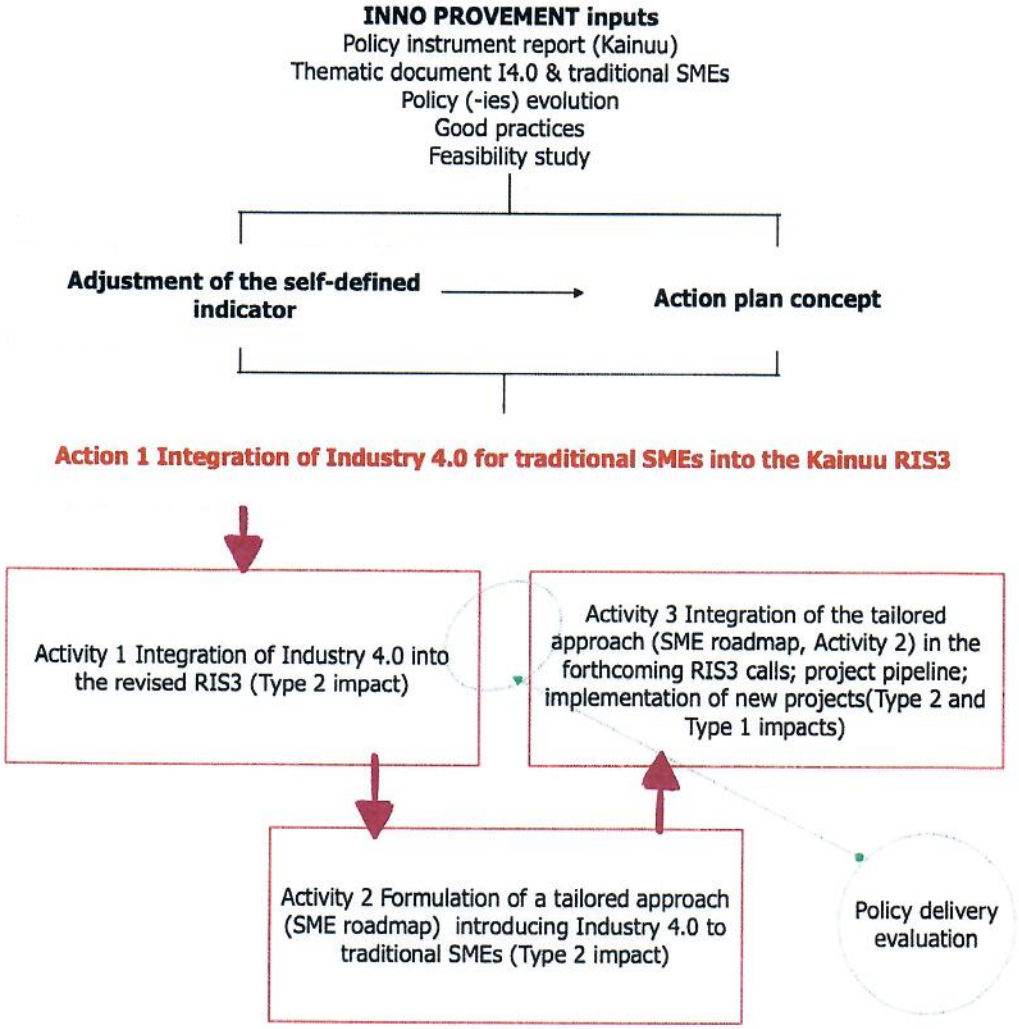
VI. Optimum level bringing together extroversion of the regional innovation system & associated interactions of the regional Industry 4.0 and data analytics initiatives with required coherence for regional embeddedness between and among previous topics.

VII. The regional innovation system should constantly reinforce and update its strengths and, in parallel, ensure a complete innovation context through strategic and operational collaborations based on complementarities and joint added value. Collaboration shall take place on regional, national and international fora.

6 Actions envisaged

The Kainuu action plan has one unique action, Action 1 **Integration of Industry 4.0 for traditional SMEs into the Kainuu RIS3.** The overall approach of policy impact is mapped in Figure 2.

Figure 2 The Kainuu action plan



The objective of Action 1 is to integrate into the Kainuu development context as a digital transition facilitator and, at the same time, to support the development of innovations in the sector and promote data analytics as part of the regional competitive advantage.

6.1 Action 1 Integration of Industry 4.0 for traditional SMEs into the Kainuu RIS3.

Action 1 is organised into three (3) activities: Activity 1 Integration of Industry 4.0 into the Kainuu RIS3; Activity 2 Formulation of a tailored approach for introducing Industry 4.0 to Kainuu SMEs; and Activity 3 Integration of Activity 2 outputs into forthcoming RIS3 calls and implementation of new projects.

