Framework development for alignment between research strategy and smart specialization strategy

Funded by
the European Union

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 810318

TABLE OF CONTENTS

Introduction: Background and rationale

It is increasingly clear that our era will be defined as a fundamental pivotal point between two historical phases: the era before COVID-19 and a post-viral period of – as yet – largely undefined and uncharted contours. Today, leading academic, business, and policy circles and seasoned analysts seem to converge around an emerging consensus that we are entering an era where we will witness a thoroughgoing restructuring of the economic and social order in which business and society have hitherto operated. At the same time, we are likely to see the rise of intense debate about what the so-called "new normal" could and should entail regarding the roles, rights, and responsibilities of all stakeholders and key actors in the economy/civil society, the state, and institutions of public governance. For the devastating effects of the virus on human life and the necessary public health measures introduced for its containment across the globe will most likely leave an indelible sense of fragility and uncertainty with unforeseeable consequences for future patterns of social behavior and interaction, powered by disenchantment with the present and new expectations of the future. On the other hand, the dynamic interdependencies between COVID-19 and the emerging structural features of Industry 4.0 raise fundamental questions regarding the future possible scenarios and trajectories of social, economic, and political development on a global scale and its regional and local manifestations.

In this new historical context the document lays out a set of thematic and operational areas in which IN4ACT can contribute to the objectives of Lithuania's Research and Innovation Smart Specialization Strategy (RIS3). The document identifies a list of priorities to be addressed, along with short descriptions of outputs the ERA Chair team can produce that are relevant to the RIS3, and the modalities of engagement with the authorities responsible for the implementation of Lithuania's RIS3 strategy. The main rationale of Deliverable D7.1 is to ensure maximum relevance of IN4ACT to Lithuania's RIS3 strategy throughout the project's life and sustained impact after the project's completion.

The primary frame of reference of the document consists mainly of the official reports of the Government of the Republic of Lithuania and associated agencies involved in the implementation, monitoring and evaluation of the RIS3 – especially the Research and Higher Education Monitoring and Analysis Centre (MOSTA) – today reorganized as the Government Strategic Analysis Centre (STRATA). Unless otherwise indicated all information regarding the formulation and evaluation of the RIS Strategy is directly drawn from these official publications (see References section) and presented in this document – *verbatim* where appropriate – in order to ensure maximum veracity and alignment of the IN4ACT research strategy with the priorities of the RIS3.

The document is structured around five sections: Section 1 outlines the main priorities and challenges/gaps in the implementation of Lithuania's RIS3, specifically as these have been identified by the available official monitoring and evaluation reports. Section 2 lays out the key aspects of the thematic structure of the IN4ACT research strategy along with its operational and implementation plan outlined in Deliverable D3.1 "ERA Chair research strategy (finalized in M16)". Section 3 lays out a "matrix of alignment" of the research output of IN4ACT indicating the areas of support to the priorities and challenges of RIS3. Section 4 briefly indicates the modalities of engagement of IN4ACT with the policy-making and governance structure of

RIS3 – laid out as an indicative plan to be fully developed as the IN4ACT research agenda enters its full implementation phase. Section 5 outlines the operationalization and activities plan which – based on discussions with the top management and research teams of the Ministry of Economics and Innovation, STRATA and Invest Lithuania – are organized around two pillars: 1) the formation of an *Industry 4.0 Business and Policy Data Analytics Hub*, and 2) the launch of *Industry 4.0 Upskilling Program* at the School of Economics and Business of Kaunas University of Technology.

Section 1: Key priorities and challenges of Lithuania's S3 strategy

Lithuania's RIS3 rationale and priorities: Lithuania's RIS3 strategy was officially approved by the Government of the Republic of Lithuania in October 2013. The approved key priority areas of research and (socio-cultural) development and innovation are as follows:

1. Energy and sustainable environment;
2. Inclusive and creative society;
3. Agricultural innovation and food technologies;
4. New production processes, materials and technologies;
5. Health technologies and biotechnologies;
6. Transport, logistics and information and communication technologies (ICT).[1]

The overarching objective of the strategy is to enhance the impact and increase the share of high value-added, knowledge-intensive and highly qualified labor-intensive economic activities in the formation of Lithuania's GDP by introducing structural changes of the economy. This goal is to be reached through the achievement of more specific targeted objectives. These include the development, implementation, and adoption of innovative technologies, products and services, business processes and methods, and by using the outputs of these activities to increase the capacity of Lithuania's economy to respond to emerging global trends and long-term national challenges, and enhance the competitiveness of the country's companies and regions in global markets.[2]

Governance and management of Lithuania's RIS3: The governance of RIS3 in Lithuania is a rather complex structure since there are two ministries and several bodies responsible for economic development involved in the design and implementation of policies. *Fragmentation of innovation policy between many small-scale agencies and the lack of a clear definition of their roles and coordination, as a result, constitute a weakness that needs to be addressed* [emphasis added].[3]

During the implementation of the RIS3 several improvements have been made through the creation of coordination bodies. The main coordinating body for the implementation of the RIS3 is the Coordination Group (established in 2014). The Group is composed of the President's Cabinet, the Ministries of Economy and Education, Science and Sport, the Research Council of Lithuania, the Lithuanian Business Support

[1] Government of the Republic of Lithuania, *Resolution Approving the Priority Areas of Research and (Socio-Cultural) Development and Innovation Development (Smart Specialization),* 14 October 2013, no 951 Vilnius.
[2] Reimeris, Ramojus, (2018). *Interim Evaluation of S3: how we did it?* MOSTA and the Ministry of the Economy of the Republic of Lithuania.
[3] Government of the Republic of Lithuania, *Resolution on the Approval of the Programme on the Implementation of the Priority Areas of Research and (Socio-Cultural) Development and Innovation (Smart Specialisation) and their Priorities*, 30 April 2014 No 411 Vilnius https://www.smm.lt/uploads/documents/en_smm/smartsp/Programme.pdf; Government of the Republic of Lithuania Resolution Approving the Priority Areas of Research and (Socio-Cultural) Development and Innovation development (Smart Specialization) 14 October 2013, No 951 Vilnius https://www.smm.lt/uploads/documents/en_smm/smartsp/Priority%20areas.pdf

Agency, the Agency for Science, Innovation and Technology, the Research and Higher Education Monitoring and Analysis Centre (MOSTA) – today restructured as the Government Strategic Analysis Centre (STRATA) – and academic and business representatives. The role of the Coordination Group, which meets on an *ad hoc* basis to address specific issues, is the supervision of the strategy development and implementation, and making decisions on financing and instruments.[4]

The strategic role of the RIS3 monitoring process is under the jurisdiction of the Strategic Council of Research and Innovation, which is chaired by the Prime Minister and is composed of Government members, university, research and business stakeholders. The Council is responsible for the development of RDI priority areas while the ministries and their agencies are responsible for the implementation of concrete policy instruments that are included in the action plans of each of the thematic priorities. The actual monitoring and evaluation function is divided between STRATA and the Ministry of Economy.[5]

Highlights of the first 2018 evaluation of Lithuania's RIS3: For the first evaluation of the RIS3 strategy MOSTA, together with the Ministry of the Economy, designed and put in place an evaluation system that included monitoring exercises and *ex-post* evaluation through a range of types of analysis such as impact analysis, foresight exercises, and input/output, outcome/impact performance indicators. The system also included plans for mid-term and final evaluations in which results of funded projects and individual policy instruments, their efficiency, outputs of thematic priorities, economic impact of priorities and the strategy were to be evaluated.

In this context, it is important to note that monitoring and evaluation is conceived of as a "policy learning process" that goes beyond accountability purposes, since it includes mechanisms for the introduction of monitoring and evaluation results in the policy-making process. Specifically, the results of monitoring and evaluation are reported to the Coordination Group which has the role of assessing progress and suggest changes in case targets are not being achieved.[6]

The first evaluation of Lithuania's RIS3 was completed in 2018. The evaluation concentrated on four main issues and contexts for analysis: 1) global trends and drivers as challenges for Lithuanian Research and Innovation policy, 2) long-term national challenges facing the Lithuanian economy and society, 3) research potential in Lithuania, and 4) review of the strengths of the Lithuanian economy and the prospects of knowledge-driven growth. These issue areas were mapped on the original RIS3 priorities. The final evaluation map comprised 6 broad fields addressing 20 priorities in total. These were as follows:

[4] https://s3platform.jrc.ec.europa.eu/documents/20182/279010/Background_Lithuania.pdf/2861ee29-7a1e-4865-935b-70f3d92555ca; Research and Higher Education Monitoring and Analysis Centre (MOSTA), (2016). *Lithuanian RIS3: How it was Designed* https://strata.gov.lt/images/Lithuanian_RIS3_Framing_Process.pdf

[5] Reimeris, Ramojus, (2018). *Interim Evaluation of S3: how we did it?* MOSTA and the Ministry of the Economy of the Republic of Lithuania.

