Industry 4.0 & SMEs in traditional industries

Contribution to the 2nd thematic component of the INNO PROVEMENT project

Regional Council of Kainuu

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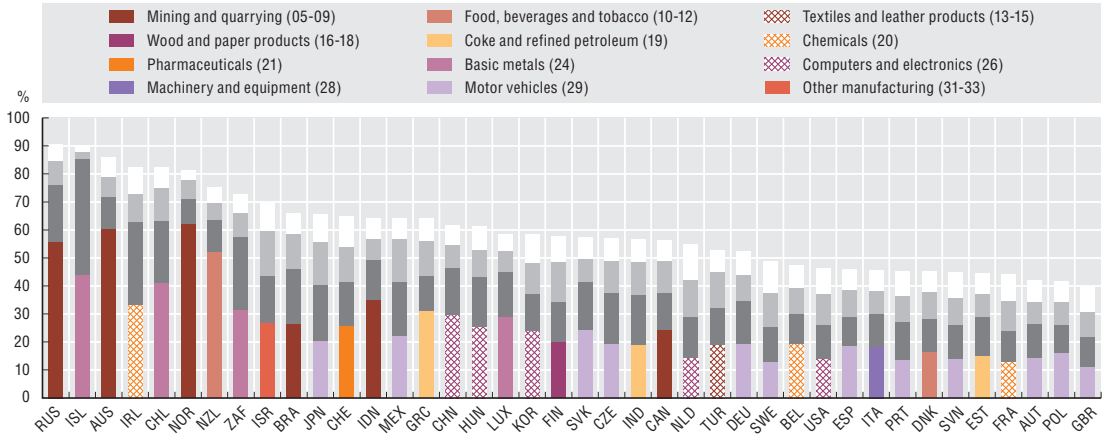
Introduction and positioning of the thematic document

Purpose and aim of the thematic paper

The purpose of the 2nd thematic paper is to discuss one of the seven (7) themes of the INNO PROVEMENT project, namely the 2nd theme, "Introducing Industry 4.0 to traditional industries", coordinated by the Regional Council of Kainuu, PP8 of the INNO PROVEMENT project. While Industry 4.0 (I 4.0 for short) has become a buzzword and a policy priority, uptake of I 4.0 by smaller businesses, active in traditional sectors, needs to be better understood so that it can be addressed more effectively by partner regions development initiatives. The aim of the thematic paper is to contribute to improving this understanding.

Most of the INNO PROVEMENT regions represent economies dominated by SMEs of traditional industries. The term "traditional industries" relates to the technology and knowledge intensity of the main business activities.

Figure 1 Top four exporting industries by country, 2011; as a percentage of total primary and manufactured goods[7]



The classification of industries according to the technology intensity of their main activities is defined by EUROSTAT[8]. According to this definition, businesses are classified into high-tech, medium tech and low tech[9]. Based on the NACE Rev. 2, classified manufacturing and service industries are listed in Annex 1 Classification of businesses according to technology intensity.

Conforming to the INNO PROVEMENT action plan, PP8 organised the scheduled interregional meeting which took place on 17th – 20th June 2019 in Vuokatti, Kainuu, Finland, dedicated to the 2nd thematic issue of the project. The objective of this paper is to review the contributions and lessons learnt from the event and draw

[7] Source: OECD, STAN Bilateral Trade Database by Industry and End-use Category (BTDIxE), www.oecd.org/sti/btd, May 2013. See chapter notes. *http://dx.doi.org/10.1787/888932893221*.

[8] *https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:High-tech_classification_of_manufacturing_industries*

[9] The EUROSTAT classification is aligned with the UNIDO classification: Classification of manufacturing sectors by technological intensity (ISIC Revision 4) http://stat.unido.org/learningCenter.

conclusions linked also to policy improvement recommendations, in view of contributing, eventually, to the formulation of the action plans of the project.

The thematic paper is structured into two parts as follows:

1. **Part 1 Introduction** organised into Purpose and aim of the thematic paper Background, Benefits, Challenges, Industry 4.0 and SMEs and Insights and recommendations sections. Part 1 reminds of Industry 4.0 concepts and through a brief literature review contributes to the classifications and methodology used to analyse contributions in Part 2.
2. **Part 2 Policy learning from the 2nd thematic meeting**

Background

The present thematic paper discusses the uptake of Industry 4.0 by traditional industries SMEs. By the term 'Industry 4.0' is understood the fourth industrial revolution after mechanisation, industrialisation and automation. The central element is networked cyber-physical systems (CPS)[10]. The term "Industry 4.0" became publicly known in 2011, through an initiative named "Industrie 4.0"´. An association of representatives from business, politics, and academia promoted the idea as an approach to strengthening the competitiveness of the German manufacturing industry[11]. It was introduced by Acatech, the German Academy for Science and Engineering (Paul Schönsleben et al, 2017, page 1[12]). It is also called the 4th Industrial revolution[13],[14] a term indicative of the strong automation[15] and data exchange trends in

[10] Erol, S., Schumacher, A., & Sihn, W. (2016). Strategic guidance towards Industry 4.0 - a three-stage process model. International Conference on Competitive Manufacturing 2016 (COMA'16). Page 23.

[11] 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. https://www.thiagobranquinho.com/wp-content/uploads/2016/11/Design-Principles-for-Industrie-4_0-Scenarios.pdf .

[12] Paul Schönsleben et al. / 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.

[13] World Economic Forum, (2018). https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/: "The First Industrial Revolution used water and steam power to mechanize production. The Second used electric power to create mass production. The Third used electronics and information technology to automate production. The Fourth Industrial Revolution is building on the Third. … There are three reasons why today's transformations represent not merely a prolongation of the Third Industrial Revolution but rather the arrival of a Fourth and distinct one: velocity, scope, and systems impact".

[14] Cornelius Baur and Dominik Wee (2015). Manufacturing's next act. Mc Kinsey, June 2015. https://www.mckinsey.com/business-functions/operations/our-insights/manufacturings-next-act.

[15] Time to join the digital dots, 22.6.2018. https://www.aero-mag.com/meggitt-applied-research-technology-group-data-capture/.

manufacturing technologies, or "Industrie 4.0 is a collective term for technologies and concepts of value chain organisation (Hermann et al. 2015[16], page 11).

Industry 4.0 eventually results in full digitisation of the production technologies and business processes, and this is called 'a smart factory': "The Smart Factories that are already beginning to appear employ a completely new approach to production. Smart products are uniquely identifiable, may be located at all times and know their own history, current status and alternative routes to achieving their target state. The embedded manufacturing systems are vertically networked with business processes within factories and enterprises and horizontally connected to dispersed value networks that can be managed in real time – from the moment an order is placed right through to outbound logistics. In addition, they both enable and require end-to-end engineering across the entire value chain." (Kagermann et al. 2013 [17], page 5).

Benefits

Overall, the benefits resulting from Industry 4.0 deployment relate to, overall, more efficient and effective processes in R&D as well as more efficient and effective processes in production.

Paul Schönsleben et al 2017, discusses a number of important benefits, summarised below:

- Maybe the most impressive opportunity comes from the potential for product customisation: "In the future under Industrie 4.0, it will be possible to incorporate individual customer- and product- specific features into the design, configuration, ordering, planning, production, operation and recycling phases. It will even be possible to incorporate last-minute requests for changes immediately before or even during manufacturing and potentially also during operation. This will make it possible to manufacture one-off items and very small quantities of goods profitably" (Kagerman et al 2013, page 21). Additive manufacturing is an example of a tool facilitating this process.
- Additive manufacturing (3D printing, whereby a 3D model is created by CAD software can be used to produce an item by building up successive layers of a material (plastic or metal)). A first benefit is having the potential to produce much more complex components than before. A second benefit is how fast and cheaply new / differentiated product components can be produced. Paul Schönsleben et al 2017 note that "the use of 3D printing to make toys in the private sector, underlines 3D printing's potential for personalised production[18]".
- Personalised medication: personalised medication is a patient-focused process that incorporates both, medication and the dispensing process.

[16] 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. https://www.thiagobranquinho.com/wp-content/uploads/2016/11/Design-Principles-for-Industrie-4_0-Scenarios.pdf

[17] 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 .

[18] Adjusted from Paul Schönsleben et al. 2017, page 3; moreover, "In the next step, the Plattform Industrie 4.0 defines the APIs (application program-ming interfaces) of the Administration Shell. The accessible interfaces provide information about the current status of the object and can change these."

With reference to Additively Ltd., Access to 3D printing, https://www.additively.com.

- In apartment and office complexes or even in shopping centres or hospitals, i.e. collective constructions internet-based building management systems (e.g. light, temperature, humidity) adapted to each individual resident's preferences
- New market is developing fast towards productising components for Industry 4.0 applications (Building the foundations for an Industrie 4.0 ecosystem: Platform Industrie 4.0 publishes a blueprint for the smart networking of assets)[19].