This structure was developed to increase the overall understanding of the transformative dimensions and requirements of Industry 4.0 and readiness to commit to this process. More than one regional authorities are involved. RIS3 integration (Activity 1.1) is part of the tasks of PP6 Regional Council of Kainuu and the same is true for the Industry 4.0 roadmap (Activity 1.2). The implementation of Activity 1.3 (project pipeline, integration into calls, and calls implementation), however, requires one more regional authority to be involved ELY Centre, dealing with individual business development projects. As a result, Activity 1.3 is characterised to deal with both types (1 & 2) of policy impact.

6.1.1 Activity 1 Integration of Industry 4.0 into the Kainuu RIS3 2021 – 2027 (Type 2 policy impact)

The revised Kainuu RIS3 is a modification of the current RIS3. However, the strategy adopts a much more extroverted profile building on three vertical themes (THEME 1: Mobilising research and fostering innovations; THEME 2: Reinforcing and diversifying the specialisation base, and THEME 3:Connectivity & Integration, Measures for interregional & international collaboration and reinforces the quest for knowledge-based growth) and on two cross-cutting themes (THEME 4: Digital transformation, and THEME 5: Green deal).

The rationale behind the updated Kainuu RIS3 is (i) strengthening further the research and innovation base (niche) of Kainuu as well as link it explicitly to returns to investment options. This is Theme 1 and it is about production of innovations; (ii) systematically addressing specialisation and diversification of the prioritised industries and reinforcement of the regional economic base. This is Theme 2 and builds on the findings of the regional comparative advantage and regional resilience analysis; (iii) investing in regionalised innovation systems including distributed knowledge bases through transregional initiatives (national, transnational and interregional) as a tool of joint development and integration. Moreover, the Kainuu RIS3 2021-2024 puts the entrepreneurial discovery process (EDP) at the heart of the whole effort, explains how this is to be achieved, and emphasises internal coherence across all themes and components.

Themes 4 and 5 are addressed vertically & horizontally: Theme 1 addresses selected aspects of both Themes 4 & 5 for further research and development, based on existing strengths of the Kainuu knowledge and research base. Theme 2 addresses all relevant uptake aspects of the two policies.

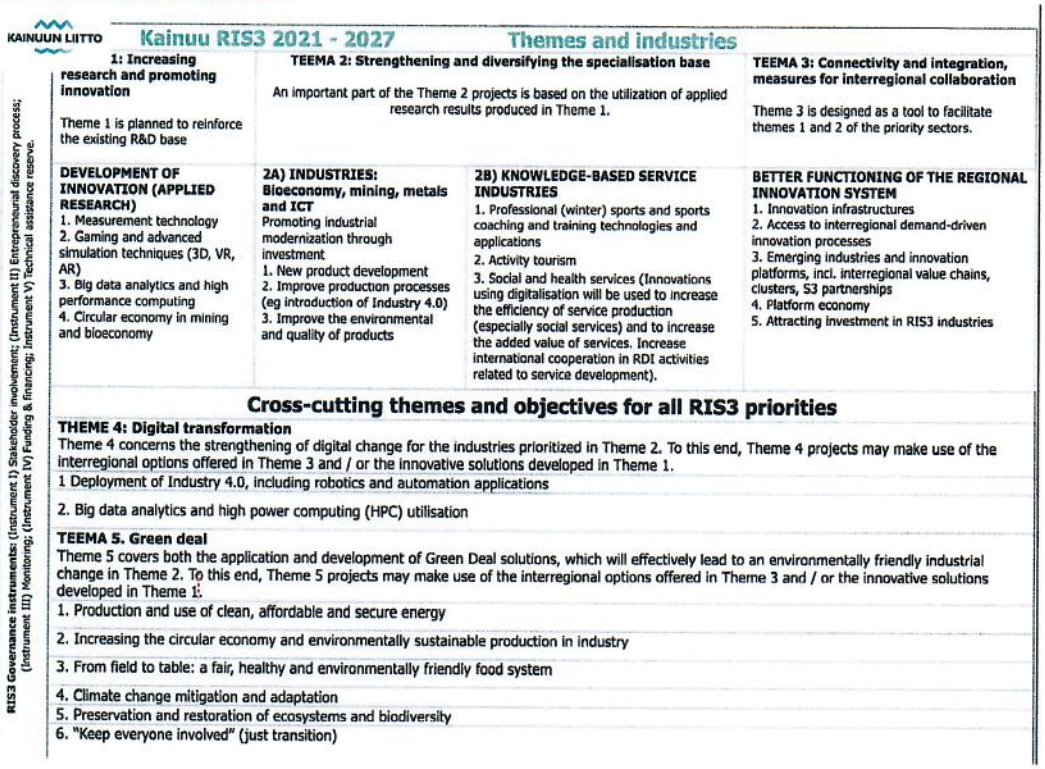
Theme 3 addresses production, diffusion/uptake of innovations of both policies, and ensures multiplier effects through interregional exchanges. Here, provisions for international and cross-border (i.e. with 3rd countries) collaborations are also taken into account. Theme 3 is a strategic tool also for developing localised investments requiring external collaborators for their development.