[6] Ibid.

1. **Energy and sustainable environment**

- Smart systems for energy efficiency, diagnostic, monitoring, metering and management of generators, grids and customers;
- Energy and fuel production using biomass/waste and waste treatment, storage and disposal;
- Technology for the development and use of smart low-energy buildings – digital construction;
- Solar energy installations and technologies for using them for power generation, heating and cooling.

2. **Inclusive and creative society**

- Modern self-development technologies and processes promoting the formation of creative and productive individuals;
- Technologies and processes for the development and implementation of breakthrough innovations.

3. **Agro-innovation and food technologies**

- Safer food and sustainable usage of biomaterials;
- Functional food;
- Innovative development, improvement and processing of biological raw materials (biorefinery).

4. **New production processes, materials and technologies**

- Photonic and laser technologies;
- Functional materials and coatings;
- Structural and composite materials;
- Flexible technological systems for product development and fabrication.

5. **Health technologies and biotechnology**

- Molecular technologies for medicine and biopharmaceutics;
- Advanced applied technologies for individual and public health;
- Advanced medical engineering for early diagnostics and treatment.

6. **Transport, logistics and information and communication technologies**

- Advanced electronic content, content development technologies and information interoperability;
- ICT infrastructure, cloud computing solutions and services;
- Smart transport systems and ICT;
- Technologies/models for the international transport corridors' management and integration of modes of transport.[7]

Monitoring objectives and methods: During the first RIS3 evaluation Lithuania's innovation system was examined in regional and EU contexts based on innovation indices. Comprehensive monitoring of the RIS3

[7] Reimeris, Ramojus, (2018). *Interim Evaluation of S3: how we did it?* MOSTA and the Ministry of the Economy of the Republic of Lithuania.

was carried along separate areas of the structure of Lithuania's RIS3, the six priority areas and 20 priorities. The monitoring process concentrated on three focus areas:

1. *Economic sectors*. RIS3 representing economic subsectors were – in accordance with NACE[8] – distinguished and mapped in regard of 2010–2014 data and three indicators: 1) value-added created, 2) number of people employed, and 3) material investments.
2. *Research potential*. Current research potential was assessed according to bibliometric data in the period of 2014–2015 (citation, international collaboration indicators, keywords), and the public disclosure of Lithuanian patent applications in the period of 2014–2017.
3. *Research and innovation activities*. Science and business engagement into RDI was identified by observing participation in projects funded by two instruments: Horizon 2020 (2014–2016) and business RDI projects under the Intellect instrument (2016).

Main results of monitoring: Since 2008 the composite indicators of the country's RDI system have improved at the same pace as of the rest of EU Member States. However, growth rates of Lithuania's exports and of the country's GDP are slowing down. The situation of the Lithuanian RDI priorities was assessed based on selected monitoring indicators and RIS3 priorities were assigned according to their results:

- High critical mass – 4 priorities.
- Have potential – 11 priorities.
- Low critical mass – 5 priorities.

High critical mass: Priorities of the high critical mass were characterized by the largest number of Q1 publications (63 to 214), patenting process (33 patents in total), research internationalization (2 out of 3 publications are with foreign co-authors, and the highest financing from Intellect / Horizon 2020 instruments (EUR 20 million). These priorities are:

- Molecular technologies;
- Advanced technologies for health;
- Functional materials and coatings;
- Photonic and laser technologies.

Have potential: Priorities demonstrating potential were assigned regarding some outstanding features. Advanced medical engineering, structural and composite materials, smart energy systems, and solar energy were selected for greater patenting activity (34 patents in total). Energy generation using biomass

[8] NACE (for the French term *"nomenclature statistique des activités économiques dans la Communauté européenne"*), refers to the Statistical Classification of Economic Activities in the European Community. It is the industry standard classification system used in the European Union. The current version is revision 2 and was established by Regulation (EC) No 1893/2006. See Regulation (EC) No 1893/2006 of the European Parliament and of the Council of 20 December 2006 establishing the statistical classification of economic activities NACE Revision 2 and amending Council Regulation (EEC) No 3037/90 as well as certain EC Regulations on specific statistical domains. OJ L 393, 30.12.2006, p. 1–39 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32006R1893

and waste, structural and composite materials, smart transport and ICT systems, digital construction, safer food were selected according to higher number of publications (142 in total).

Low critical mass: The priorities assigned to this group features poor results regarding the indicators mentioned above. Fewer than 1/3 of the funding applications within Intellect instrument met the criteria of RDI or / and RIS3. The priorities with the respective funding are:

- Digital content – EUR 3.3 million
- Implementation of breakthrough innovations EUR 2.7 million
- Educational technologies – EUR 1.7 million
- International transport corridors – EUR 0.8 million
- Biorefinery – EUR 0

As the first evaluation report of the RIS3 strategy stresses two factors had a significant impact on the overall performance of RIS3 activities. First, only some preliminary agreements had been concluded, while several instruments of the RIS3 had not been implemented yet. Second, no quantifiable progress had been achieved under any of the instruments. Therefore, it was not possible at the time to provide any kind of authoritative comprehensive analysis on progress.

According to the evaluation report, compared to the EU average, the strongest aspects of the Lithuanian RDI system are as a follows:

- Good overall economic infrastructure and high quality legal regulation;
- Human resources: Lithuania is distinguished in the EU by some of its education system tendencies: a greater number of the population with secondary education and low pupil-teacher ratio in it; a large share of population with higher education due to the low popularity of vocational education. However, PISA and PIAAC studies by the OECD show that the level of skills of both Lithuanian school students and adults are lower than the EU average;
- Funding and support: Public RDI expenditures in 2015 amounted to 0.72% of GDP (a significant part of which accounted for EU funding) – this indicator corresponds to the EU average. In terms of the volumes of risk capital investment (0.08% of GDP in 2015) Lithuania exceeded the EU average.

On the other hand, in terms of several dimensions of two indices (human resources, funding and support) the Lithuanian RDI system lags significantly behind the EU-28 average. Lithuania's main weaknesses in this respect are as follows:

- International competitiveness of the research system remains low. According to the EIS data of 2015, only 4.5% of the publications of Lithuanian researchers were among the 10% of the world's best quoted publications (EU average is 10.5%). In addition, since 2008, despite annual fluctuations, this indicator has largely remained unchanged. In terms of international scientific co-authored publications per million population, Lithuania is ahead of only three other EU countries. Nevertheless, since 2008, the range of international cooperation initiatives of Lithuanian researchers has grown faster than the EU average. Finally, Lithuanian universities continue to face considerable challenges to attract quality international doctoral candidates in their PhD study

programs: in 2015, doctoral students from non- EU countries accounted for only 1.4% of all doctoral students. Although this picture has improved since 2008, it remains among the lowest in the EU.

- Despite pockets of excellence, knowledge-intensity of the national economy is still low. It is already clear that Lithuania will not achieve the goal of the Europe 2020 strategy to reach 1.9% of GDP investment in RDI.
- The impact of RDI on the national economy and its competitiveness remains comparatively low. Employment in knowledge-intensive sectors has stagnated since 2008. The share of export of knowledge-intensive services and medium-high or high-tech products has not changed in the overall export structure. Corporate revenues from the sales of new products and innovations in private enterprises (within the total turnover) have halved since 2008.

In general, there has been an imbalance in the RDI system in Lithuania over the past decade. Overall conditions have good, the education system well developed and public RDI investments were relatively high. However, *the performance of the RDI system and the impact of RDI on the competitiveness of the country are still relatively poor* [emphasis added]. This indicates a need to review and overhaul the previously applied investment strategy and governance principles of the system.

Overview of the development of economic sectors

Methodological challenges and tentative solutions: The main methodological challenge that faced the first evaluation of the RIS3 strategy was to establish a link between RIS3 priorities and NACE economic indicators [emphasis added]. RIS3 priorities define groups of products, services or technologies, while aggregated economic data is provided about groups of companies or sub-sectors of the economy defined by NACE.