These findings are confirmed and summarised by another author in **Table 1** Evaluation of potential benefits of Industry 4.0 for SMEs, below:

Table 1 Evaluation of potential benefits of Industry 4.0 for SMEs[20]

Type of cost	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%

Impacts on society (social cohesion impacts & readiness)

- Loss of many jobs to automatic processes and IT-controlled processes is taking place, especially for lower educated parts of workforce. Societies are not prepared for this eventuality at this moment: for example, it is being argued that "Many experts suggest that the fourth industrial revolution will benefit the rich much more than the poor, especially as low-skill, low-wage jobs disappear in favour of automation"[21].
- As discussed by Osborne & Frey 2013[22], page 44 "According to our estimates around 47 percent of total US employment is in the high risk category. We refer to these as jobs at risk – i.e. jobs we expect could be

[19] On 27.11.2018, the Platform's experts demonstrated how Administration Shells can help companies integrate their assets (e.g. hardware and software components) in production. In so doing, the Platform is helping to complete the basis for digital ecosystems in which all assets interact interoperable. https://www.plattform-i40.de/I40/Redaktion/EN/PressReleases/2018/2018-11-26-building-the-foundations-for-an-i40-ecosystem.html

[20] Christian Schröder (2017), page 10 (original source: Condensed presentation after Bauernhansl (2014).

[21] Marr, Bernard, (2014). Why Everyone must get ready for the 4th Industrial Revolution. *F*orbes. Retrieved 22-12-2018, https://www.forbes.com/sites/bernardmarr/2016/04/05/why-everyone-must-get-ready-for-4th-industrial-revolution/#5af877b33f90. "By one estimate, as many as 47 percent of U.S. jobs are at risk from automation (The Guardian, 24.1.2016, Fourth Industrial Revolution brings promise and peril for humanity. https://www.theguardian.com/business/economics-blog/2016/jan/24/4th-industrial-revolution-brings-promise-and-peril-for-humanity-technology-davos).

[22] Carl Benedikt Frey and Michael A. Osborne (2013). The future of employment: how susceptible are jobs to computerisation? https://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf.

automated relatively soon, perhaps over the next decade or two". Wolfgang Schroeder 2016[23], page 5 "… *the likelihood of automation is 42 per cent when dire*ctly applying the study to Germany. *By shifting the method to the evaluation of activities instead of professions, the result is less alarming:* about 12 per cent of jobs in Germany are at risk. As regards the risk structure, there are differences by education and income. Employees with elementary and primary education have an automation risk of 80 per cent in Germany; for those holding doctor's degrees, the figure is only 18 per cent").

Challenges

In our understanding there are various types of challenges. They relate to contextual requirements, business models, business readiness, assessment tools, technologies, societal impacts and so on. Below there is discussion of perceived challenges, emphasising an SME perspective for the uptake of I 4.0. However, the focus of this thematic report is on I 4.0 & traditional SMEs. It follows that the discussion in this section emphasises this perspective.

Industry 4.0 and traditional SMEs

The 2nd thematic unit of the INNO PROVEMENT project is dedicated to Industry 4.0 in traditional SMEs'. Industry and services sectors that are classified as traditional or mixed-traditional technologies (see **Annex 1**) account for a large (if not the largest) part of business sectors, products and employment. These are businesses that are classified as medium- or low- technology level. I 4.0, is relevant to these businesses: it affects radically the context in which these businesses operate (regulatory environment, cross cutting technologies, market, research, education, skills, ...) and requires of them to be transformed into high-tech businesses.

The assumption is that traditional SMEs, i.e. businesses that are not high tech and especially smaller businesses, need a more tailored approach in order to benefit from I 4.0. This concern is underlined by research[24] as well as by policy initiatives, as, for example the innovation platform *SME integration to Industry 4.0*[25] of the Joint Research Centre. The priorities of the platform include improving products and services; reducing costs; managing operations in more efficient way; improving competitive positioning of the SME. The platform concept is to reach these priorities through awareness raising, utilisation of platform options, and finally setting up of projects that promote tools, systems and approaches with special focus on monitoring SME production. The table 2 summarizes the objectives of SME integration into Industry 4.0 initiative.

[23] Wolfgang Schroeder (2016). Germany's Industry 4.0 Startegy: Friedrich Ebert Stiftung, FES London.

[24] On-going project *Industry 4.0 for SMEs - Smart Manufacturing and Logistics for SMEs in an X-to-order and Mass Customization Environmen*t, H2020-EU.1.3.3. - Stimulating innovation by means of cross-fertilisation of knowledge. Grant agreement ID: 734713. " Identifying the needs and enablers for a smart and intelligent SME-Factory, creating adapted concepts and design solutions for production and logistics systems in SMEs and developing suitable organisation and business models will be the three main objectives of this research network.". https://cordis.europa.eu/project/rcn/207061/factsheet/en. Project website: http://www.sme40.eu.

[25] http://s3platform.jrc.ec.europa.eu/sme-integration-to-industry. INNO PROVEMENT partners from Hungary and Marche participate in this initiative as well.

Table 2 Summary of the platform *SME integration to Industry 4.0* objectives

Type of improvement	**Strategic axes**[26]		
	Awareness	Platform	Projects
Improve products and/or service			
Reduce costs			
Manage operations in a more efficient way thanks to Production Performance Monitoring			
Improve competition position (access to data and information useful to fasting and better answer to the market needs)			

Source: authors, by adjusting the approach presented in the JRC site http://s3platform.jrc.ec.europa.eu/sme-integration-to-industry.

Our argument is that, while the above approach is a very important step, still, SMEs' motivation and readiness towards adopting I 4.0 require straightforward, tailored business model (-s), and this model is missing. Some of the parametres of such a model are discussed in this section, as they have resulted from the INNO PROVEMENT project policy learning, supported by literature review. It is the day-to-day marginal utility of I 4.0 to SMEs that appears to define their decisions. The parametres that the INNO PROVEMENT project experience has revealed as important are:

(1) Conceptual readiness: The experience from the field-work in the Policy instrument assessment report as well as from another Interreg Europe project (SKILLS+, PGI 00088) indicate that businesses do not have a comprehensive picture of I4.0 as a business development model. Therefore, understanding of what I4.0 means to a business environment, understanding that the issue is not about digital applications to business and production functions but, rather, it is about digitising (automating, self-regulating, self-assessing and interlinking) business & production modules[27], is important to be addressed. In the SKILLS+ project we bridged this understanding by explaining that I 4.0 applications are in reality functions of F(x, y) of two types of variables, x= modularised business & production processes and y=ICT applications. We call this basic notion 'I 4.0 for beginners' (SKILLS+, PGI 00088).

(2) Attitudinal readiness: Besides, understanding of the I4.0 concept, researchers have remarked the attitudes of traditional SMEs towards advanced solutions. Attitudes of businesses to I4.0 or other types of advanced digitisation are continuously studied and analysed and linked to types of industries (traditional or not). Researchers notice, for example, workers (high-tech workers being seen as more creative than the rest of workers); product customization (the actual demands that customers and competition put on traditional businesses indicate that this factor is not really significant);

[26] Inid., above. "**Awareness: making SMEs aware** about the opportunities offered by Industry 4.0 paradigms and about the clear added value of a reinforced cross-border cooperation in these fields; **Platform:** the creation of digital ecosystems based on The Open Source Platform, accelerating time-to-market, speed up innovation and minimise risks, including data collection and analysis; the SaaS approach (Software as a Service) facilitates SMEs' access to innovative digital services without having to invest on expensive infrastructures or licences; **Projects**: promoting tools, systems and approaches that can be effectively integrated within the SMEs production, with a special focus on production performance monitoring systems to gather data so that manufacturing processes can be streamlined.".

[27] The distinction between 'functions' and 'modules/comprehensive output-based units' was a path, identified through another Interreg Europe project (SKILLS+, https://www.interregeurope.eu/skills+/), that facilitated the I 4.0 discussion with traditional, smaller businesses.

management attitude: traditional industries management hesitate to invest (= risk) in advanced technology solutions -even if they are very prepared to improve the quality and competitiveness of their products; moreover, SMEs tend to see investing into new business models with particular caution (Holopainen 2016, Ylhäisi 2017, Harpaz 2004 and Israel 2028, Müller 2017).

(3) Demonstration of relevance: It is important to realise that such attitudes relate also to the perception that traditional SMEs have of costs and benefits of I4.0. For any business, traditional SMEs included, the trade-offs between investments and gains related to Industry 4.0 must be clearly outlined and demonstrated. While Industry 4.0 is an inevitability, business attitudes towards adopting I 4.0 solutions appear to vary according to technology and knowledge intensity as well as size. Despite the cost reduction of ICT and electronics, other costs, related to equipment substitution, infrastructure, and education ("Implementation of the Industrie 4.0 vision will enable employees to control, regulate and configure smart manufacturing resource networks and manufacturing steps based on situation- and context-sensitive targets", Kagerman et al. 2013, page 21), will all be part of the total invested.

(4) Identification of and access to opportunities: Researchers have identified that among the most important reasons for SMEs to adopt I4.0 solutions is linking to value chains (Müller et al 2017, Schlütter and Hetterscheid 2017). Müller et al examine cooperation strategies among SMEs in view of adopting I 4.0. They identify that both cooperation strategies and technologies for cooperation based on I 4.0 are challenging. Often businesses do not seem to consider that cooperation strategies are a priority. The authors recommend (page 314) "For corporate practice, we recommend developing new business models in context of Industry 4.0 working together in cooperation. Also, we advise to consider reorganise corporate culture such as openness to develop business models in cooperation. Further, we suggest policy makers to provide corporate practice with legal conditions such as data standards and data property supporting efforts to work in cooperation". The conclusion is that businesses should be encouraged to develop cooperation strategies.