The discussion and approval of the revised RIS3 by the Kainuu stakeholders took place during two meetings, on 22.9.2020 and 1.10.2020. The revised Kainuu RIS3 was approved by the Regional Board of Kainuu on 9.12.2020. It is accessible at: . The feedback from the EC to the revised Kainuu RIS3 has been positive. Therefore, we consider Activity 1 completed.

The work on the RIS3 revision started in Spring 2019, intensified during autumn 2019, and faced COVID-related delays throughout 2020. Because of the RIS3 revision timetable, it was necessary to start organising

for and planning the INNO PROVEMENT action plan earlier. The way INNO PROVEMENT action plan impact priorities Type 2 were taken into account is by inputs from INNO PROVEMENT team to the RIS3 revision team. Both activities are part of the Regional Development Department of the Regional Council of Kainuu.

Figure 3 The revised Kainuu RIS3



The cost of Activity 1 was covered by own costs of PP8 for the external expertise (15 000€, University of Turku), and by a combination of own staff and INNO PROVEMENT Phase 1 staff costs, an approximate total of 45 000€.

6.2 Activity 2 Industry 4.0 path, uptake by SMEs (Type 1 policy impact).

Conclusions of the INNO PROVEMENT project are that (i) business opportunities provided by Industry 4.0 concepts are not yet broadly understood and appreciated by SMEs; (ii) SMEs lack required competences for confronting and benefitting from digital transformation, (iii) operational tools supporting the development and diffusion of professional skills for supporting the uptake of Industry 4.0 by SMEs are needed, (iv) regional authorities, in view of addressing the uptake of Industry 4.0 by traditional (=medium to lower tech) sector SMEs, need to clarify the criteria for issuing targeted calls. In addition, the INNO PROVEMENT project inputs to the regional administration process takes into account prior inputs as follows:

a. The Findings and Recommendations identified through the Feasibility study, were matched with the Policy Instrument report and the 2nd Thematic Document to be able to reach prioritised projects.

b. The ((1) Number of Industry 4.0 projects; (2) A detailed model for applying I 4.0 to traditional industries including data analytics, and focusing on a digital transformation

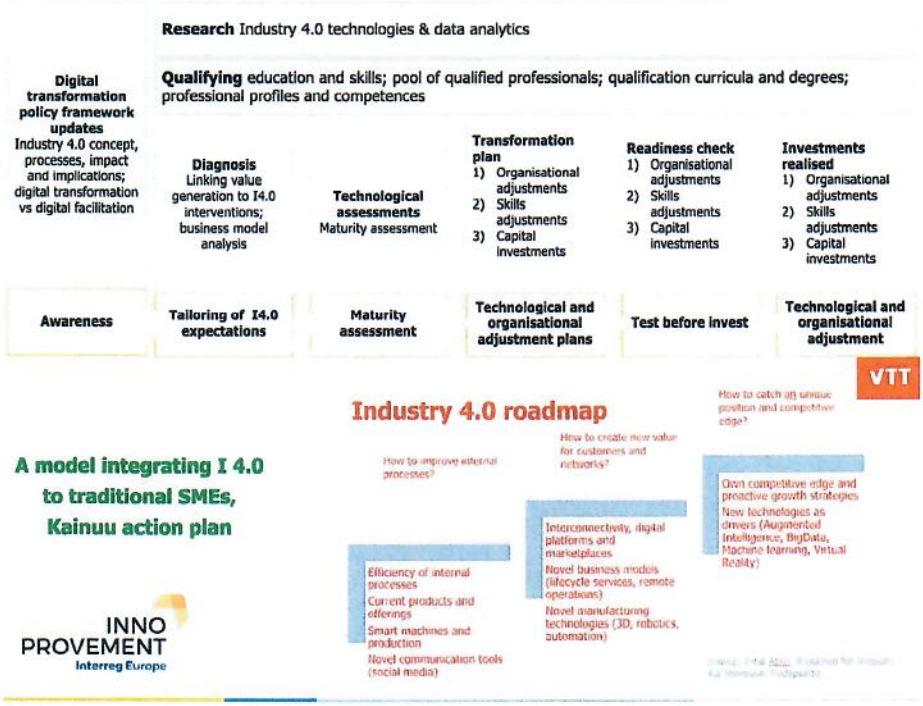
perspective; (3)Qualification in education & skills-training, for creating & maintaining a pool of Industry 4.0 experts and qualified personnel; (4) Number of initiatives scaling up to business intermediaries skills to promote Industry 4.0 dissemination solutions; (5)Number of projects supporting Industry 4.0 innovations accessing markets). The self defined indicator expectations were matched to the current situation in the region and were grouped into two result indicators ((1), (3), (4) and (5)) and three enabling indicators ((2), (3) and (4)).

c. The enabling indicator *(2) A detailed model for applying I 4.0 to traditional industries including data analytics and focusing on a digital transformation perspective* was decided to be elaborated as a precondition, as part of the terms of reference for the implementation of the rest of the self-defined indicators.