So, monitoring and assessment can rely on two alternatives: 1) direct data aggregation on individual companies which contribute to the implementation of priorities; 2) association of NACE sub-sectors identified in the official statistics (2-, 3- and 4-digit level) with priorities. Since the implementation of RIS3 is only accelerating, it is not clear which companies will contribute to the implementation of the priorities, but as official statistics of the previous years was given, the second option was selected.

The link between priorities and economic sub-sectors for the evaluation was defined according to the following these steps:

1. The links between RIS3 topics and economic sub-sectors were identified in a high tech development (HTD) study (Visionary Analytics, 2014). The study maps the sectors that develop and use products / services technologies proposed in the strategy;
2. The links established in the HTD study were further adjusted by including only those sub-sectors which develop proposed technologies.

The link established in the manner above has two shortcomings. First, the data of the economic sub-sectors is relatively old, the most detailed data (NACE 4-digit level) being from 2014. Second, in terms of the content and scope, NACE sub-sectors are only partially suitable for monitoring the implementation of priorities but relative indicators nevertheless could still be used for monitoring. Large economic sectors are attributed to

certain priorities (digital construction, agro-innovations and food technology, and transport). In addition, for instance, the education sector is at the same time the “developer” as well the “user’” of educational technologies. At the same time, the economic sub-sectors of agro-innovations and food technologies, and smart transport and ICT priorities overlap. As a result, available data can only be analyzed at the level of priority area or group of some priorities. Finally, the sub-sectors related to the advanced medical engineering priority are small and there are no data on them available.

In light of these shortcomings*, the methodology needs further improvement or replacement based on the refinement of key performance indicators (KPIs) of the groups of companies to be examined in subsequent evaluations of RIS3* [emphasis added].

Growth trends: In many sectors of the Lithuanian economy which contribute to the implementation of the RDI priorities, the number of employed staff and the produced value-added in 2010–2014 grew considerably faster than the average, 16% and 55% respectively. Sub-sectors which develop photonic and laser technologies have demonstrated rapid rates of development. The growth in the number of FTE employees was nearly 50% faster than the Lithuanian average. Meanwhile, sub-sectors which develop molecular technologies have been characterized by exceptional value-added growth which has doubled over five years.

However, the sub-sectors which contribute to the implementation of the above priorities are small, which makes it easier for them to demonstrate such impressive growth compared with, for example, the ICT or transport sectors. Among the large economic sub-sectors, those which contribute to the implementation of the digital construction priority enjoyed the most dynamic growth. The number of employees there grew as fast as it did in the rest of the Lithuanian economy. However, their value-added grew particularly fast, at a rate comparable to that experienced in the molecular technology area. The number of employees also grew strongly in sub-sectors which contribute to ICT technology development. Nevertheless, the value-added growth there was slower than the country’s average, as it decreased by 7% (due to extremely strong competition within the telecommunications sub-sector).

The following economic sub-sectors which contribute to the implementation of the three RDI priorities demonstrated poorer value-added and employee change dynamics than the average in the Lithuanian economy:

- *Agro-innovation and food technologies:* poorer performance within the food production sub-sector could have been caused by losses in the Russian market due to sanctions which previously accounted for a substantial share of production.
- *Educational technologies:* state funding for education has a significant impact on the economic indicators of this priority. The number of employees and the added value created by the contributing sub-sectors grew at a slower rate than the average growth rate in Lithuania. In addition, added value in the publishing sub-sector grew even more slowly and the number of employees declined there.

- *Smart energy systems:* poorer indicators of power distribution and transmission sub-sectors in the short term could have been determined by business optimization and price regulation in companies in which the state holds the major share.

Growth prospects: It is likely that in the future, and especially in the context of COVID-19, those sectors which today are highly productive and invest in equipment, machinery, premises, etc. will continue to grow in strength and will remain competitive. Sectors which contribute to the implementation of the following RDI priorities – molecular technologies; smart energy systems; ICT (which covers digital content, cloud computing and services priorities); functional materials and coatings and photonic and laser technologies – demonstrate the highest productivity rates and the largest investments in tangible assets.

The weakest performance has been recorded in the sectors of advanced technologies within health and education. On the one hand, poorer performance can be explained by lower investment and productivity-intensity of service sectors in general. Finally, those sub-sectors contributing to the implementation of digital construction priority make the least use of the investment potential of all the sub-sectors. Although value-added significantly increased, investments in tangible assets were among the smallest within the priority.

Research potential: Regarding the scope of RIS3 publications a total of 761 publications related the topics of the RIS3 priorities of which 721 publications have been assessed by experts as fully corresponding to the priority and a further 40 have been assessed as corresponding partially. A total of 506 publications have appeared in the Web of Science first-quartile (Q1) journals. Compared to the total number of publications prepared by the country which have appeared in Q1 journals in 2014– 2015, the share selected by experts as corresponding to the RIS3 priorities thus account for one third of publications which appeared in Q1 journals (the share could have fallen outside the scope due to the journals selected). Analysis of the distribution of scientific publications by fields of science shows that less than 20% of all medical and agricultural publications have been selected. Meanwhile, 59% of publications in the areas of engineering and technology sciences have been selected as complying with the RIS3 priorities.

The citation indicator of the RIS3 publications is lower than all country's Q1 publications. The normalized citation indicator of Lithuanian Q1 publications is 2.03, and that of the publications which correspond to priority topics is 1.65. This shows that the publications of Lithuanian scientists in Q1 journals are cited twice as often as the world average, while the publications which correspond to the topics of priorities received 38 percent of citations less than all Lithuanian Q1publications. Indeed, the indicator for publications cited at least once is higher among the set of publications related to RIS3. However, it is too early to make generalizations concerning the impact of the scientific papers of RIS3 because they have only been published quite recently (2014–2015).

International collaboration and citation indicators by priority areas: Analysis of the selected publications according to the citation and international collaboration indicators shows that publications of nine priorities are cited more often than the world average. The international collaboration indicator of 13 priorities is higher than the Lithuanian average. In terms of the number of publications, the citation indicator of the largest priority (functional materials and coatings) with its 214 publications is 20% lower than the world

average. Meanwhile, in the area of advanced technologies for health publications are cited almost three times more than the world average.

Distribution of publications in journals by priority areas: The selected RIS3 research papers have been published in 279 different periodicals (from which 187 are Q1 journals). The selected publications on the topics of RIS3 priorities account for nearly one third of Lithuanian papers in Q1 journals. It should be noted that in the areas of medical and agricultural sciences, less than 20% of publications were selected by experts as corresponding to the topics of RIS3. The critical mass of scientific papers focuses on four priorities: molecular technologies, advanced technologies for health, photonic and laser technologies and functional materials and coatings. The international collaboration indicator of these priorities is higher than the average of Lithuanian publications and the citation indicator is higher than the world average (with the exception of functional materials and coatings priority). Nine out of every 10 of the RIS3 publications were prepared by researchers in these institutions: Vilnius University, Kaunas University of Technology, FTMC (Center for Physical Sciences and Technology), and VGTU (Vilnius Gediminas Technical University). The international collaboration indicator of these publications is higher than the Lithuanian average and the VU (Vilnius University), LSMU (Lithuanian University of Health Sciences) and VGTU (Vilnius Gediminas Technical University) papers are cited above the world average.

Performance under the Horizon 2020 program: According to data from October 2016, Lithuanian organizations submitted a total of 1,456 applications as partners and coordinators under the EU research and innovation program Horizon 2020. Of these, 170 applications (12%) received funding. Lithuanian organizations coordinate 25 projects and participate as partners in the remaining ones. Out of 170 funded applications, 94 projects focus on RDI activities and of these 65 applications (69%) are closely associated with the RIS3 priorities. Of the 94 projects dedicated to RDI activities, 65 were identified as being related to the smart specialization priorities of Lithuania. Project allocation to the priorities of RIS3 however is not entirely accurate. In the future, the process and criteria of allocation will be reviewed and improved with the help of experts. Therefore, the allocation of the projects of the Horizon 2020 program in this report is indicative and reflects trends, but are not necessarily completely accurate.

RIS3 priorities based on the statistics of the financed Horizon 2020 projects.