Our conclusion here, supported by recent research[28], is that we need to emphasise new business models not only technological solutions. Visionary strategies and long-term thinking can help here. Ibarra et al 2018 (pages 6-9)[29], propose ways how this can happen in terms of the different priorities that a business would need to respond to Industry 4.0 adoption. One such important approach is about new value chain participation, page 9, **Figure 2** Changes in Business Model components to achieve the customer interface improvement.

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[28] W.H. Bauer, M.; Schlund, S.;Vocke, C., Transforming to a Hyper-connected Society and Economy – Towards an "Industry 4.0". Procedia Manufacturing. 3 (2015) 417-424.

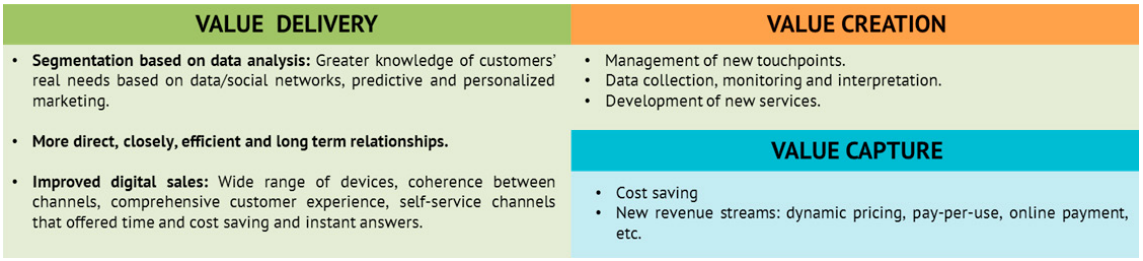
Gerlitz, L., Design Management as a Domain of Smart and Sustainable Enterprise: Business Modelling for Innovation And Smart Growth in Industry 4.0. Entrepreneurship and Sustainability Issues. 3(3) (2016) 244-268.

M.P. Hermann, T.; Otto, B. Design principles for industrie 4.0 scenarios. in Proceedings of the Annual Hawaii International Conference on System Sciences. 2016.

Burnmeister, Ch., Lüttgens, D., Piller, F.T. (2016). Business Model Innovation for Industrie 4.0: Why the "Industrial Internet" Mandates a New Perspective on Innovation. Retrieved on 16.7.2019 from https://www.researchgate.net/publication/312057075_Business_Model_Innovation_for_Industrie_40_Why_the_Industrial_Internet_Mandates_a_New_Perspective_on_Innovation.

[29] Ibarra, D., Ganzarain, J., Igartua, J- I. (2018). Business model innovation through Industry 4.0: A review. Manufacturing Engineering Society International Conference 2017, MESIC 2017, 28-30 June. 11th International Conference Interdisciplinarity in Engineering, INTER-ENG 2017, 5-6 October 2017, Tirgu-Mures, Romania. Procedia Manufacturing 00 (2017) 000–000. Retrieved on 16.7.2019, from Science Direct, https://www.sciencedirect.com/science/article/pii/S2351978918302968.

Figure 2 Changes in Business Model components to achieve the customer interface improvement[30].



The above findings *indicate that for traditional industries, the I 4.0 benefits discussed in **Table 1**, require to be understood better and, especially, to be linked to the business rational of 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 relate the benefits listed in **Table 1** to the cost structure of traditional SMEs, then calculate the real value, and then decide the uptake of tailored I 4.0 solutions, **Table 3**.

Table 3 Linking I4.0 benefits to business costs

Type of cost **1**	**Total value** **2**	**Participation of cost-types into the overall cost of the traditional SME** **3** **3= Type costs/total costs**	**Real value of I 4.0 to an SME** **4** **4= 2*3**	**SME-prioritised digitisation investments** **5**
Inventory cost	-30% to - 40%	Inventory costs (IC)/total cost (TC)	[-30% to - 40%] * IC/TC	
Manufacturing costs	-10% to -20%	MC/TC	[-10% to -20%] * MC/TC	
Logistical costs	-10% to -20%	LC/TC	[-10% to -20%] * LC/TC	
Complexity costs (additive manufacturing, product customisation, …)	-60% to -70%	CC/TC	[-60% to -70%] * CC/TC	
Quality costs (product customisation, personalised medicine, …)	-10% to – 20%	QC/TC	[-10% to – 20%] * QC/TC	
Maintenance costs	-20% to -30%	MC/TC	[-20% to -30%] * MC/TC	

[30] Ibid., above, page 9.

Source: authors, adjusted from Christian Schröder (2017), page 10 (original source: Condensed presentation after Bauernhansl (2014).

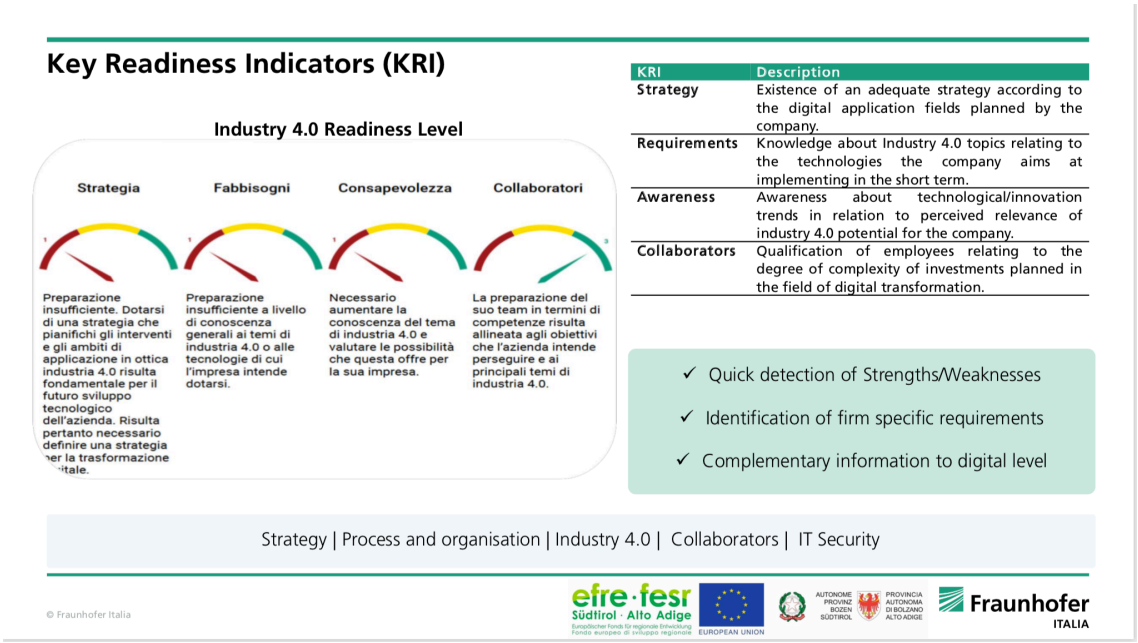
Such an exercise might eventually lead to the identification of a business model bridging the priorities of traditional industries SMEs to the I4.0 concepts and practices. Thus, in addition to the cost structure also SMEs position in the value chain and therefore, the value added their products and services offer to their customers are important elements when considering the new business opportunities delivered by I 4.0.

Industry 4.0 deployment readiness in businesses

In the previous section, considerable attention has been paid to the conditions that frame the readiness of businesses to consider I 4.0. In this section, the readiness steps per se are discussed.

Fraunhofer Italia, in the project I4.0 Roadmap[31] emphasises that "There is no such thing as a one-size-fits-all solution on the way to Industry 4.0, but only firm-specific circumstances". The project itself aims at developing a roadmap to stand by local manufacturing and building sector SMEs throughout the technological and organisational planning of Industry 4.0. The objective was "a new holistic assessment of a firm's technological portfolio and its developments over time, as well as adaptations of processes, workforce and business models towards Industry 4.0". The project analysis goes on to identify the roadmap, **Figure 3** I 4.0 Roadmap project, key readiness indicators (KRI).

Figure 3 I 4.0 Roadmap project, key readiness indicators (KRI)[32].



KRIs assess and classify a business' readiness according to whether the business has insufficient, sufficient or advanced level of readiness in regard to I 4.0 uptake. The roadmap, like other tools comprises sessions of assessment, self-assessment and planning[33]. One important contribution of the approach is explicitly

[31] I4.0 Roadmap [CUP: B53D07000290008], www.roadmap4industrie.it.

[32] Ibid., previous, output *Future needs research*, during the ISPIM2019-Florence 19th June 2019, page 4.

[33] Ibid., previous, output Descrizione del servizio I4.0 Roadmap.

linking to key enabling technologies (KET)[34], an aspect strongly helpful to both businesses and regional and other public policy makers.

Another important part of businesses readiness towards I4.0 adoption is the maturity assessment. Maturity assessment is still not standardised, it is evolving (PriceWaterHouse, Erol et al 2017). There is a forthcoming thematic unit in the INNO PROVEMENT project dedicated to the analysis of the maturity assessment of businesses.