State of play

The purpose of Activity 2 was to formulate a detailed roadmap for the uptake of Industry 4.0. The concept, as it resulted from the Phase 1 processing is mapped as a comprehensive concept in Figure 4 below.

Figure 4 A model promoting Industry 4.0 to traditional SMEs, Kainuu RIS3 approach[37]



During the period March – October 2021, for the implementation of Activity 2, a roadmap was formulated on the base of Figure 4 and discussed with stakeholders on 21.10.2021. The plan is to present the whole approach to stakeholders on 9.11.2021.

[37] Source: Inspired from the 2nd Thematic document and adjusted from presentations during the INNO PROVEMENT 3rd thematic interregional meeting. Also inspired by the Hungarian SME uptake of Industry 4.0 GP.

Table 9 Industry 4.0 SME uptake roadmap

Roadmap units	Summary
1 Awareness raising	The Regional Council of Kainuu in collaboration with the ELY Centre, organise an awareness raising event, introducing the theme of Industry 4.0 uptake. The objective to link the I4.0 roadmap to forthcoming calls, and also discuss the range and approach of project calls that will be organised accordingly. National level delegates and external experts are also foreseen. Participants include all types of stakeholders eligible to submit project proposals in Kainuu.
2 Project calls	Three types of project calls are foreseen: (1). I4.0 uptake by SMEs (*3.1 I 4.0 uptake by SMEs)* (2). I4.0 & big data technology and applications research (*3.2 I4.0 and big data technology and applications research)* (3). Education and qualifications (*3.3 Education & qualifications)* Types (1) and (2) of project calls can be contemporaneous. Type (3) calls are related to knowledge and skills gaps detected during the implementation of type (1) projects, so the calls will be announced within one year of the announcement of type 1 and 3 calls.
3 Project selection & implementation	
3.1 I 4.0 uptake by SMEs	
3.1.1 Diagnosis	Before any technological maturity assessment is undertaken, experts analyse companies' internal business & production processes, level of digitalisation of these processes (if any) and map the associated costs and profits. The output of this phase of the project (phase 1) is a map of each one of the participating businesses that diagnoses the company's processes, cost and benefit structure associated with the company's production and business processes. The "peaks", i.e. the most costly and the most profitable parts identified through the analysis, will indicate the most probable I4.0 interventions.
3.1.2 Technological assessment	During this 2nd phase of the project, there is I4.0 maturity assessment, with special focus on the "peak" modules identified in phase 1. This will result in a document with staged recommendations to businesses what they could do in terms of I4.0 uptake to save costs and what they could do to enhance profits. One very important thing is the connectivity between different modules, because the connectivity is about decision making and decision making is about big data one the one hand and about automated transfer of decision making on the other hand. Therefore, even the most "naïve" of digitalisations contains these critical things with which the business must get acquainted. Once the maturity assessment is done, experts ask businesses whether they want to continue further with a digital transformation plan, totally, partially, or not at all. Businesses are not forced to go on. However, we expect those that are committed to be committed. Those businesses that are prepared to continue, are then getting the needed co-funding to proceed to phase 3.
3.1.3 Transformation plan	Experts make digital transformation plans based on the outputs of phase 1 and phase 2 and the interests of businesses. The transformation plan indicates what kinds of skills adjustments, organisational adjustments, and capital investments businesses need to make to proceed with digital transformation. At this stage, skills and business gaps are analysed by the project steering group and recommendations are made for announcing related education & skills calls. This leads to the announcement of *3.3 Education & qualifications calls.*
3.1.4 Readiness check	Once the digital transformation plan is prepared, there is a final check as to the readiness of businesses to implement it. The readiness check includes the same categories as those included into the transformation plan, i.e., business' readiness to proceed to skills and organisational adjustments and capital investments.
3.1.5 Realisation of investments	This is phase 5, and it is about the implementation of the digital transformation plan, as also agreed during phase 4 (readiness check).
3.2 I4.0 and big data technology and applications research	These calls are investing on regional excellence in selected technologies as well as on the further development and improvement of applications. These projects are outward, excellence oriented, innovation driven initiatives.
3.3 Education & qualifications	Calls are announced and projects are selected and implemented to address skills and qualifications gaps in I4.0 and big data. The content and objectives of these projects is linked to the related gaps identified in phases 1 and 2.

6.3 Activity 3 Integration of the tailored approach (SME Industry 4.0 path) into policy instrument calls (Type 2 and Type 1 policy impact)

Activity 3 is mainstreaming Activity 2. There are three (3) sub activities: integration of the roadmap into funding instruments, calls announcement, and evaluation of the effectiveness of the new measures.

(1). The roadmap is presented to the regional stakeholders for discussion and comments, improvements are made if needed.

(2). ROADMAP INTEGRATION: Preparatory meetings between the Regional Council of Kainuu and ELY Centre, in view of integrating the roadmap into funding instruments; some of them are ERDF (Regional Council of Kainuu), some of them are ESF (ELY Centre).