- A significant critical mass has formed in the priorities of solar energy, flexible production systems and molecular technologies. The value of the projects implemented in each of these priorities exceeds EUR 2 million.
- Participants of the solar energy priority are SMEs only and participants of four projects of the flexible production systems priority are research and higher education institutions. The other priorities are dominated only by companies. Only two projects are carried out in the priority of molecular technologies, but their total value exceeds EUR 2 million.
- There is a sufficient critical mass in five priorities – advanced medical engineering, the implementation of breakthrough innovations, structural and composite and functional materials and coatings and the generation of energy from biomass.

Partnerships of Lithuanian organizations: At the time of the RIS evaluation, representatives from Lithuania were participating in 49 Horizon 2020 projects which corresponded to the areas of the RIS3 strategy and which involved international partners. Representatives from Lithuania were participating in five joint projects with Latvian organizations and four joint projects with Estonian organizations. Partners from other EU countries included Slovenia (seven joint projects), Luxembourg (two), and Bulgaria, Cyprus, Iceland and Malta (one joint project). Lithuanian research and business organizations had also implement joint projects with partners in Australia, Canada, Israel, Kenya, Macedonia, Russia, the Republic of South Africa, Taiwan, Turkey, Ukraine, Uruguay and the USA.

Results of the first call under the Intellect instrument: According to its objectives and scope, the *Intellect Instrument* was one of the most important instruments during phase of the implementation of the RIS3 being evaluated. It was designed to encourage companies to invest in RDI activities for the development of innovative products, services or processes, and to promote the growth of companies and the establishment of new innovative companies by investing in RDI infrastructure and its development. Companies may carry out RDI activities in conjunction with partners (research institutions, universities and private legal entities). A total of EUR 60 million was allocated to the first call for proposals under the Intellect instrument. The maximum amount of financing per project is up to EUR 4,200,000. Applications may be submitted by private legal entities or public institutions which carry out RDI activities. Research and higher education institutions cannot be the main applicants.

Potential of Intellect Instrument priorities to contribute to the implementation of the program: The potential of priorities to contribute towards the strategic goal of the RIS3 Program – to promote structural change within the Lithuanian economy – was assessed on the basis of two criteria:

- Business commitment to invest in RDI. This criterion shows whether the priorities set by the state correspond to the investment priorities of knowledge-intensive businesses. This can be measured by the business investment volumes specified in applications which successfully passed the first selection phase, i.e. applications which correspond to the RDI and RIS3 criteria.
- Critical mass of investment allocated by the state. RIS3 priorities may promote structural changes in the economy only if there is a critical mass of investment, i.e., if a significant number of projects are financed and significant financing is allocated for their implementation.

When assessing the results of the *Intellect Instrument* on the basis of both criteria, RIS3 priorities can be divided into four categories:

- Critical mass and a breakthrough potential are achieved: priorities of molecular technologies, flexible production systems, and advanced technologies for health. More than 10 projects are financed under these priorities. State investment is more than EUR 3.5 million, and business commitment to invest (applications selected in stage one) was more than EUR 5 million.
- Forming of the critical mass and potential: priorities of digital content, photonic and laser technologies, functional materials and coatings, advanced medical engineering, safer food, smart energy systems and structural and composite materials. From four to nine projects are implemented under these priorities, with state investment ranging from between EUR 1.5 million

and EUR 3.5 million and businesses planning (applications selected in stage one) to invest at least EUR 2 million.

- A small critical mass: priorities of educational technologies, implementation of breakthrough innovations, cloud computing and services, functional food, generation of energy from biomass, digital construction, smart transport and ICT systems and International transport corridors. A small number of relatively small projects are financed and the business commitment to invest in many of these priorities was less than EUR 1.5 million.
- No funding was allocated to the projects of two priorities: solar energy and biorefinery. Business commitment to invest in RDI in the solar energy priority was very small. It is likely that the promoters of this priority submitted applications under another priority for solar energy administered by LBSA.

Thematic concentration: Analysis of thematic concentration helps identify whether projects financed within the scope of the same priority aim to develop the same or different technologies, products, services etc. The higher the concentration, the greater the likelihood that synergies will form between the financed projects, resources will be concentrated and a critical mass will be achieved for structural changes within the economy. *The thematic concentration in the priorities of the RIS3 has been limited* [emphasis added]. Only three priorities (flexible production systems, advanced technologies for health and digital content) had two technologies in the same area, which will be implemented in more than three projects. Most of the projects representing different priorities are developing different technologies and there is no technology that would repeat in the applications more than three times.

Further steps in developing the monitoring system: During the implementation of the program, when new data is accumulated, quantitative monitoring and assessment will become more accurate and detailed. The obtained results will also be supplemented with the results of the science and business cooperation survey. *It is extremely important that, in cooperation with the State Tax Inspectorate, R&D expenditure data declared by businesses will be used to assess the scope of RDI activities* [emphasis added].

When developing the monitoring system, the following two aspects should be emphasized:

1. *A need to identify the main shortcomings and to supplement and refine existing monitoring indicators* [emphasis added]. The necessary condition for the new proposed indicators is the ability to analyze them within 20 priorities. The system of monitoring should remain transparent and simple still.
2. *The need to ensure a systematic and unified codification of the RIS3 projects by topics and thematic specificities* [emphasis added]. Due to the fact that the implementation of the projects has not yet started, it was not possible to perform monitoring of the criteria planned in the priorities' action plans. When implementation starts, monitoring will be of a more technical nature. In order to ensure such monitoring, during applications assessment phase implementing agencies must clearly identify the RIS3 priorities and thematic specifies (financing should actually be allocated by topics).

Baltic Sea Region initiatives for RIS3: The Baltic Sea Region is home to 85 million inhabitants which accounts for 17 percent of the EU's total population. One of the objectives of the EU Strategy for the Baltic Sea Region (EUSBSR) is to promote it as a globally competitive location for research and innovation for

sustainable economic growth. Three overall goals guide this macro-regional cooperation: “Save the Sea”, “Connect the Region” and “Increase Prosperity”.[9]

Operating on a macro-regional scale, the role of policy area innovation is to: 1) Enable shared learning through knowledge-transfer activities, 2) Create and strengthen networks across the Baltic sea region, 3) Align resources and regulations e.g. through co-ordination of funding sources, and 4) Facilitate the joining up of forces in common programs and investments

The Baltic Institute of Finland is assigned with the responsibility of coordinating the policy area together with Ministry of Economic Affairs and Communications in Estonia and the Ministry of Science and Higher Education in Poland. The Policy Strategy Guide, 2016-2020, aims to provide policymakers and innovation actors with guidance and inspiration for how best to utilize the EU strategy on the area of innovation.

The Baltic Sea Region Smart Specialization Strategy ecosystem (BSR S3 ecosystem):

- In the current 2014-2020 EU programming period, the BSR has embraced the RIS3 policy agenda to support collective innovation ambitions across the macro-region.
- Joint efforts are helping to better define industrial strengths, accelerate innovation ambitions, develop a BSR-wide value chain orientation and enhance the profile of the BSR as an innovation partner of choice within and beyond the EU.
- Following the announcement of the European Commission’s draft proposals for post-2020 Cohesion Policy, it is widely expected that the EU will commit to a stronger RIS3 policy agenda, through innovation-focused interregional collaborations and investments. This reinforces the BSR’s RIS3 approach and ambition.
- By building previous work and successes the macro-region has a strategic opportunity to strengthen its RIS3 approach with enforcing pan-Baltic value chains, and to create an innovation ecosystem with strong and sustainable foundations.[10]

Section 2. Main research objectives and targeted impact areas of the IN4ACT research strategy

The main organizing concept of the IN4ACT research strategy is that Industry 4.0, as a core aspect of what is increasingly referred to as the Fourth Industrial Revolution, is a long-term systemic process that is bound to significantly affect the entire range of business management practices and economics regardless of the industrial sector in which firms are located as well as the institutional contexts in which they operate. Its implementation depends fundamentally on putting into place a wide-ranging set of ‘enabling framework conditions’. These range from technological infrastructures, standardization protocols across digitized

[9] https://s3platform.jrc.ec.europa.eu/documents/20182/369046/Esa+KOKKONEN-EUSBSR+10.19.pdf/0259103a-9183-41c7-aa5e-825183b04169

[10] Ramojus Reimeris, (2018). *Interim Evaluation of S3: how we did it?* MOSTA and the Ministry of the Economy of the Republic of Lithuania; MOSTA and the Ministry of the Economy of the Republic of Lithuania, (2017). *Lithuania Smart Specialization Strategy: Progress First Report*, Vilnius.

systems, security/protection of know-how, new business models, novel forms of work organization, new skillsets, and governance, legal and regulatory frameworks at regional, national and EU levels. In addition, the implementation of Industry 4.0 will require sustained engagement with and buy-in from all key stakeholders across private and public spheres. In other words, the realization of the potential of Industry 4.0 is dependent on the reconfiguration of existing structures of production, civil society and public administration.