Contextual challenges

Uptake of I4.0 requires systemic facilitation and support, i.e. it requires investments, not just at corporate, but also at government level. Tangible investments for infrastructure and intangible investements for skills are needed. "Implementation of the vision for Industrie 4.0 will require further expansion of the relevant network infrastructure and specification of network service quality through service level agreements. This will make it possible to meet the need for high band- widths for data-intensive applications and for service providers to guarantee run times for time-critical applications". (Kagermann et al 2013, page 22).

Methodological challenges

As already introduced earlier, I 4.0 uptake leads to the Smart Factory – business development model. It implies that "the embedded manufacturing systems are vertically networked with business processes within factories and enterprises and horizontally connected to dispersed value networks that can be managed in real time…"[35]. The deployment of this approach modifies radically business and production processes, requiring standardisation and controlled openness of production (Weyer et al, 2015); corresponding educational competences and standardised knowledge qualifications. Recent literature deals with the need to develop I 4.0 educational standards, including technological, production, value chain and related business services competences[36].

Cross-cutting technological & organisational challenges

These include, for example (adapted from Boner[37], unless otherwise referenced):

- IT security issues, which are greatly aggravated by the inherent need to open up those previously closed

[34] Ibid., previous, output I4.0 Roadmap – Check list for implementation, pages 13-14.

[35] 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 .

[36] Coskun, S., Kayıkcı, Y., and Gençay, E. (2019). Adapting Engineering Education to Industry 4.0 Vision. Technologies 2019, 7, 10; doi:10.3390/technologies7010010 www.mdpi.com/journal/technologies.

Rennung, F., Luminosu, C-T., Draghici, A. (2016). Service Provision in the Framework of Industry 4.0. SIM 2015 / 13th International Symposium in Management. ScienceDirect. Procedia - Social and Behavioral Sciences 221 (2016) 372 – 377 Available online at www.sciencedirect.com1877-0428 © 2016 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Benesova, A., and Tupa, J. (2017). Procedia Manufacturing, Volume 11, 2017, Pages 2195-2202. https://doi.org/10.1016/j.promfg.2017.07.366. Retrieved from https://www.sciencedirect.com/science/article/pii/S2351978917305747, on 15.7.2019.

[37] Bonner, Mike. "What is Industry 4.0 and What Does it Mean for My Manufacturing?". Retrieved 22-12-2018.

production shops; in general: lack of standards and poor data security. (Christian Schröder (2017) [38], page 12).

- Reliability and stability needed for critical machine-to-machine communication (M2M), including very short and stable latency times
- Need to maintain the integrity of production processes
- Need to avoid any IT snags, as those would cause expensive production outages
- Need to protect industrial know how (contained also in the control files for the industrial automation gear)
- Lack of adequate skill-sets to expedite the march towards fourth industrial revolution
- Threat of redundancy of the corporate IT department
- SMEs often lack comprehensive strategy (Christian Schröder (2017) 39, page 4).
- General reluctance to change by stakeholders
- Low top management commitment
- Unclear legal issues and data security
- Unclear economic benefits/ Excessive investment
- Lack of regulation, standard and forms of certifications
- Insufficient qualification of employees
- Interinstitutional relationships clarifications required, resulting from the "impact on product conception, production and distribution, and especially on the way companies create, distribute and appropriate value", Klingenberg 2017 page 1[40].

Insights and recommendations

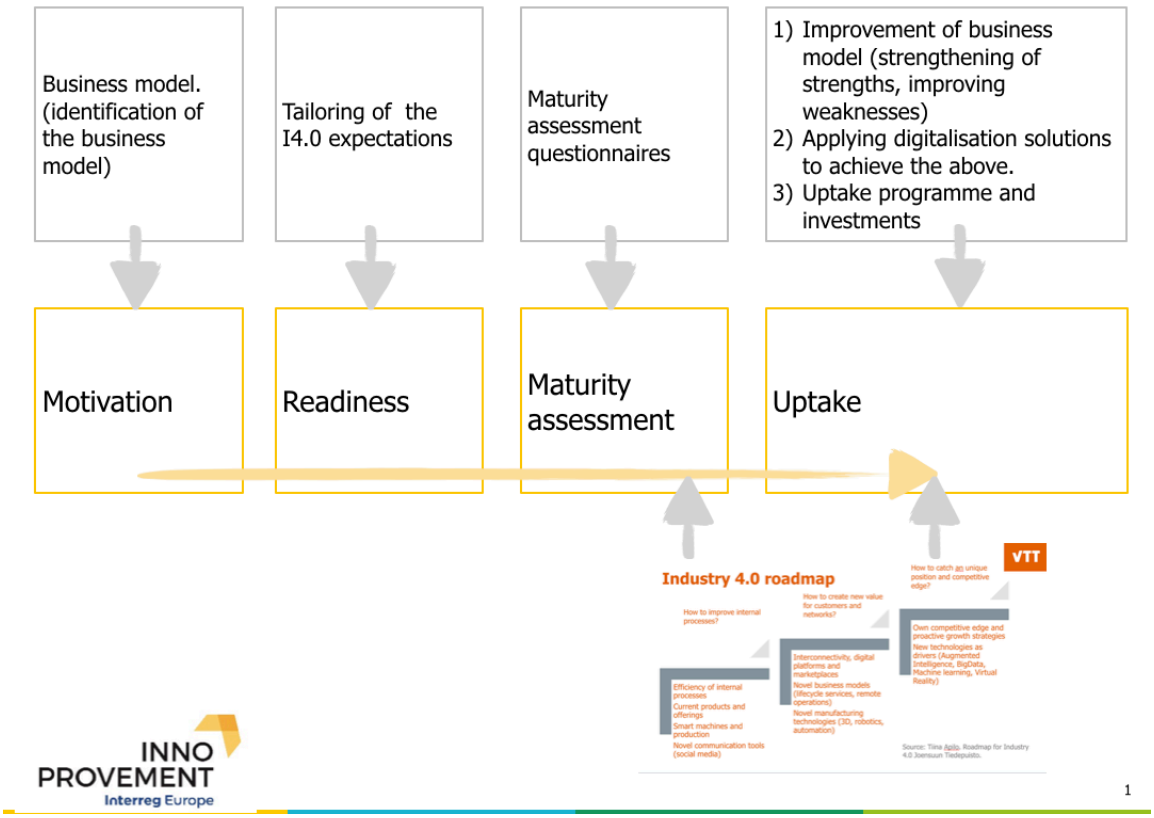
Industry 4.0 presents many opportunities to businesses, even if a number of technological, legal, organisational, cognitive and organisational issues need to be addressed. *Industry 4.0 should be understood and approached as a cross fertilisation process, business x technology, value chain x technology, and on this base it should be optimised for each different case.* In this introductory section, Industry 4.0 benefits, challenges and issues relating to traditional SMEs have been discussed. To this list, we have proposed to add one more field, that of *the business model*. i.e. to become aware of how the Industry 4.0 parametres - for example those listed in Table 1 - match the revenue, costs, and growth objectives of the SME, and make this the start for the I 4.0 adoption by the SME, **Figure 4**.

[38] Christian Schröder (2017) The challenges of Industry 4.0 for Small and Medium Sized Enterprises: Friedrich Ebert Stiftung, www.fes-2017plus.de.

[39] Christian Schröder (2017).

[40] Cristina Orsolin Klingenberg, José Antônio do Vale Antunes Jr. (2017). Industry 4.0: what makes it a revolution: Paper presented in EurOMA 2017, https://www.researchgate.net/publication/319127784.

Figure 4 I4.0 uptake by SMEs, visualisation of a staged approach



The process and steps pathed out in Figure 4 indicate that, from a policy perspective, and when focusing on the adoption of Industry 4.0 by SMEs, we need to address a few earlier steps along the I4.0 path. We have realised this is not sufficiently dealt with until now. Some related insights are listed below:

(1) businesses need to understand better the modules (and eventually the standardization of the modules) that make up both internal and external business processes, and which correspond to I 4.0 parametres. Business processes need to be re-thought in terms of modularised units, and this can be part of a renewed business plan approach

(2) the benefits from I4.0 (for example **Table 1** Evaluation of potential benefits of Industry 4.0 for SMEs) need to be linked and quantified in terms of day-to-day business processes relevant to SMEs (**Table 3** Linking I4.0 benefits to business costs)

(3) mapping the business activities in terms of value chains should be disseminated and competences for the application of this approach should be encouraged

(4) SMEs should start considering and thinking of cooperation strategies rather than 'internationalisation'. It implies that value chain options should be accessible to them. Accessing value chains is not a given. On the one hand paths facilitating access to value chains should be described while businesses should map their activites in terms of value chains

(5) such knowledge (as indicated in items 1 to 4 above) is still not well understood, and there should be education and training for entrepreneurs, students and researchers so that the traditional business plan approach is updated to be I 4.0-coherent

(6) commonly accepted educational and training standards should be developed and qualifications should be acknowledged at interregional level

(7) I4.0 maturity assessment will link naturally to the modularised business processes. However, a systematic, qualified approach assessing the readiness of a business to absorb and benefit from Industry 4.0 is necessary. It would be important to promote suitable qualifications and synergies with already existing good practices, and ensure experts with such validated qualifications

(8) at the same time, regions should be aware of a number of challenges and be ready to invest in needed research and advancements of I 4.0. Policy platforms can be very useful tools for exchanging among regional policy decision makers. In particular, how to build RDI capacity and skills, and how to enhance directionality of actions.