Following the approval of the Kainuu revised RIS3, the required formulation and approval of the annual list of prioritised projects (TOPSU) was done. INNO PROVEMENT contributed to this list, which was approved on 3.3.2021[38]. The approved list has been included into the REACT EU programme[39],[40].

(3). CALLS: Calls are announced, 2022.

(4). RIS3 POLICY DELIVERY EVALUATION: The roadmap introduces some innovative aspects to regional calls and projects. Therefore, a more in-depth assessment of how well this new approach has worked, and whether it is retained for the future or modified, is also included. This is on top of the usual SF evaluations.

7 Kainuu action plan implementation, gantt

Table 10 Kainuu action plan implementation timetable

Indicative list of activities	Years and semesters									
	2019		2020		2021		2022		2023	
	1	2	1	2	1	2	1	2	1	2
Action plan preparation and RIS3 revision										
RIS3 revision preparation		done								
INNO PROVEMENT action plan elaboration		done								
Activity 1, Type 2 impact		done								
Activity 2, Type 1 impact					done					
Activity 3, Type 2 & Type 1 impact						In process				

38

39

40 REACT EU programme is part of Strucutral Funds that was agreed in the context of addressing the negative and long term impacts of covid19.

8 Annexes

8.1 Classification of businesses according to technology intensity

I. Manufacturing businesses[41]

High technology:

- Manufacture of basic pharmaceutical products and pharmaceutical preparations (21)
- Manufacture of computer, electronic and optical products (26)
- Manufacture of air and spacecraft and related machinery (30.3)

Medium-high-technology:

- Manufacture of chemicals and chemical products (20)
- Manufacture of weapons and ammunition (25.4)
- Manufacture of electrical equipment (27)
- Manufacture of machinery and equipment n.e.c. (28)
- Manufacture of motor vehicles, trailers and semi-trailers (29)
- Manufacture of other transport equipment (30) excluding Building of ships and boats (30.1) and excluding Manufacture of air and spacecraft and related machinery (30.3)

Medium-low-technology:

- Reproduction of recorded media (18.2)
- Manufacture of coke and refined petroleum products (19)
- Manufacture of rubber and plastic products (22);
- Manufacture of other non-metallic mineral products (23)
- Manufacture of basic metals (24)
- Manufacture of fabricated metal products, except machinery and equipment (25) excluding
- Manufacture of weapons and ammunition (25.4)
- Building of ships and boats (30.1)
- Repair and installation of machinery and equipment (33)

Low-technology:

- Manufacture of medical and dental instruments and supplies (32.5)
- Manufacture of food products (10)
- Manufacture of beverages (11)
- Manufacture of tobacco products (12)

[41] EUROSTAT, Glossary: High-tech classification of manufacturing industries, retrived on 15.5.2019 from https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:High-tech_classification_of_manufacturing_industries.

- Manufacture of textiles (13)
- Manufacture of wearing apparel (14)
- Manufacture of leather and related products (15)
- Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials (16)
- Manufacture of paper and paper products (17)
- Printing and reproduction of recorded media (18) excluding Reproduction of recorded media (18.2)
- Manufacture of furniture (31)
- Other manufacturing (32) excluding Manufacture of medical and dental instruments and supplies (32.5)

I. Service businesses[42]

Knowledge- intensive services (KIS)

50 to 51	Water transport; Air transport;
58 to 63	Publishing activities: Motion picture, video and television programme production, sound recording and music publish activities; Programming and broadcasting activities; Telecommunications; computer programming, consultancy and related activities; Information service activities (section J);
64 to 66	Financial and insurance activities (section K);
69 to 75	Legal and accounting activities; Activities of head offices, management consultancy activities; Architectural and engineering activities, technical testing and analysis; Scientific research and development; Advertising and market research; Other professional, scientific and technical activities; Veterinary activities (section M);
78	Employment activities;
80	Security and investigation activities;
84 to 93	Public administration and defence, compulsory social security (section O); Education (section P), Human health and social work activities (section Q); Arts, entertainment and recreation (section R).

Knowledge- intensive market services (excluding high-tech and financial services)

50 to 51	Water transport; Air transport;
69 to 71	Legal and accounting activities; Activities of head offices, management consultancy activities; Architectural and engineering activities, technical testing and analysis;
73 to 74	Advertising and market research; professional, scientific and technical activities;
78	Employment activities;
80	Security and investigation activities;

[42] Eurostat indicators on High-tech industry and Knowledge – intensive services, Annex 3 – High-tech aggregation by NACE Rev.2. Aggregations of manufacturing based on NACE Rev. 2

High-tech knowledge- intensive services

59 to 63	Motion picture, video and television programme production, sound recording and music publish activities; Programming and broadcasting activities; Telecommunications; computer programming, consultancy and related activities; Information service activities;
72	Scientific research and development

Knowledge- intensive financial services

64 to 66	Financial and insurance activities (section K).

Other knowledge-intensive services

58	Publishing activities
75	Veterinary activities
84 to 93	Public administration and defence, compulsory social security (section O); Education (section P), Human health and social work activities (section Q); Arts, entertainment and recreation (section R).