In this context, the strategy seeks to extend beyond traditional research and scientific disciplinary boundaries. On one hand, this involves the adoption of an interdisciplinary perspective transcending traditional forms of academic specialization; on the other, it demands sustained engagement with stakeholders and social actors beyond the boundaries of academia, i.e., systematic engagement with the world of business, civil society, and institutions of governance, policy and regulation. This is the methodological principle underlying the IN4ACT research strategy.

Given the scale, breadth, and systemic nature of the process of transformation associated with Industry 4.0, the IN4ACT research strategy is structured around three operational levels that leading international research considers as having a decisive influence on the future prospects of Industry 4.0: the *micro-level* (the level of the firm), the *meso-level* (regional economic and innovation ecosystems), and the *macro-level* (systems of governance, policy, regulation, and sustainability). The research streams on each of these levels are organized into sub-streams of specialized research domains. These streams should be considered as conceptual orders, not as actually existing compartments, since any of the identified research domains under any specific stream is likely to be in interaction with, and influenced by, other areas under different streams.

The levels, along with the identified key research streams, are as follows:

Level I: Micro-level: Industry 4.0 at the level of the firm, functions and phases of production:

I. 1: The decomposition/re-composition of production and the changing value composition of Global Value Chains (GVCs). The main research priority in this sub-stream concerns the changing calculus of opportunities and threats of specific business profiles and value propositions. The emergence GVCs and production networks mean that the relevant unit in economic analysis is no longer the industry or sector but the “business function” or “activity” along the supply chain. Countries, regions and companies increasingly tend to specialize in specific business functions or activities rather than specific industries. The rise of GVCs illustrates why specialization no longer takes place solely in industries but in specific functions or activities in the value chain.

I. 2: Artificial intelligence, cloud computing, big data, algorithmic models, and the Internet of Everything. The main research subjects is this sub-stream are the functions and uses of predictive analytics, the technological and organizational characteristics Industry 4.0 organizational forms, and their implications for different business activities such as knowledge management, marketing and human resources, among others. Taken together, big data, algorithmic models and the Internet of Everything embody considerable transformative potential as they are changing the basis of competition, redrawing industry boundaries and creating openings for new waves of disruptive companies.

I. 3: The platform economy, its typology and economic specificity. This research sub-stream explores the nature of the "platform economy". A central characteristic of Industry 4.0 is the rise of global platforms that are structurally connected to the physical world. Platforms are hybrid structures of software, hardware, operations, and networks. A fundamental feature of platforms is the presence of network effects: as more users engage with the platform, the platform becomes more valuable and attractive to potential new users. This is one of the main reasons why some platforms have experienced viral growth. At the same time, platform enterprises have been disruptive as they have upended numerous brick-and-mortar chains and are making deep inroads into other traditional industries. And it is these new business models and the ecosystems being built around them that are driving a profound change in the global macroeconomic environment. For platform ecosystems constitute the foundation for new value creation in the digital economy.

I. 4. Platform economy business models. This research sub-stream examines the defining characteristics of the "platform economy" business model. The business model that dominated much of the postwar industrial era was centered on the corporate imperative for growth, scale, vertical integration and hierarchy attached to "job ladders", it was asset-heavy, and its performance was measured by industrial "territory" and market "footprint". The platform economy consists of enterprises with a variety of business models targeting a wide range of market segments. There are, however, certain key common elements to them. Even though with variations across different domains, the dominant business model of the platform economy is "ICT-and algorithm-heavy", "finance-heavy" in the sense that company "size" relates predominantly to market capitalization value, "asset-" and "labor-light" and oriented toward market capture in the form of monopoly (Google, Facebook) or monopsony (Amazon). The sub-stream also explores the ramifications of the platform economy business model for the rest of the "old" economy.

I. 5 Industry 4.0. as a matrix of risk and opportunity (with added emphasis on SMEs). This sub-stream concentrates on certain key elements of Industry 4.0 with specific emphasis on SMEs. These include: technological, organizational, and strategic management challenges, business model (re)design, management challenges concerning security and protection of know-how, risks of loss of control (to larger firms), reduced independence, flexibility and adaptability, performance measurement methodologies.

Level II: Meso-level: Industry 4.0 at the level of regions and regional innovation ecosystems:

II. 1. Centralization vs. decentralization in Industry 4.0. This research sub-stream explores the sets of challenges and opportunities arising from the platform economy for regional economies and innovation ecosystems. These hinge on whether "domain expertise", that is deep knowledge about a single industry, which tends to concentrate in specific cities or regions, will continue to hold competitive advantage in the foreseeable future. One issue of fundamental importance, in this context, concerns the dynamics of centralization vs. decentralization of the platform economy and Industry 4.0 and their locational implications for existing as well as emerging industries.

II. 2. The changing economic geography and its implications for regional business ecosystems. This research sub-stream delves deeper into the impact of the Industry 4.0 on economic geography. Recent

research indicates that the technologies and economic activities Industry 4.0 brings in its path are reshuffling the ranks of cities and regions across the globe. The dominant trend is concentration. Indeed, the extent to which economic activity has become concentrated in the world's cities and metropolitan areas is astonishing. Even though it is probably too early to confidently predict specific patters of change, research shows that as capitalism's spatial division of labor – the distribution of economic activities across geographical locations – becomes more finely honed, fewer and fewer cities and regions are able to hold on to the most economically valuable activities and niches.

II. 3. Commoditization and "smart specialization". This sub-stream explores the reverse side of this: the process of commoditization and the responses to it, that is, strategies of 'smart specialization'. If the highest portions of the GVCs lead to concentration and centralization of high value-added activities anything below is becoming subject to varying degrees of commoditization. The decomposition of manufacturing and services, outsourcing, and the spatial distribution of production activities around the globe, coupled now to the integration of cloud computing, big data, algorithms and the Internet of Everything in the productive process have unleashed a process of commoditization across the countries of advanced capitalism. Result? Increasing difficulty of value-added differentiation in GVCs, price-based competition throughout markets for standard goods and services, and pressure on wages and profit margins alike, not only for companies but for entire regional economies and innovation ecosystems across advanced countries. A key question here – probably of an existential nature for some regions – is: is smart specialization likely to provide a sustainable counterweight to the reinforced dynamics of commoditization associated with Industry 4.0?

II. 4. Symbiotic vs. parasitic ecosystems. This sub-stream is structured around two questions regarding the adequacy of smart specialization as a framework supporting sustainable innovation in the context of Industry 4.0. First, smart specialization stresses, correctly, that innovation is an ecosystem phenomenon. However, it does not specify the exact role each actor plays in the risk landscape of innovation. Many errors of current innovation policy are due to placing actors in the wrong part of this landscape – both in time and space. For instance, is venture (private) capital the appropriate form of finance for all types of innovation in the emerging technologies? Or is it the case that "patient" (public) investment is more appropriate in some critical technology areas with longer maturation cycles? Second, how can smart specialization ensure that increased investments by the state in the innovation ecosystem will not result in the private sector investing less, and using its retained earnings to extract short-term profits instead of in riskier areas like human capital formation and R&D, to promote long-term growth? In this context, one important research subject concerns the differentiating characteristics of ecosystems that foster a "symbiotic" relationship between public and private sectors from ones that foster a "parasitic" one.

Level III: "Macro-level: Industry 4.0 at the level of governance, policy, regulation and sustainability:

III. 1. Comparative readiness for Industry 4.0: assessment and measurement methodologies. This sub-stream focuses on how countries across the EU and internationally respond to the management and policy challenges presented by Industry 4.0 and their strategies to leverage production as a national capability. The research focus is on the comparative readiness for Industry 4.0 by elaborating and applying the World Economic Forum's *Readiness Diagnostic Model Framework*. Readiness is generally regarded as the ability to capitalize on future production opportunities, mitigate risks and challenges,

and be resilient and agile in responding to unknown future shocks. The assessment is made up of two main components: *structure of production* (complexity and scale), or a country's current baseline of production, and *drivers of production* (technology and innovation, human capital, global trade and Investment, institutional framework, sustainable resources, demand environment), or the key enablers that position a country to capitalize on Industry 4.0 to transform production systems.