The overarching indication in terms of regional policy, appears to be, at this stage, that (1) regions explicitly integrate uptake of I4.0 into their RIS3; (2) the project funding criteria however, would be good to reflect the findings 1 through 7 above. This approach implies comprehensive, programme – based initiatives, participation in policy platforms, and reinforcing the quest for facilitating access to value chains.

Policy learning from the 2nd thematic meeting

Reminder

The 2nd thematic meeting took place 17th- 20th June 2019, in Kainuu, Finland (Annex 2 Agenda of the 2nd thematic meeting).

The purpose of the meeting was to open up the issue of I 4.0 and traditional SMEs and motivate discussion among the partners. A good practice template adjusted from the Interreg Europe template, was prepared and accepted by the partners (Annex 3 The good practice template of the 2nd thematic meeting). Partners were requested to contribute & discuss during the meeting at least one example of I 4.0 adopted by a traditional industry SME; special reference to the role of policy support to this effort was also included in the template. It was not expected to have perfect good practices, but, rather, to jointly reach better understanding through the policy exchange, and finally, come up with some policy-related conclusions[41].

The 2nd thematic meeting was coordinated by an external expert who represented a Finnish institution with strong competence in I 4.0, including KET technology infrastructures that are networked across EU. **Table 4** Summary of contributions to the 2nd thematic meeting aims at bringing together all the regional experiences including the good practices and the policy issues.

Table 4 Summary of contributions to the 2nd thematic meeting[42]

Partner	Focus of the good practice
Ministry of Finance, Hungary, PP1	Development of technological systems in SMES (applying SMEs, pre-qualification needed) Hungary: Policy activities, feedback from stakeholder meeting. Companies don't need sectoral approach, size of the company is influencing more, policy makers have different views **Addressed policy instrument:** Economic Development and Innovation Operational Programme (EDIOP) Priority Axis (PA) 2 R&D&I Measure 2.1 "Enhancing R&I activity of research and technology intense enterprises" Other relevant policy measures: (1) Economic Development and Innovation Operational Programme Priority Axis 1 SME Competitiveness; (2) Economic Development and Innovation Operational Programme Priority Axis 3 ICT Measure 3.2 "Developed digital economy, IT supported processes in SMEs"; (*3) Open call "Industry 4.0" funded from domestic sources*.

[41] Welcome contribution by Jouni Ponnikas, Regional Council of Kainuu, PP8 contact person, (2019). INNO PROVEMENT meeting_Welcome& Introduction_Jouni (2).

[42] Source of **Table 4:** Summary of contributions to the 2nd thematic meting by the INNO PROVEMENT partners PP1/PP2 (HU), PP3 (CZ), PP5 (IT), PP6 (PT), PP7 (PL) and PP8 (FI). **(2)** Summary material contributed by Katri Valkokari, VTT expert, rapporteur of the meeting; "Katri Valkokari - good practises - workshops -conclusions summary of the GP contributions". VTT is running a number of qualified KET applciation units, https://ec.europa.eu/growth/tools-databases/kets-tools/kets-tc/map. **(3)** Review of all contributions and populating the table, Ninetta Chaniotou.

Partner	Focus of the good practice
	Discussion on the policy focus: - No preferential treatment to traditional industry projects - Projects belonging to Irinyi Plan (industrial strategy with a focus on manufacturing industry) are preferred in EDIOP PA1 - Projects belonging to the National Smart Specialisation Strategy are preferred in EDIOP PA 2 **Good practice, metal industry (forthcoming)** The company is a leader in the market for wet (impregnated) wipes. To keep its leading position, the company needs to continuously improve technology. This is the goal of the proposal. Higher-quality operation can be achieved through the acquisition of more knowledgeable machines and technologies, including production capacity increases, and the creation of state-of-the-art products in parallel with the highest customer service. The investment will result in capacity expansion and process development that follows market needs, improves the company's technological preparedness and resource efficiency, and improves competitiveness. W The equipment needed for this plan is: - • A warehouse system with radio controlled pallet truck, - • Electric forklift and pedestrian powered forklift loading for the new warehouse system. - • A production line for Z-V folded wet wipes, which brings the current capacity to almost double, provides the most up-to-date online connection between the machine and the corporate management system. - • A horizontal single-sheet product, capable of breezing a blind triangle, unique on the market. With this machine, the width of the product range that can be produced and the export ability indirectly increase significantly. - • A line of production of cross-folded wet wipes. With this technology, an advanced online connection is available between the machine and the corporate management system.
Ministry of Industry and Trade, Czech Republic, PP3	**Industry 4.0 and SMEs, background and policy focus** - High demand of manual work (low degree of automatisation) , production costs. - Awareness of P-4.0 is still very low in the business sphere. The case is better for daughter companies with German ownership. - There are differences in the perception of the risk of I-4.0 impacts among companies operating in the CR (inadequate understanding in the management about the strategic value of the I4.0 transformate as change of the whole production system)

Partner	Focus of the good practice
	- Lack of information about I4.0 – SMEs are unable on their own to create their own strategy for the transformation of their business model. Lack of adequate support services and tools to accelerate new technology take-up. - Investing in ICT, new technology solutions, is highly costly, SMEs lack the financial resources for the investment project (also without access to prior testing in real time conditions) - Opportunity for SMEs in the CR to act as suppliers for the modernization of production technologies of large companies - high level of service specialization for integrated systems, advanced sensors, machine vision, etc. - High level of specialization of the Czech industry in the application areas with above average growth potential in electrical engineering and electronics industry, automative, IT and mechanical engineering, IT, which have a large share in employment and can represent the drivers of the internal restructuring of other traditional industrial areas. - Similar Findings to the Finnish partners - Insufficient awareness of I4.0 principles in SME management and lack of understanding through the possibility of getting acquainted with examples of good practice. - One of the project outputs following this baseline regional assessment should be to contribute to better identification and demonstration of best practices of I4.0 SMEs´ implementation, especially regarding the effectiveness of the use of public funding through OPEIC programmes. - Roundtable - necessary to increase not only awareness (e.g. via soft tools) but also strongly to support theoretical and practical preparedness of industrial enterprises (esp. SMEs) within the digitisation process esp. I4.0 in broader context (investment funds continuation and increase). **Good practice contribution, metal company** - Company has adopted and is practicing some level of automation - Company has made some organisational adjustments to modularise business processes - Company has taken steps to operationally link & automate the linkages between/among different modules of the business processes - Company has not gone through maturity assessment. - Before the life time of the project, the current production had very high demands on the manual work of the company employees. As a result, production wasn't entirely effective and the applicant's company didn't fully exploit its market potential. This was related to the limited possibilities

Partner	Focus of the good practice
	in terms of the company's expansion into new foreign markets. Another problem of the company was also insufficient storage space. - Issue ddressed / Acquired Technologies: The robotic chaotic storage, robotic workplace for the sheet metal folding, assembly station for the installation of gate components, CNC automatic dimension unit, wireless network with infrastructure, set of Wi-Fi readers, label printers and MST applications. - The project will have a positive contribution in terms of increasing the production with the current workforce, which also addresses the current low unemployment rates on the Czech market. The acquired technology will also contribute to reducing physical demands on employees working with the technologies. This would also enable to retain personnel to higher age and/or hire personnel with reduced physical abilities.
Marche Region, Italy, PP5	**Contextual issues** - External change drivers (2009 economic crisis etc, Action Plan dedicated to change. Enabled International culture and new business models). - Micro companies, approaching I4, but still don't know what to do - Small and medium, are changing internal processes **Maturity of levels Industry4.0, policy issues** - Top down: national level policies versus bottom up (regional calls) → infrastructures regional clusters, digital innovation hubs, competence centre, I4.0 technology platform - Policy instrument have already classified and grouped potnetial I 4.0 customers into total new-comers to I 4.0 and into businesses that are already partially familiar with digitisation etc. To reflect this in different project lines: - To support a larger number of SMEs (craft business), regional authorities should ask for small digitalization investments in order to allow micro businesses to apply for fundings (dig techs are not expensive…). - To support the cultural change of manufacturing labour force, regional authorities should ask for projects employing trained workers having special skills in Industry4.0 - Project evaluation to understand what already on-going and what SMEs is need **Good practice ALCI, metal industry** - ALCI Group: a pool of small companies specialized in technology supply in industrial environmental, from manufacturing to system integration. - Integrated development (environmental, social and economical sustainability) and work ethic.