Less knowledge- intensive services (LKIS)

45 to 47	Wholesale and retail trade; Repair of motor vehicles and motorcycles (section G)
49	Land transport and transport via pipelines
52 to 53	Warehousing and support activities for transportation; Postal and courier activities;
55 to 56	Accommodation and food service activities (section I)
68	Real estate activities (section L)
77	Rental and leasing activities
79	Travel agency, tour operator reservation service and related activities
81	Services to buildings and landscape activities
82	Office administrative, office support and other business support activities
94 to 96	Activities of membership organisation; Repair of computers and personal and household goods Other personal service activities (section S)
97 to 99	Activities of households as employers of domestic personnel; Undifferentiated goods- and services-producing activities of private households for own use (section T); Activities of extraterritorial organisations and bodies (section U).

Less knowledge- intensive market services

45 to 47	Wholesale and retail trade; Repair of motor vehicles and motorcycles (section G)
49	Land transport and transport via pipelines
52	Warehousing and support activities for transportation
55 to 56	Accommodation and food service activities (section I)
68	Real estate activities (section L)

77	Rental and leasing activities
79	Travel agency, tour operator reservation service and related activities
81	Services to buildings and landscape activities
82	Office administrative, office support and other business support activities
95	Repair of computers and personal and household goods

Other less knowledge- intensive services

53	Postal and courier activities
94	Activities of membership organisation
96	Other personal service activities
97 to 99	Activities of households as employers of domestic personnel; Undifferentiated goods- and services-producing activities of private households for own use (section T); Activities of extraterritorial organisations and bodies (section U).

9 Bibliographical references

1. Acosta, M. (2018). SKILLS FOR THE FOURTH INDUSTRIAL REVOLUTION A response to Industry 4.0 challenges. Master's Thesis. Marcela AcostaAalto University School of Business Information and Service Management Fall 2018. Aalto University, P.O. BOX 11000, 00076 AALTO .

2. Al-Noukari, M., & Al-Hussan, W. (2008, April). Using data mining techniques for predicting future car market demand; DCX case study. In Information and Communication Technologies: From Theory to Applications, 2008. ICTTA 2008. 3rd International Conference on (pp. 1- 5). IEEE.

3. Anthony RN. (1965). Management Planning and Control Systems: A Framework for Analysis. Boston. Havard Business School Press. 1965.

4. Bailey, D. and De Propris, L. (2014). Manufacturing reshoring and its limits: the UK automotive case. Cambridge Journal of Regions, Economy and Society, 7(3), 379–395. Bailey, D., Bellandi, M., Caloffi, A. and De Propris, L. (2010) Place-renewing lead- ership: trajectories of change for mature manufacturing regions in Europe. Policy Studies, 31(4), 457–474.

5. Baines, T. S., Lightfoot, H. W., Benedettini, O., & Kay, J. M. (2009). The servitization of manufacturing: a review of literature and reflection on future challenges. Journal of Manufacturing Technology Management, 20(5), 547-567.

6. Bitard, P., Edquist, C., Hommen, L. et al. (2008) Reconsidering the paradox of high R&D input and low innovation: Sweden. In: Edquist C. and Hommen L. (eds), Small Country Innovation Systems: Globalization, Change and Policy in Asia and Europe. Cheltenham: Edward Elgar, 237–280.

7. Boston Consulting Group (2015). Industry 4.0: the future of productivity and growth in manufacturing industries.

8. Chaniotou N. and Keränen S (2019). SKILLS+ project, Action plan for Kainuu. https://www.interregeurope.eu/fileadmin/user_upload/tx_tevprojects/library/file_1576241960.pdf

9. Chon, S. H., Slaney, M., & Berger, J. (2006, October). Predicting success from music sales data: a statistical and adaptive approach. In Proceedings of the 1st ACM workshop on Audio and music computing multimedia (pp. 83-88). ACM.

10. Cohen, J., Dolan, B., Dunlap, M., Hellerstein, J. M., & Welton, C. (2009). MAD skills: new analysis practices for big data. Proceedings of the VLDB Endowment, 2(2), 1481-1492.

11. D. Wang, "Building Value in a World of Technological Change: Data Analytics and Industry 4.0," in *IEEE Engineering Management Review*, vol. 46, no. 1, pp. 32-33, 1 First quarter, March 2018.

12. EU Parliament (2015b). Industry 4.0, available at: .

13. European Commission (2016a). Accelerating the digital transformation of European industry and enterprises.

14. European Commission (2016b). A new European initiative to help Europe's businesses seize digital opportunities.

15. European Commission (2015a). Digital Transformation of European Industry and Enterprises' – report from the Strategic Policy Forum on Digital Entrepreneurship. First report on digital entrepreneurship 23.3.2015.

16. European Commission (2018). Digital Transformation Scoreboard: EU businesses go digital: Opportunities, outcomes and uptake.