III. 2. The future of work: Industry 4.0 skillsets. This sub-stream concentrates on the impact of the technologies and business models associated with Industry 4.0 on employment and skills. Research shows that the global labor share of national income has been in decline since the early 1980s, and this is occurring within the large majority of countries and industries. It has to do, partly, with the decline in the relative price of investment goods. Underpinning some of these developments is the decline in medium-skilled routine jobs in recent years reflected in the polarization of skills in demand and labor market dynamics, effectively leading to the hollowing out of middle-class jobs. This is one aspect of a deeper fragmentation of the labor process itself. This involves a shift from the "death of the career" and its replacement by "jobs" with employees often moving from firm to firm, or working as independent to a shift from jobs to "tasks" to be performed under task-oriented contracts. The main research subjects here are: skillset requirements of Industry 4.0, comparative vulnerability of skills and occupational profiles to obsolescence due to Industry 4.0, the design of work processes and workplaces, skills and training needs at firm level, the role of migration in assisting Industry 4.0 processes, human resources management, and national education/training strategies

III. 3. Industry 4.0 and socially inclusive development: the challenges of rising inequality and the threat of social exclusion. This research sub-stream concentrates on the subjects of inequality and social exclusion. Both have been consistently identified by most observers and analysts as a major force of potential destabilization that could challenge and even reverse globalization in its current form but also the prospects of the Industry 4.0 for the next decade. The key research areas of the sub-stream are: increasing levels of inequality within firms and society and its policy and management challenges for Industry 4.0. initiatives, social exclusion and geographic segregation by income, education, and class, and strategies of socially inclusive development.

III. 4. Governance: regulation, innovation and sustainability. This research sub-stream explores emerging issues related to governance, regulation and sustainability. The broad changes brought about by digital technologies and the pervasive effects of big data and the algorithmic models that manage them are giving rise to major challenges for institutions and governance structures of the economy and society. Secret and proprietary algorithmic models are beginning to govern human behavior in increasingly larger areas of economic, social and, indeed, political life. The core research subjects of the sub-stream are: the challenges of algorithmic models for the application of policy and regulation, standardization challenges, competition and anti-trust regulation, the emerging challenges of monopoly and monopsony, labor law and consumer protection, global governance regarding big data and the platform economy, social accountability and legal compliance (e.g., GDPR), energy and environmental implications of Industry 4.0., inter-state tensions regarding the collection, storage and uses of data, the circular economy and sustainability.

This research strategy is currently being implemented through an elaborate operational and stakeholder engagement plan that is composed of two broad areas. The first addresses three communities that play

a critical role in the implementation of Industry 4.0 specifically, and Lithuania's RIS3 more generally: 1) universities/research centers, 2) key actors and associations of the world of business and civil society, and 3) key policy-making and regulatory bodies – all at national (Lithuania), EU and international levels. The second part involves engagement and dissemination streams of activity designed to achieve maximum impact of the results of the IN4ACT project. These are: 1) participation in external funded research schemes (Lithuanian, EU, and others), 2) sustained participation and presentations at high-level international conferences, and 3) publications at high-level academic journals and management and policy-relevant publications and position papers in professional journals and official publications.

Section 3: Matrix of alignment between Lithuania's RIS3 strategy and IN4ACT research strategy

This section provides an outline of a "matrix of alignment" between Lithuania's RIS3 and the IN4ACT research strategy indicating the areas of support to the priorities and challenges of RIS3. It is important to note that the matrix is an initial mapping of estimated support areas. It is expected that it will be revised and further refined as IN4ACT and the RIS3 enter into more systemic dialogue for cross-fertilization of insights and experiences.

LT RIS3 Priorities and Challenges	IN4ACT alignment and contributions
Addressing the imbalance in Lithuania's RDI system: Since 2008 the composite indicators of Lithuania's RDI system have improved at the same pace as of the rest of EU Member States. However, growth rates of exports and of GDP are slowing down. The effect of RDI on the national economy and its competitiveness remains relatively low. Employment in knowledge-intensive sectors has stagnated since 2008. The share of export of knowledge-intensive services and medium-high or high-tech products has not changed in the export structure. Corporate revenues from the sales of new products to the market and innovations in private enterprises (within the total turnover) have halved since 2008. In general, there has been an imbalance in the RDI system in Lithuania over the past decade: overall conditions were good, the education system well developed and public RDI investments were relatively high. Nevertheless, the performance of the RDI system and the impact of RDI on the competitiveness of the country are still relatively poor.	The IN4ACT research strategy can provide support through the research activities organized under stream "Macro-level: Industry 4.0 at the level of governance, policy, regulation and sustainability", specifically under sub-streams III. 1. Comparative readiness for Industry 4.0: assessment and measurement methodologies and III. 4. Governance: regulation, innovation and sustainability.
Addressing the weaknesses of the RDI system: Compared to the EU average, the strongest aspects of the Lithuanian RDI system are as a follows: good overall economic infrastructure and high quality legal regulation; human resources: a greater number of the population with secondary education and low pupil-teacher ratio in it; a large share of population with higher education due to the low popularity of vocational education. However, based on OECD analyses and evaluations the level of skills of both school students and adults are still lower than the EU average. In terms of the many dimensions of two indices (human resources, funding and support) the Lithuanian RDI system lags significantly behind the EU-28 average. Lithuania's main weaknesses in this respect are as follows: international competitiveness of the research system remains low; despite pockets of excellence, knowledge-intensity of the national economy is still low.	The IN4ACT research strategy can provide support through the research activities organized under stream "Macro-level: Industry 4.0 at the level of governance, policy, regulation and sustainability", specifically under sub-stream III. 2. The future of work: Industry 4.0 skillsets as well as the planned international co-authored publications.
Addressing cross-sectoral performance differentials in the RIS3 priority sub-sectors: Sub-sectors which contribute to the implementation of the RIS3 priorities, i.e., photonic and laser technologies demonstrated rapid extensive development. The following economic sub-sectors which contribute to the implementation of the three RDI priorities demonstrated poorer value-added and employee change dynamics than the average in the Lithuanian economy: *agro-innovation and food technologies, educational technologies, smart energy systems.* Sectors which contribute to the implementation of the following RDI priorities: molecular technologies; smart energy systems; ICT (which covers digital content,	The IN4ACT research strategy can provide support through the research activities organized under stream Level II: Meso-level: Industry 4.0 at the level of regions and regional innovation ecosystems" and more specifically under sub-streams II. 1. Centralization vs. decentralization in Industry 4.0. II. 3. Commoditization and "smart specialization".

cloud computing and services priorities); functional materials and coatings and photonic and laser technologies can be characterized by the highest productivity and the largest investments in tangible assets. The weakest performance has been recorded in the sectors of advanced technologies within health and education. Poorer performance can be explained by lower investment and productivity-intensity of service sectors in general. Finally, those sub-sectors contributing to the implementation of digital construction priority make the least use of the investment potential of all the sub-sectors. Although value-added value significantly increased, investments in tangible assets were among the smallest within the priority.	
Strengthening focus, quality and international collaboration of research on RIS3 priorities: Regarding the scope of RIS3 publications total of 761 publications corresponded to the topics of the Smart Specialization priorities of which 721 publications were assessed by experts as fully corresponding to the priority and a further 40 were assessed as corresponding partially. A total of 506 publications appeared in the Web of Science first-quartile (Q1) journals. Compared to the total number of publications prepared by the country which appeared in Q1 journals in 2014– 2015, the share selected by experts as corresponding to the Smart Specialization priorities thus account for one third of publications which appeared in Q1 journals. The analysis of the distribution of scientific publications by fields of science shows that less than 20% of all medical and agricultural publications were selected. Meanwhile, 59% of publications in the areas of engineering and technology sciences were selected as complying with the Smart Specialization priorities.	The IN4ACT research strategy can provide support through the research activities organized under stream Level II: Meso-level: Industry 4.0 at the level of regions and regional innovation ecosystems" and more specifically under sub-streams II. 1. Centralization vs. decentralization in Industry 4.0. II. 3. Commoditization and "smart specialization" as well as the planned international co-authored publications.
Strengthening RIS3 research relevance and performance under the Horizon 2020 program: Of 1,456 applications submitted by Lithuanian organizations in the Horizon 2020 program in 2016, 170 applications (12%) received funding. Lithuanian organizations coordinate 25 projects and participate as partners in the remaining ones. Out of 170 funded applications, 94 projects focus on RDI activities and of these 65 applications (69%) are closely associated with RIS3 priorities. Of the 94 projects dedicated to RDI activities, 65 were identified as being related to the smart specialization priorities of Lithuania. However, the criteria for categorizing projects with respect to their relevance to RIS3 priorities need improvement and refinement. The process and criteria of categorization will be reviewed and improved with the help of experts.	The IN4ACT research strategy can provide support through the research activities organized under stream Level II: Meso-level: Industry 4.0 at the level of regions and regional innovation ecosystems" and more specifically under sub-streams II. 1. Centralization vs. decentralization in Industry 4.0. II. 3. Commoditization and "smart specialization" as well as the planned targets for EU funded research (under the post-Horizon 2020 program).
Performance under the Intellect instrument: The Intellect instrument is designed to encourage companies to invest in RDI activities for the development of innovative products, services or processes, and to promote the growth of companies and the establishment of new innovative companies by investing in RDI infrastructure and its development. When assessing the results of the instrument on the basis of both criteria, RIS3 priorities can be divided into four categories: 1) Critical mass and a breakthrough potential are achieved, 2) Forming of critical mass and potential, 3) A small critical mass, and 4) No funding was allocated to the projects of two priorities: solar energy and biorefinery. The analysis of thematic concentration helps identify whether projects financed within the scope of the same priority aim to develop the same or different	