Partner	Focus of the good practice
	- Background: the economic crisis that was one of the factors that led to re-structuring needs and rationalisation of the business processes. - Governance: international business culture among the management. - Industry 4.0 uptake, opublicly funded project, comprehensive appropach: *Manufacturing and Labour 4.0" from 2017 to 2019*. The very interesting aim was to implement a digital system that is able to control the entire production machineries. From the field this system measure and forecast the production flow.
COMPETE 2020, Portugal, PP6	**Policy focus:** COMPETE 2020 **Good practice discussion** - Apparel industry, mechanics, involvement of companies to digital transformation. Different needs in each industry and each company has its own way to implement the change towards Industry 4.0. - The presentation dealt with the good practice CETIVE[43] from Portugal: The main problem was the textile crisis in the region during the 90's. The Technological Centre for Textiles (CITEVE) was created in a territory with a great tradition on textiles, to support the modernization and the competitiveness of the textile companies, within a public policy and benefiting from public funds. However by the end of the 90's and the beginning of the 2000's, it seemed that the government abandoned the national strategy to improve textiles in Portugal. CITEVE, the Technological Centre and the companies themselves, supported by citizenship, started a great movement of reinforcement of the modernization of the sector. This idea was backed by the high level group on textiles and the EU Commission, that recommended in a report to foster R&D and innovation for the textiles sector by implementing simpler rules for access of SMEs to R&D and innovation programmes. In 2006, CITEVE created a Department on Innovation management to support R&D and Innovation for the companies by stressing the foundation of CENTI (Centre of Nanotechnology and Smart Materials) in 2009, the CITEVE certification service and the Textile Technology and Fashion Cluster in 2014. This process brought the opportunity for companies producing traditional products shift to innovative materials/products. Nowadays, Portugal is a reference area to produce textiles at international level.
Lodzkie Region, Poland, PP7	**Policy orientation** - The regional assessment carried out by the Lodzkie Region shows that, apart from programs intended for the implementation of high-technology,

[43] Innovation in textile industry/industry 4.0 (CETIVE) good practice was identified through another Interreg Europe project, ecoRIS3 https://www.interregeurope.eu/ecoris3/. The CETIVE GP description is accessiblr at: https://www.interregeurope.eu/policylearning/goodpractices/item/1770/innovation-on-textile-industry-4-0-industry/.

Partner	Focus of the good practice
	very important are also solutions improving the qualifications of employees of SME sector. - The Regional Operational Program for the Lodzkie Region currently offers instruments that take into account the needs of SMEs which want to implement Industry 4.0 solutions both in terms of investment in technology and development of professional competences. - As a part of the Regional Operational Program for Lodzkie Region 2014-2020, investments in innovative technologies are financed from: Priority Axis II "Innovative and competitive economy", measure II.3 "Enhancing the competitiveness of SMEs", submeasures II.3.1 "Innovations in SMEs" and II.3.2 "Financial instruments for SMEs". Improving professional qualifications is financed from: Priority Axis X "Adaptability of workers and companies in the region", measure X.2. "Development of workers and companies" is implemented (submeasure X.2.1 – "Competitiveness of companies and their workers") - The support is addressed to employees of micro, small and medium enterprises as well as self-employed people from the Lodzkie Region. - Subsidising up to 80% of the training budgets of companies, up to PLN 6.000 / ca 1.400 EUR (including the SME's own contribution) per employee. - Funds transferred in the form of development bonuses can be spent on training, vocational courses and consultancy included in the DEVELOPMENT SERVICES LIST. In order to optimize existing solutions, however, it is necessary to develop criteria that will take into account specific requirements of Industry 4.0 Need to launch new product for the markets. **Good practice Multi-Business Enterprise "Elastic" ltd, textiles industry** - Company has adopted and is practicing some level of automation: Automatic textile cutting room with equipment: digitally controlled cutter and textile spreading machine, table with conveyor belt and designing software system. The automatic cutting room enables: (1) automatic spreading of the material and (2) automatic material transfer to the cutter. - Company has made some organisational adjustments to modularise business processes. - Company has taken steps to operationally link & automate the linkages between/among different modules of the business processes. **The main reasons for the introduction of Industry 4.0 solutions**: (1) the need to launch a new product on the market - post-surgery clothing for animals; (2) increasing of production capacity and production efficiency.

Partner	Focus of the good practice
	It was necessary to automate production at the cutting room division - the most important one, which affects further production technology. Preparation of a product for sewing by cutting requires big accuracy, savings on fabrics and speed of production time. These tasks can be managed only by an automatic device. **How it was achieved**: (1) cooperation with the Technical University of Lodz which conducted research on technical indicators of knitted fabric, which post-surgery clothes for animals are cut from; (2) good financial results of the company, Elastic Inc. obtained a bank loan to finance preparatory technical works and the purchase of a machines; (3) co-financing application was prepared and submitted to the Entrepreneur Service Centre in response to the call: Regional Operational Programme for the Lodzkie Region 2014–2020 Priority Axis II "Innovative and competitive economy", Measure II.3 "Enhancing the competitiveness of SMEs", Sub measure II.3.1 "Innovations in SMEs" **Evidence of success**: The most important features of the Automatic digital controlled Cutting Room: - simultaneous cutting of up to 5 cm of pressurized material layers - optimal positioning of the individual garment elements on the fabric - guarantee of almost 100% repeatability - higher productivity at this stage of production leads to increasing production on the scale of the whole company - replacing manual templates by easily transferable and easy to secure templates in electronic form - reduction of production errors and in consequence less production waste; saving of raw materials
Kainuu, Finland, PP8	**Policy focus** - Our perspective is the perspective of regional authorities: we all in this meeting aim at exchanging, learning and reaching evidence-based concepts that can be applied for forming Industry 4.0 uptake policy approaches and project criteria. - One challenge the uptake of Industry 4.0 poses to smaller businesses is that to some degree, we still miss the business model that makes Industry 4.0 conceptually and practically accessible to this type of businesses. **Industry 4.0 policy and how it ıs related to the Kainuu RIS3** - In the Kainuu RIS3, KET are present in a number of cross cutting provisions, as well as in certain of the prioritised sectors. What the Kainuu RIS3 reveals is the potential of local businesses to contribute to the preferred technologies.

Partner	Focus of the good practice
	- However, the uptake of Industry 4.0 as industrial scaling up tool, is not emphasised, i.e. Industry 4.0 is not explicitly mentioned. - In the RIS3, there are references to robotics & the gaming industry, as producers of technological innovations. - INNOPROVEMENT project, came to a very good moment, as we are making the RIS3 revision, and we can stress I 4.0 uptake and ensure as well a related, systemic approach. **Industry 4.0 policy priorities** Project criteria supportive of Industry 4.0 include: - RDI activities in order to show the technological change project is targeting; - RDI cooperation between different RD units or working together with private sector and educational institutions triple helix / quadruple helix; - Smart specialization connections to the programme; - Knowledge intensive activities; - Promoting low carbon economy; - Using digitization as a game changer - Projects are supposed to bring added value to whole region through the implementation of the proposals. **Good practices** **Intermediary,** WOODPOLIS. Woodpolis is development unit, timber-cluster have 14 companies involved, 330 employees all together, export- oriented and energy+ → transparency of agenda and co-learning (support services was identified as important development area), - companies perceived that they have good knowledge about digitalisation (marketing, sales, distribution), - companies identified that digital marketing is topic that can be done together, product development and innovation - case descriptions collected for benchmarking - New partners to collaborate with in order to implement the ageenda identified - Push logic can be utilised to certain level, but companies need to find internal motivation and partners with whom - Project based funding for ecosystem orchestration, company board meetings once a month, companies are funding a part **Technology adoption**: Crosslam company, manufacture of wood, utlisation of automation of production processes.

Partner	Focus of the good practice
	- Company from Woodpolis area, manufacturing CLT (ecofriendly, carbon neutral) - Production process, regional saw mill deliveries all material, synergies between companies (material cycle and complementary products) - Company has gone through maturity assessment. - Digitalisation in production process, as ERP systems were not flexible enough, MES as excel based system, automation of measurement is next step, and 3D designing the further development step (BIM is not usable for manufacturing) - ICT Competences **Technology innovator**: Entrepreneur of a Logistic company, also founder of digitalisation company (ROOLS) – coaching approach, need to - Information is analysed manually, distributed in several places - Learning from industry, big ship turns slowly, small changes needed → idea of spin-off coaching industry "vision is to change the concept of doing work, - Sub-otimization of process is the key challenges, interfaces need to be developed - Generation is changing, how to get work force to manufacturing environment - Energy-efficiency and future forms, total energy efficiency - Agile applications – easy scale up, not huge ICT systems Contracts are signed by younger generation, work force is older and are attached to outdated approaches.

Policy learning: insights from the partner contributions and discussion

Table 5 Insights from the partner contributions

Themes	Conclusions
Policy focus, Priorities for intervention	(1) FRAMEWORK: (1.1) The Structural Funds Thematic Objective 1 is the relevant tool across all the contributing regions. (1.2) Sometimes national funds. (1.3) Industrial policy also linked to I 4.0 project funding

<table>
<tr><td></td><td>(1.4) In general policy instruments have not diversified towards traditional industries. One policy instrument diversifies between I4.0 newcomers (very small businesses) and more mature companies.

(2) FIELD(-S) OF APPLICATION OF THE POLICY INSTRUMENT: Cross-cutting.

(3) TYPES OF PROJECTS

(3.1) Co-funding for equipment (automation)

(3.2) Co-funding for development of skills to support digitalisation

(3.3) Projects that combine equipment automation with skills development

(3.4) Co-funding for digitalisation

(3.5) 5/6 projects developed together with schools of engineering in localised universities

(4) RECOMMENDATIONS BY THE PARTNERS

(4.1) Projects combining more than one ICT-based scaling up interventions

(4.2) Projects diversifying according to types (= ICT maturity) and size of businesses

(4.3) Projects with skills development in the I4.0 applications</td></tr>
<tr><td>Target groups</td><td>(1) INDUSTRIES (traditional industries classified by level of technology[44]).