17. European Commission (2020a). A European strategy for data Brussels, 19.2.2020 COM(2020) 66 final.

18. European Commission (2020b). The European data strtaegy.

19. European Commission Digital Transformation Monitor (2017d). Smart vineyard: management and decision making for wine producers.

20. European Commission, DG Connect, Anne Bajard (2017a).Artificial Intelligence activities

21. European Commission, Digital Transformation Monitor (2017e). Digitising mechanical engineering: leveraging the potential of the cloud and data. May 2017.

22. European Commission, Digital Transformation Monitor (2017b). Big data: a complex and evolving regulatory framework. January 2017.

23. European Commission, Digital Transformation Monitor (2017c).

24. Westkämper, E. (2014). Towards the re-industrialization of Europe: a concept for manufacturing for 2030, Springer, 2014.

25. Heymann, E. and S. Vetter, S. (2013). Europe's re-industrialisation: the gulf between aspiration and reality, Deutsche Bank Research, 2013.

26. Fosso Wamba, S., Akter, S., Edwards, A., Chopin, G. and Gnanzou, D. 2015. 'How "big data" can make big impact: findings from a systematic review and a longitudinal case study'. International Journal of Production Economics, 165, 234–246, DOI: https://doi. org/10.1016/j.ijpe.2014.12.031.

27. Hammer, M., Somers, K., Karre, H. and Ramsauer, Ch. (2017). Profit per hour as a target process control parameter for manufacturing systems enabled by Big Data analytics and Industry 4.0 infrastructure. The 50th CIRP Conference on Manufacturing Systems. ScienceDirect. Procedia CIRP 63 (2017) 715 – 720. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license ( ).

28. Hartmann, P.M., Zaki, M., Feldmann, N. and Neely,A.2016.'Capturing value from big data: a taxonomy of data-driven business models used by start-up firms'. International Journal of Operations & Production Management, 36(10), 1382–1406. doi: 10.1108/ IJOPM-02-2014-0098.

29. Hermann, Mario Pentek, Tobias Otto, Boris, (2015). Design Principles for Industrie 4.0 Scenarios: A Literature Review. Technische Universität Dortmund, Working Paper No. 01/2015, page 5.

30. Herstad, S.J., Aslesen, H.W. and Ebersberger, B. 2014. On industrial knowledge bases, commercial opportunities and global innovation network linkages. Research Policy, 43(3), 495–504.

31. Isaksen,A.andTrippl,M.2016.Exogenously led and policy-supported new path devel-opment in peripheral regions: analytical and synthetic routes. Economic Geography, 93(5), 436–457.

32. Kabugo , J C , Jämsä-Jounela , S L , Schiemann , R & Binder , C 2020 , ' Industry 4.0 based process data analytics platform : A waste-to-energy plant case study ' , International Journal of Electrical Power and Energy Systems , vol. 115 , 105508 . https://doi.org/10.1016/j.ijepes.2019.105508

33. Kager mann, H., Helbig, J., Hellinger,A. and Wahlster,W. 2013.'Umsetzungsempfehlungen für das Zukunftsprojekt Industrie 4.0: Deutschlands Zukunft als Produktionsstandort sichern; Abschlussbericht des Arbeitskreises Industrie 4.0. Forschungsunion'. Abschlussbericht des Arbeitskreises Industrie.

34. Kagermann, H., W. Wahlster and J. Helbig, eds., (2013): Recommendations for implementing the strategic initiative Industrie 4.0: Final report of the Industrie 4.0 Working Group. https://www.acatech.de/wp- content/uploads/2018/03/Final_report__Industrie_4.0_accessible.pdf .

35. Kinkel, S., Dewanti, R.T., Zimmermann, P. and Coates, R. (2017) Measuring Teshoring Trends in the EU and the US. MAKERS Report. Available at: www.makers-rise. org/wp-content/uploads/2018/02/D4.1-Measuring-reshoring-trends-in-the-EU- protected.pdf.

36. Kondratieff, N.D. (1979). The long waves in economic life. Review (Fernand Braudel Center), II(4): 519–562.

37. Kondratieff, N.D. and Stolper, W.F. (1935) The long waves in economic life. Review of Economics and Statistics, 17(6): 105–115.

38. Kumar, A., & Sharma, A. (2016). Paradigm shifts from e-governance to s-governance. *The Human Element of Big Data: Issues, Analytics, and Performance*, *213*.

39. Lee, B. E., Michaloski, J., Proctor, F., Venkatesh, S., & Bengtsson, N. (2010, January). MTConnect-based Kaizen for machine tool processes. In ASME 2010 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference (pp. 1183-1190). American Society of Mechanical Engineers.

40. Lee, J. Kao, H.-A. and Yang, Sh. (2014). Service innovation and smart analytics for Industry 4.0 and big data environment. Product Services Systems and Value Creation. Proceedings of the 6th CIRP Conference on Industrial Product-Service Systems. Procedia CIRP 16 (2014) 3 – 8. Open access article under the CC BY-NC-ND license .