technologies, products, services etc. The higher the concentration, the greater the likelihood that synergies will form between the financed projects, resources will be concentrated and a critical mass will be achieved for structural changes within the economy. Currently the thematic concentration in the priorities of the RIS3 is limited. Only three priorities (flexible production systems, advanced technologies for health and digital content) have two technologies in the same area, which will be implemented in more than three projects. Most of the projects representing different priorities are developing different technologies and there is no technology that would repeat in the applications more than three times.	
Developing and refining the monitoring system: During the implementation of the RIS3 strategy, when new data is accumulated, quantitative monitoring and assessment will become more accurate and detailed. The obtained results will also be supplemented with the results of the science and business cooperation survey. It is extremely important that, in cooperation with the State Tax Inspectorate, R&D expenditure data declared by businesses will be used to assess the scope of RDI activities. When developing the monitoring system, the following two aspects should be emphasized: 1) A need to identify the main shortcomings and to supplement and refine existing monitoring indicators. The necessary condition for the new proposed indicators is the ability to analyze them within 20 priorities, 2) The need to ensure a systematic and unified codification of the RIS3 projects by topics and thematic specificities.	The IN4ACT research strategy can provide support through the research activities organized under stream "Macro-level: Industry 4.0 at the level of governance, policy, regulation and sustainability", specifically under sub-streams III. 1. Comparative readiness for Industry 4.0: assessment and measurement methodologies and III. 4. Governance: regulation, innovation and sustainability.
Addressing the key evaluation methodological challenges: The main methodological challenge that faced the first evaluation of the RIS3 strategy was to establish a link between RIS3 priorities and NACE economic indicators. RIS3 priorities define groups of products, services or technologies, while aggregated economic data is provided about groups of companies or sub-sectors of the economy defined by NACE. In light of these limitations, the methodology needs further improvement or replacement based on the refinement of key performance indicators (KPIs) of the groups of companies to be examined in subsequent evaluations of RIS3.	The IN4ACT research strategy can provide support through the research activities organized under stream "Macro-level: Industry 4.0 at the level of governance, policy, regulation and sustainability", specifically under sub-streams III. 1. Comparative readiness for Industry 4.0: assessment and measurement methodologies and III. 4. Governance: regulation, innovation and sustainability.
Reinforcing the RIS3 strategy implementation as a 'policy learning process': The Lithuanian RIS3 monitoring and evaluation is conceived as a policy learning process that goes beyond accountability purposes, since it includes mechanisms for the introduction of monitoring and evaluation results in the policy-making process.	The IN4ACT research strategy can provide support through the research activities organized under stream "Macro-level: Industry 4.0 at the level of governance, policy, regulation and sustainability", specifically under sub-streams III. 1. Comparative readiness for Industry 4.0: assessment and measurement methodologies and the planned upskilling program for policy makers to be development at the School of Economics and Business of Kaunas University of Technology.
Addressing the challenge of RIS3 policy fragmentation: *Fragmentation of innovation policy* between many small-scale agencies and the lack of a clear definition of their roles and coordination constitute a weakness that needs to be addressed.	

Section 4: Modalities of engagement

It is expected that the main modalities of engagement of IN4ACT with the authorities in charge of the implementation of Lithuania's RIS3 strategy will take the form of regular annual – and when considered necessary more frequent – meetings designed to ensure relevance and impact (as defined in the IN4ACT Technical Annex). These meetings are designed to ensure the timely exchange of information, knowledge, and experience, but equally important, to pave the path for more systematic dialogue and cross-fertilization of insights and experiences through the joint organization of conferences and/or roundtable discussions involving representatives of Lithuania's RIS3 program, the IN4ACT ERA Chair, and the broader policy-making, business, and academic/research communities.

These activities will be further supported through the IN4ACT annual exploitation, dissemination and communication reports which are planned as follows:

D5.3 Year 2 exploitation, dissemination and communication review Report (M24);
D5.5 Year 3 exploitation, dissemination and communication review report (M36);
D5.6 Year 4 exploitation, dissemination and communication review report (M48);
D5.7 Year 5 exploitation, dissemination and communication review report (M60);
D5.8 Plan for Exploitation and Dissemination of Research – Update (M60).

Section 5: Operationalization and activities plan

One of the core objectives of IN4ACT project is to maximize the impact and social reach of its research in the business and policy-making communities of Lithuania but also across the EU. In this respect, the project is in the process of developing an operational and activities plan with concrete objectives / milestones to be in place during the period of September 2020 to September 2021. More precisely, based on discussions with the top management and research teams of the Ministry of Economics and Innovation, STRATA and Invest Lithuania – the project has developed an operationalization and activities plan that is organized around two pillars: 1) the formation of an *Industry 4.0 Business and Policy Data Analytics Hub*, and 2) the launch of an *Industry 4.0 Upskilling Program* at the School of Economics and Business at Kaunas University of Technology. Their missions, planned outcomes, and beneficiaries groups are outlined below.

1. Industry 4.0 Business and Policy Data Analytics Hub:

Mission: Digitalization of the Lithuanian economy and structures of public administration, green recovery, circular economy, upgrading in global value chains, preparation for Industry 4.0 challenges.

Planned outcomes:

- Technology and organizational roadmaps for transitions to Industry 4.0 in business (especially SMEs) and structures of public administration in Lithuania and broader EU and international contexts;
- Mapping Global Value Chains with emphasis on the changing calculus of risks and opportunities for Lithuanian companies and across the EU (especially building on the European Commission's *Global Value Chains Mapping: methodology and cases for policy makers. Thematic work on value chain mapping in the context of Smart Specialization*);
- Business and policy scenario-building followed by recommendations on the future relevance and uses of data in business decision-support systems and in the design of policy for calibrated and well-targeted responses to emerging Industry 4.0 needs;
- Industry 4.0 skills development roadmap (short, medium and long term skills capacity-building, flexible modes of work, remote work, new approaches to workplace design, etc.); data-analytics based recommendations on educational content reform and emerging upgrading priorities at different educational levels;
- Re-design of business models, platform design, and effective/efficient participation in collaborative platforms;
- Re-design of policy-making processes based on the collection and analysis of data through advanced data analytics tools;
- Technology and industry roadmaps for transitions to circular economy; data-analytics driven business and policy scenarios modelling;
- Continuous systematic analysis and reports of Industry 4.0 initiatives from different countries/industries in the EU and internationally;
- Digital transformation management and change management in the contexts of business and public administration;

- Collection and sharing of leading Industry 4.0 Lithuanian and EU cases;
- Initial data sources and collaboration partners in data analytics:
  - *Lithuanian Department of Statistics:* Secondary data on usage of configurations of organizational and digital technologies (country, sector, organization level; all sectors; longitudinal 2012-2019; collected by EU statistical offices); Data on digital skills of the population (EU, country, person; all sectors; longitudinal from 2012-2019; collected by EU statistical offices).
  - *Bank of Lithuania:* Lithuanian companies' performance database encompassing the data on about 30 variables of total population of Lithuanian business companies (~100.000 companies) spanning a period of7 years. The database includes around 21 million. data points.
  - *Fraunhofer ISI:* Data on usage of service-oriented business models and configurations of organizational and digital technologies (EU, country, sector; production sector only; longitudinal (2012, 2015, 2018; collected by a network of EU universities coordinated by The Fraunhofer ISI, Germany).