<table>
<tr><td>Medium-high-technology:</td><td></td></tr>
<tr><td>Manufacture of chemicals and chemical products (20);</td><td></td></tr>
<tr><td>Manufacture of weapons and ammunition (25.4);</td><td></td></tr>
<tr><td>Manufacture of electrical equipment (27);</td><td></td></tr>
<tr><td>Manufacture of machinery and equipment n.e.c. (28);</td><td></td></tr>
<tr><td>Manufacture of motor vehicles, trailers and semi-trailers (29);</td><td></td></tr>
<tr><td>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);</td><td></td></tr>
<tr><td>Building of ships and boats (30.1)</td><td></td></tr>
<tr><td>Manufacture of air and spacecraft and related machinery (30.3);</td><td></td></tr>
<tr><td>Medium-low-technology:</td><td></td></tr>
<tr><td>Reproduction of recorded media (18.2);</td><td></td></tr>
<tr><td>Manufacture of coke and refined petroleum products (19);</td><td></td></tr>
<tr><td>Manufacture of rubber and plastic products (22);</td><td></td></tr>
<tr><td>Manufacture of other non-metallic mineral products (23);</td><td></td></tr>
<tr><td>Manufacture of basic metals (24);</td><td></td></tr>
<tr><td>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);</td><td>3</td></tr>
<tr><td>Repair and installation of machinery and equipment (33)</td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td>Low-technology:</td><td></td></tr>
<tr><td>Manufacture of medical and dental instruments and supplies (32.5)</td><td></td></tr>
<tr><td>Manufacture of food products (10);</td><td></td></tr>
<tr><td>Manufacture of beverages (11);</td><td></td></tr>
<tr><td>Manufacture of tobacco products (12);</td><td></td></tr>
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</td></tr>
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[44] Based on NACE Rev. 2 3-digit level of technology classification, access: *https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:High-tech_classification_of_manufacturing_industries*

	Manufacture of textiles (13); 2 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); 1 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) (2) I 4.0 APPLICATION **INDUSTRY 4.0 READINESS OF THE SME** 1) Company has high level of overall digitalisation 3 2) Company has adopted and is practicing some level of automation 6 3) Company has gone through I4.0 maturity assessment 1 4) Company has made some organisational adjustments to modularise business processes 5 5) Company has taken steps to operationally link & automate the linkages between/among different modules of the business processes 6) Company has addressed I4.0 comprehensive applications already. (3)
Opportunities for focused action (good practices at regional level)	(1) SCALING-UP CURRENT PRODUCTION; improving competitiveness by reducing production cost of current product (mostly happening) (2) SCALING UP BUSINESS TO NEXT LEVEL; awareness raising of I4.0 opportunities (seldom happening) (3) SYSTEMIC APPROACH FOR VALUE CHAIN PARTICIPATION; identification of partners, cooperation strategy (hardly ever happening) (4) INVESTMENT IN INDUSTRY RELEVANT CENTRES OF COMPETENCE; potential of Structural Funds and RIS3 (capital investments not to forget investment in skills)

Discussion issues and policy options as they were raised during the 2nd thematic meeting sessions:

During the meeting, the network analyses were made in order to understand the multi-level and multi-actor needed to enhance the Industry 4.0 utilisation in traditional industry SMEs. The issues discussed were:

- What are the most critical change drivers for SMEs? What kind support do they need?
- What are the most appropriate policy instruments?
- What are the most effective good practices at regional level?

The interests of six different actors groups (SMEs, large companies, intermediaries, policy makers, research&education) were analysed to define, how to engage different players to collaborative development.

It was recognised that place-based networks are a natural forum for these different actors to come together and collaborate and therefore, regional actions that support these are important.

Towards the INNO PROVEMENT action plan

The literature review (Introduction and positining of the thematic document) and the analysis of the contributions to the 2nd Thematic meeting (Policy learning from the 2nd thematic meeting), lead to a non-exhaustive list of possible and hopefully probable policy impact options that could be discussed in the regional stakeholder groups:

a. Industry 4.0 should be understood and approached as a cross fertilisation process, business x technology, value chain x technology, and on this base it should be optimised for each different case.

b. Focus on businesses

c. Businesses need to understand better the modules (and eventually the standardization of the modules) that make up both internal and external business processes, and which correspond to I 4.0 parametres. Business processes need to be re-thought in terms of modularised units, and this can be part of a renewed business plan approach.

d. The benefits from I 4.0 (for example **Table 1** Evaluation of potential benefits of Industry 4.0 for SMEs) need to be linked and quantified in terms of day-to-day business processes relevant to SMEs (**Table 3** Linking I4.0 benefits to business costs).

e. Mapping the business activities in terms of value chains shiould be disseminated and competences for the application of this approach should be encouraged.

f. SMEs should start considering and thinking of cooperation strategies rather than 'internationalisation'. It implies that value chain options should be accessible to them. Accessing value chains is not a given. On the one hand paths facilitating access to value chains should be described while businesses should map their activities in terms of value chains.

g. Focus on education

h. Such knowledge (as indicated in items a to d above) is still not well understood, and there should be education and training for entrepreneurs, students and researchers so that the business plan approach is updated to be I 4.0-coherent.

i. Commonly accepted educational and training standards should be developed and qualifications should be acknowledged at interregional level.

j. I 4.0 maturity assessment will link naturally to the modularised business processes. However, a systematic, qualified approach assessing the readiness of a business to absorb and benefit from Industry 4.0 is necessary. It would be important to promote suitable qualifications and synergies with already existing good practices, and ensure experts with such validated qualifications.

k. Focus on research

l. Regions should be aware of/ invest in needed research and advancements of I 4.0 as a number of challenges have been identified. Policy platforms can be very useful tools for exchanging among regional policy decision makers.

m. Production of innovations is based on research and localised development potential that may also be networked and that may lead to further RIS3 specialisations. Uptake of I 4.0 depends on industry itself. Therefore, for a region to implement targeted improvements, in depth

knowledge is needed of I 4.0 as an enabling tool. "I 4.0 absorbing industry" needs to be there as well.

n. It follows, (item 2), that strong interdisciplinary competences are part of the deployment of I 40 and regions are expected to take into account and support meeting this demand.

o. Focus on regional policy

p. The overarching indication in terms of regional policy, appears to be, at this stage, that (i) regions explicitly integrate applications of I 4.0 into their RIS3; (ii) the project funding criteria however, would be good to reflectmotivations, readiness and maturity on the I 4.0 pathway. This approach implies comprehensive, programmes, participation in policy platforms, and reinforcing the quest for facilitating access to value chains.

q. I 4.0 policy integration means, at this stage, integration into TO1 (or, equivalently RIS3). Regions need to distinguish between uptake of I 4.0 and production of I 4.0 innovations. The two do not always or necessarily meet; for example, some regions might have high software production potential while, at the same time, adoption by businesses of comprehensive ICT-based solutions (such as industry 4.0 for example) might be a challenge. RIS3, then, when relevant, needs to address both realities, Figure 5 Industry 4.0 and traditional SMEs: policy improvement implications.

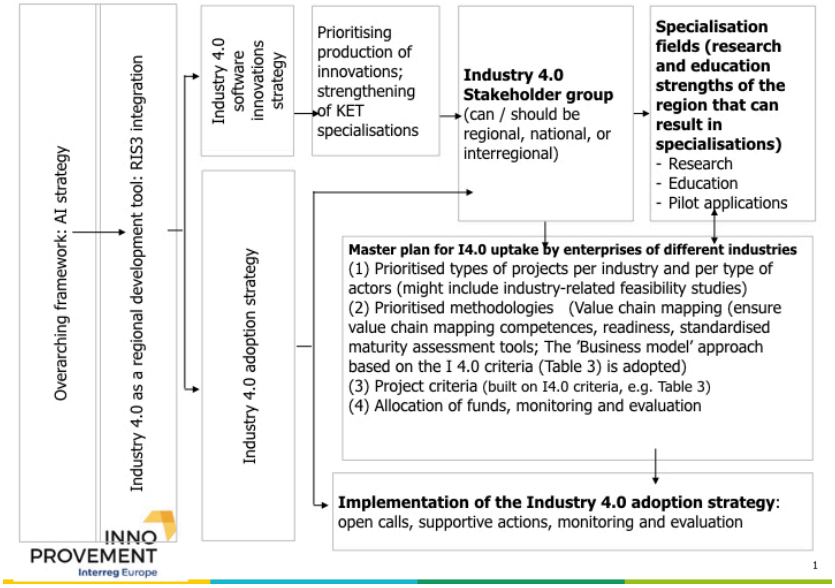
r. INNO PROVEMENT regions, in their contributions, have remarked, in their good practice descriptions that automation demands came from businesses, i.e. from a pool of competitive actors seeking to maintain their position in the market. The structural funds were in a position to support these requests and this is a policy – based good practice per se. In the RIS3, however, there is an explict request for scaling up industries, and it is important to consider including measures for top-down mobilisation as well, especially of smaller businesses, towards I 4.0 adoption. One very good example comes from the good practice CETIVE in Portugal. A centre of competence was set up in order to renew the traditional (and dying out) textile industry. Industry 4.0 applications are part of it. The renewal is achieved by combining industry-related advanced excellence applications and cross-cutting digital solutions (Industry 4.0).

s. It would be important to eventually share and adopt a common language towards adopting I 4.0. For example, business awareness, motivation (concrete business model, Table 3), readiness, maturity, organisational, skills, and equipment investments; the I 4.0 impact fields listed in Table 2 and reiterated in Table 3: Inventory cost, manufacturing costs, logistics costs, Complexity costs (additive manufacturing, product customisation, …), Quality costs (product customisation, personalised medicine, …), Maintenance costs could become part of I 4.0 project criteria.

t. A schematic approach towards integrating I 4.0 into TO1 and / or RIS3 is proposed in **Figure 5** Industry 4.0 and tradtiional SMEs: policy improvement implications.