41. Lee, J., Lapira, E., Bagheri, B., & Kao, H. A. (2013). Recent advances and trends in predictive manufacturing systems in big data environment. Manufacturing Letters, 1(1), 38-41.

42. Martinez, V., Bastl, M., Kingston, J., & Evans, S. (2010). Challenges in transforming manufacturing organisations into product-service providers. Journal of Manufacturing Technology Management, 21(4), 449-469.

43. McAfee, A., & Brynjolfsson, E. (2012). Big data: the management revolution. Harvard business review, 90(10), 60-68.

44. Mont, O. (2004). Product-service systems: panacea or myth?. Lund University. Graham, P. (2005). Web 2.0. Consultado (21/12/2008) en: http://www. nosolousabilidad. com/articulos/Web20. htm.

45. OECD. 2014. Measuring the Digital Economy: A New Perspective. OECD Publishing, Paris.

46. OECD. 2015. Data-Driven Innovation: Big Data for Growth and Well-Being. OECD Publishing, Paris.

47. Patrick Dallasega, "Industry 4.0 Fostering Construction Supply Chain Management: Lessons Learned From Engineer-to-Order Suppliers", *Engineering Management Review IEEE*, vol. 46, no. 3, pp. 49-55, 2018.

48. Pegoraro, D., De Propris, L. and Bailey, D. (2017) Paper on Reshoring Trends and Drivers of Shorter Value Chains. MAKERS Report. Available at: www.makers-rise.org/wp- content/uploads/2017/10/D4.2-Reshoring-protected.pdf.

49. Ponnikas, J., Chaniotou, N., Sarvaranta, L., Valkokari, K., Vilhu, E., Leinonen, M. (2019). Industry 4.0 & SMEs in traditional industries. INNO PROVEMENT project output, Translating Industry 4.0 to improved SME policy instruments *targeting innovation INNO PROVEMENT PGI05280,* .

50. Propris, L. de, and Bailey, D., editors (2020). Industry 4.0 and Regional Transformations Published April 29, 2020 by Routledge, ISBN 9780367178413, retrieved from www.taylorfrancis.com, on 24-7-2020.

51. Provost, F., & Fawcett, T. (2013). Data Science and its Relationship to Big Data and Data-Driven Decision Making. Big Data, 1(1), 51-59.

52. RAMI 4.0 model – The life cycle and value stream dimension – all about industrial data,

53. Roland Berger Consultants (2014). Industry 4.0: the new industrial revolution, how Europe will succeed.

54. Schönsleben, Paul et al. (2017). What benefits do initiatives such as Industry 4.0 offer for production loctions in hihg-wage countries? Procedia CIRP 63 (2017) 179 – 183. 2212-8271 © 2017 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/). Peer-review under responsibility of the scientific committee of The 50th CIRP Conference on Manufacturing Systems doi:10.1016/j.procir.2017.03.356.

55. Schröder, C. 2016. 'The challenges of Industry 4.0 for small and medium-sized enterprises'. Friedrich-Ebert-Stiftun, Division of Economic and Social Policy, Bonn.

56. Schröder, Ch. (2017) The challenges of Industry 4.0 for Small and Medium Sized Enterprises: Friedrich Ebert Stiftung, .

57. Sharma A., Pandey H. (2020) Big Data and Analytics in Industry 4.0. In: Nayyar A., Kumar A. (eds) A Roadmap to Industry 4.0: Smart Production, Sharp Business and Sustainable Development. Advances in Science, Technology & Innovation (IEREK Interdisciplinary Series for Sustainable Development). Springer, Cham.

58. Strategic Policy Forum on Digital Entrepreneurship (2015). Digital transformation of European industry and enterprises, European Commission, 2015.

59. Sung, T.K. and Gibson, D.V. (2000). Knowledge and technology transfer: levels and key factors. Retrieved from Research gate, on 9.5.2020. https://www.researchgate.net/publication/229037546 Theofanis P. Raptis, Andrea Passarella, Marco Conti, "Data Management in Industry 4.0: State of the Art and Open Challenges", Access IEEE, vol. 7, pp. 97052-97093, 2019.

60. Tate, W. L. (2014) Offshoring and reshoring: U.S. insights and research challenges. Journal of Purchasing and Supply Management, 20(1): 66–68.

61. Tate, W. L., Dooley, K. J. and Ellram, L. M. (2011) Transaction cost and institutional drivers of supplier adoption of environmental practices. Journal of Business Logistics, 32(1): 6–16.

62. Tate, W. L., Ellram, L., Bals, L. and Hartmann, E. (2009) Offshore outsourcing of services: an evolutionary perspective. International Journal of Production Economics, 120(2): 512–524.

63. Vandermerwe, S., & Rada, J. (1989). Servitisation of business: adding value by adding services. European Management Journal, 6(4), 314-324.

10 Approval

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Name of the organisation(s) : :

Regional Council of Kainuu, INNO PROVEMENT project PP8

Signatures of the relevant organisation(s):

Pentti Mallinen, Regional Mayor

Jouni Ponnikas, Regional Development Director