Beneficiaries groups: Top and middle level managers of Lithuanian companies; Lithuanian and EU business associations (e.g., LINPRA, Confederation of Lithuanian industrialists, among others), clusters etc., business communities/networks (e.g., Fintech, manufacturing etc.), decision makers of public institutions; students.

2. Industry 4.0 Upskilling Program

The implementation Industry 4.0 and qualitative transformation of Lithuania's economy require new crucial and specific competencies such as production process simulation and automation, 3D printing application, machine-to-machine processes, information technologies and their use, IT security and data protection, data analysis and solutions, as well as the ability to develop new products and adapt / update existing business models that would ensure the rise of the business in the value chain towards the end user, export development and diversification. Moreover, due to rapidly changing environment employees working in industry need personal skills such as adapting to changes, continues learning, time management, working in virtual teams, which in turn adjusts human resource management processes. Considering the challenges and requirements of Industry 4.0 Lithuanian industrial enterprises need to strengthen their capacities and update the competencies of their employees. Particular attention should be paid to upskilling of industrial engineers.

Mission: Digitalization of Lithuanian economy and structures of public administration, adjustment of skills, preparation for Industry 4.0 challenges through upskilling and knowledge development of engineers, business managers currently working in industry, and policy-makers in order to adapt to the technological challenges of Industry 4.0.

Planned outcomes:

- Development of an upskilling education program directed at engineers, business managers, and decision makers in public administration in order to enhance understanding and build

organizational and institutional capabilities to address key technological, organizational, and institutional challenges of Industry 4.0;

- Specific focus areas of the program will initially undertake emerging Industry 4.0 skills mapping and address issues such as: new tools and machinery, specifically “machine learning”, production process simulation and automation, 3D printing application, IT security and data protection, the economics of networks and platforms, the economic potential of mobile technologies, data analytics and advanced uses of big data, process simulation, predictive analytics, adoptive personal skills and capabilities;
- Creation of an infrastructure of blended learning based on an innovative learning platform geared to “mindset change” and practical implementation of initiatives of Industry 4.0 in the contexts of business management and agile policy-making in line with the requirements of Industry 4.0;
- Development of an interdisciplinary executive education program covering a broad range of challenges related to the domains of technology and engineering, business management and economics with special emphasis of the “platform economy”, and policy and regulation at different levels of public administration (regional, national, and EU);
- Content development, educational design, and instruction will be carried out by a seasoned team of leading scholar and practitioners from KTU, Lithuania, across and EU and North America;
- Program configuration and customization according to personal professional / company / organization / institutional needs. It is estimated that the program will have a duration of 3-4 weeks.

Beneficiaries groups: Engineers, top and middle level managers of Lithuanian industrial companies; Lithuanian and EU sectoral business associations, clusters etc., decision makers at public institutions in Lithuania and across the EU.

References

1. Erawatch Country Reports 2012: Lithuania.
2. Government of the Republic of Lithuania Resolution Approving the Priority Areas of Research and (Socio-Cultural) Development and Innovation development (Smart Specialization) 14 October 2013, No 951 Vilnius https://www.smm.lt/uploads/documents/en_smm/smartsp/Priority%20areas.pdf
3. Government of the Republic of Lithuania, *Resolution on the Approval of the Programme on the Implementation of the Priority Areas of Research and (Socio-Cultural) Development and Innovation (Smart Specialisation) and their Priorities*, 30 April 2014 No 411 Vilnius https://www.smm.lt/uploads/documents/en_smm/smartsp/Programme.pdf
4. Identification of Specific Research and (Socio-Cultural) Development and Innovation (RDI) Priorities in Lithuania: Proposals for RDI Priorities. Updated and amended report. Prepared by a consortium led by Visionary Analytics UAB under an agreement No ESF F9-10/13 with the Research and Higher Education Monitoring and Analysis Centre https://strata.gov.lt/images/ss/Proposals_for_Smart_specialization_Lithuania.pdf
5. Ministry of the Economy and Innovation of the Republic of Lithuania, (2019). *Lithuanian Industry Digitisation Roadmap 2019-2030* https://industrie40.lt/wp-content/uploads/2019/03/Lithuanian-Industry-Digitisation-Roadmap-2019-2030_final.pdf
6. Reimeris, Ramojus, (2018). *Interim Evaluation of S3: how we did it?* MOSTA and the Ministry of the Economy of the Republic of Lithuania.
7. Report of an expert group to the Ministry of Education and Science and Ministry of Economy of the Republic of Lithuania: *A contribution to priority setting for future research, studies and innovation in Lithuania*, 22 October 2012.
8. Research and Higher Education Monitoring and Analysis Centre (MOSTA), (2018). *Background document: Lithuania.* Document prepared for the Lithuania's peer review.
9. Research and Higher Education Monitoring and Analysis Centre (MOSTA) and the Ministry of the Economy of the Republic of Lithuania, (2017). *Lithuania Smart Specialization Strategy: Progress* First REPORT, Vilnius https://strata.gov.lt/images/leidiniai/SMART-01-ENGL.pdf
10. Research and Higher Education Monitoring and Analysis Centre (MOSTA), (2016). Lithuanian RIS3: How it was Designed https://strata.gov.lt/images/Lithuanian_RIS3_Framing_Process.pdf
11. Research and Higher Education Monitoring and Analysis Centre (MOSTA), (2015). *Effectiveness of higher education – overview and recommendations*. Policy Brief https://strata.gov.lt/images/leidiniai/Effectiveness_of_higher_education_Policy_brief.pdf
12. Research and Higher Education Monitoring and Analysis Centre (MOSTA), (2013). *Current Strengths and Future Growth Potential in Lithuania's Economy: Background discussion paper to support development of Smart Specialisation Strategy in Lithuania* https://strata.gov.lt/images/documents/ss/Current_strengths_and_future_growth_potential_in_Lithuania.pdf
13. Research and Higher Education Monitoring and Analysis Centre (MOSTA), (2013). *Global Trends and Drivers as Challenges for Lithuanian Research and Innovation Policy.* Background paper to support the development of a Smart Specialisation Strategy in Lithuania https://strata.gov.lt/images/Global_trends.pdf
14. Research and Higher Education Monitoring and Analysis Centre (MOSTA), (2013). *Long Term National Challenges Facing Lithuania's Economy and Society*. Background discussion paper to support development of Smart Specialisation Strategy in Lithuania https://strata.gov.lt/images/documents/ss/Report_on_longterm_national_challenges.pdf
15. Research Potential in Lithuania" *Background discussion paper to support development of Smart Specialization Strategy in Lithuania,* 2013 http://sumani2020.lt/documents/tyrimai_ir_ataskaitos/sumani2020_tyrimai_ir_ataskaitos_5.pdf
16. Vyriausybės Strateginės Analizės Centras ir Ekonomikos ir Inovaciju Ministerija, (2018). *Sumani Specializacija Lietuvoje: Nuo 2014-20 Prie 2020-2027* https://strata.gov.lt/images/tyrimai/S3-Lietuvoje-prie-2021-2027.pdf

About IN4ACT

The objective of the IN4ACT project is to implement structural changes at the School of Economics and Business of Kaunas University of Technology through the opening of an ERA Chair in “Industry 4.0 Management and Economics” research, to increase research excellence, socio-economic impact, international reputation, and attractiveness to international talented researchers and students.

An ERA Chair holder and a team will be recruited to: 1/ Implement an ambitious research agenda on the impact of future manufacturing (Industry 4.0) on management practices and economics; 2/ Drive changes at the KTU School of Economics and Business related with research management and human resources, especially to comply with the ERA priorities; 3/ Improve the School's exploitation, dissemination, and communication capacities; 4/ Grow networks and increase links with stakeholders, especially to increase participation in Horizon 2020.

Website: http://in4act.ktu.edu
LinkedIn: https://www.linkedin.com/company/in4act
Twitter: https://twitter.com/ktuin4act; @ktuin4act

Funded by the European Union

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 810318