To make innovation happen, the key ingredients - learning, research and business - have to come together.

Figure 5 Industry 4.0 and tradtiional SMEs: policy improvement implications



Annex 1 Classification of businesses according to technology intensity

I. Manufacturing businesses[45]

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)

[45] 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.

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);
- 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)

II. Service businesses[46]

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).

[46] 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

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;

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).

Annex 2 Agenda of the 2nd thematic meeting

Thematic meeting: Application of Industry 4.0 to traditional industries

June 17 – 20, Hôtel Holiday Club Katinkulta, Vuokatti, Kainuu, Finland

June 17th

Partners arrival and welcome dinner at 19:00 in Hôtel KatinKulta.

June 18th

Time table	Activities
9:00 11:00-11:15 coffee break	1) Welcome (Dr. Jouni Ponnikas, Director Regional Development, Regional Council of Kainuu) and expectations from the meeting (Hungary Ministry of Finance, Lead Partner). 2) Introduction of the theme of the meeting / science-based contribution to the topic: Industry 4.0 and traditional industries, are there tailored solutions? What do we know about applications of I4.0 and types of businesses? Reference to Kainuu state of play regarding Industry 4.0 uptake, technologies and policies. Next steps: Are there concrete principles and paths we should follow? (Dr. Katri Valkokari, Research Manager, VTT Business, innovation and foresight, and Dr. Jouni Ponnikas). 3) Presentation of INNO-PROVEMENT good practices (GP), according to the Interreg Europe good practice template and the jointly agreed criteria that have been also included into the template. One GP contribution per partner region is expected. u. The purpose of this session is to discuss and learn from the partner regions' experiences and efforts in relation to Industry 4.0 applications. (VTT expert Dr. Katri Valkokari is coordinating the discussion and summarising the findings).
12:30 – 13:30	Networking lunch; hôtel Katinkulta.
13:30 – 16:30 *Media is invited and is participating in the discussion* 15:00 – 15:15 Coffee break	1) Case studies from Kainuu: traditional businesses that are involved / have been involved in I 4.0 applications, even if not comprehensively. v. Introduction by Dr. Jouni Ponnikas. The purpose of this session is to share experience & feedback from the businesses' point of view. Presentations by actual businesses include Woodpolis: Tapani Kiiskinen (clustering among Woodpolis businesses as an opportunity for Industry 4.0 applications), Croslam: Miia Korhonen,

Time table	Activities
	FinterPuu: Timo Roininen. Also an ERDF project will be presented; OredVR helps ore visualisation using VR/AR technologies and big data, presenter Jonna Kalermo-Poranen, Kajaani University of Applied Sciences. w. 2) Inputs by knowledge & innovation agencies units: Advanced manufacturing Unit (VTT). Dr. Katri Valkokari is presenting the unit. 3) Bringing together the morning and afternoon sessions: partner discussion and drawing of conclusions; gaining insights towards our GPs and our forthcoming action plans. (Rapporteur of the session is Dr. Katri Valkokari).
19:00	Dinner: Kippo restaurant.

June 19th

Time table	Activities
9:00 – 12:30 11:00-11:15 coffee break	1) The view of the policy makers: comparison of funding criteria to the findings of the 1st day. Indications regarding the potentially needed policy instrument changes. Conclusions. Rapporteur and facilitator of the session is Dr. Katri Valkokari. 2) Interregional Steering Committee and planning of the next meeting (11:15 – 12:30).
12:30 – 13:30	Networking lunch, hôtel Katinkulta.
13:30 – 16:30 15:00 – 15:15 Coffee break	Site visit with presentation (TERRAFAME). The focus of the site visit is how I 4.0 is applied and used in the TERRAFAME plant. Terrafame Ltd is a multi-metal company producing nickel, zinc, cobalt and copper at its mine and metals production plant located in Sotkamo, Finland. One of the key oibjectives of the company is to conduct environmentally sustainable, safe and profitable operations. https://www.terrafame.com/terrafame-ltd.html
19:00	Dinner: Sotkamo, Vuokatti dinner location TBC.

June 20th

Departure of partners

Note: All catering is offered to the INNO PROVEMENT partners by the Regional Council of Kainuu, PP8.

Annex 3 The good practice template of the 2nd thematic meeting

Good Practice template

- In order to submit a practice, you will have to register in the Interreg Europe website. You can submit your practice through your user dashboard ('Good practices' tab).
- Optional fields are shown in **red**. All other fields are compulsory.

1. Author contact information *[Technical: Contact information comes from your community profile. You can edit it by visiting your user dashboard] Ideally, the owner of the good practice should fill in the form. Indeed, if you submit a good practice, your personal and organisational profile in the Interreg Europe community will be linked to it.*	
Name	
Email	
Telephone	
Your organisation	
Country	
Region	
City	

2. Organisation in charge of the good practice *[If your organisation is not the one in charge of the good practice, you can indicate the relevant organisation in this section of the form. But your contact details will still be linked to the submitted good practice.]*	
Is your organisation the main institution in charge of this good practice?*	

In case 'no' is selected, the following sections appear:

Location of the organisation in charge:	*Country*	
	Region	
	City	
Main institution in charge		

3. Good practice general information	
Title of the practice	
Does this practice come from an Interreg Europe Project	*Yes*

In case 'yes' is selected, the following sections appear:

Please select the project acronym	INNO PROVEMENT	
Thematic objective of the practice	*Drop-down list of the 6 specific objectives*	
Geographical scope of the practice		
Location of the practice	Country	
	Region	
	City	

4. TITLE OF THE GP	
Short summary of the practice	*[160 characters] This text works as a preview for the good practice and it will appear at card level.*
GUIDANCE	*We are seeking to have, during in the next meeting in Kajaani, one good practice per partner that to some degree demonstrates Industry 4.0 uptake readiness and level by traditional industries. The term "traditional industries" comes from the classification of economic sectors according to internationally accepted measures of the scope and R&D activity and use of advanced technologies. The purpose is through I 4.0 (for example) to increase labour productivity of traditional economic sectors.* *When identifying SME for the GP description, please make sure they come from traditional industries or mixed-traditional industrial sectors, please utilise references from the medium-high to low technology industries as listed by EUROSTAT reference at https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:High-tech_classification_of_manufacturing_industries*
Detailed information on the practice	*[1500 characters] Please provide information on the practice itself. In particular:* *1. What is the problem addressed and the context which triggered the introduction of the practice?* *2. How does the practice reach its objectives and how it is implemented?* ***3.** Who are the main stakeholders and beneficiaries of the practice?* ***GP DESCRIPTION*** *1.- Please indicate the traditional or mixed – traditional industry in which the SME is mainly active. Please check only one of the options below.* *Table 1 SME profile Based on NACE Rev. 2 3-digit level of technology classification*

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);

	ESTIMATED I4.0 NEXT STEP DEPLYMENT COSTS:
The role of the regional authorities & the structural funds	- *Has the company received any support from any regional / national authority, including the Structural Funds?* - *Was the support satisfactory? What kind of actions did it include?* - *Would the SME expect something better from the support institution?*
Timescale (start/end date)	*e.g. 2010 – ongoing*
Evidence of success (results achieved)	*[500 characters] Why is this practice considered as good? Please provide factual evidence that demonstrates its success or failure (e.g. measurable outputs/results).* • *Does the SME feel that the Industry 4.0 uptake has had good impact on the business and product processes? What were the main benefits?*
Challenges encountered (optional)	*[300 characters] Please specify any challenges encountered/lessons learned during the implementation of the practice.* *What was the most difficult for the business in order to improve its. Industry 4.0 readiness -please mark all those that apply and explain briefly:* - *Finding funds* - *Finding knowledge support including qualified consultants* - *Organisational adjustment, changes within the business processes* - *Training of the personnel* - *Dealing with the personnel that lost jobs as a result of automation*
Potential for learning or transfer	*[Technical: A good practice be edited throughout a project life time (e.g. to add information on the transfers that have occurred)]*
Further information	*Link to where further information on the good practice can be found*
Keywords related to your practice	*Select existing keywords or add*
Upload image	*[2000px wide recommended]*
Expert opinion	*[1500 characters]* ***[to be filled in by the Policy Learning Platforms experts]***

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