Final Report: **Advanced materials as a pioneering innovation and business field**

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Summary

First of all, we would like to express our humble gratefulness for Å-forsk generous support of our research project which initiated a new avenue based on interdisciplinary topics in materials science and the societal context. Thank you for trusting in us and supporting our research.

Traditional forms of collaboration need to be rethought, enhanced and renewed. Some ways to address this challenge is to study insufficiency and tensions in collaborative structures engaging companies, academia, public and national authorities; platforms that enable new cooperation efforts and the exchange taking place in these platforms that aim at creating new opportunities and ways forward. Such exchanges are tension laden fields where different stakeholders' interests, stakes and logics are at play. The challenges characterizing the initial stage of the collaboration concern issues of infrastructure and physical location of the research; the ambiguous relation between academia and the research institutes; configuration of the different utilities and interests in the network. In this project we have studied the capacity building in the topic of advanced materials as regional strength (smart specialization), and the transition phases from an expert group working on the idea to implementation of a project and cooperation exchange (Innovative Materials Arena) with an operational team.

The contribution of this piece of research is twofold. A deeper understanding of the complex processes involved in re-structuring collaboration patterns to mobilize existing resources and create new opportunities for innovation for both market actors and society. Such an understanding is important for developing both research and practical knowledge in the field of innovation and its governance. Understanding the insights by the practitioners was extremely important through continuous dialogue with the work group of experts and the project team, based on informed observations and theoretical perspectives used in the study.

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1 Smart Specialization Policy

Research & innovation is an important focus area for increased economic growth in Europe. It is of particular importance for the long-term goals. European regions are therefore encouraged by European Commission to develop "Research and Innovation Strategies for Smart Specialization" (RIS3)[1] to identify as well as exploit markets and resources for regional development and growth based on their socio-economic conditions and challenges.

Smart Specialization is an innovative approach proposed by European Commission to bring together local authorities, academia, businesses and society to boost growth and jobs in Europe. It prioritizes domains, areas and economic activities where regions have a competitive advantage. It was initiated for discussion in 2010 and in 2014 the smart specialization became officially part of the policy framework. All regions in Europe should identify their areas of strength, mobilize the stakeholders and carry out activities aiming to boost growth and jobs in the region.

The implementation of smart specialization is a challenge. A recent report provided an update based on some case studies[2]. There was also a summary from the first global workshop on Smart Specialization in September 2018[3]. The Evaluation of RIS3 is now particularly important for the 2021-2027 period. However, regions have now to plan, execute and use evaluation results. There is currently no support for evaluation mechanisms from European Commission, which is natural given the complex nature of RIS3 which is different for each region. At the same time, due to the uniqueness for each focus area, there is room for new models for capacity building in certain domains, as addressed by this paper.

The economic growth is interlinked with the building of capacity. One way to gather stakeholders in an area of strength for capacity building is to create clusters or networks. Clusters are tools for boosting existing strengths when there is a sufficient number of local stakeholders in that particular area. However, clusters may also be limited by geographical constraints, such as having a number of local actors in a certain field. Regions may still have strong local stakeholders, but they are more individual ones in their particular field. Still collaborations are needed.

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[1] European Regions are implementing Smart Specialization (RIS3) that is an innovative approach/strategy to bring together local authorities, academia, business and society to boost growth and jobs in Europe. A RIS3 prioritizes domains, areas and economic activities where regions have a competitive advantage and this number of these priorities vary from region to region.
[2] Tolias, Yannis (2019) *Position Paper on S3 Evaluation*, Publications Office of the European Union, Luxemburg, 2019, ISBN 978-92-76-02923-6, doi:10.2760/520648, JRC116444
[3] Gómez Prieto, J., Demblans, A., Palazuelos Martínez, M., Smart Specialisation in the world, an EU policy approach helping to discover innovation globally, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-08393-1, doi:10.2760/962643, JRC117005

Therefore we study network and collaboration exchange mechanisms. We will delimit the study to the research and innovation related to academic, industry and SME exchange and study tensions underlying the challenges of implementation of collaboration exchange and suggest possible solutions.

1.1 Smart Specialization in Östergötland

The regional development strategy in Region Östergötland addresses four areas of concern in the region: food, environment/climate, smart industry and e-health. Smart specialization underlies these areas by five focus topics of specialization:

Effective logistics - involving goods, personal and material management, processes for service delivery
Business models and arenas for sustainable systems solutions – involving bio-based circular economy, waste, energy
Smart, robust and secure connected products and systems - involving Internet security - integrated communication electronics, sensors, printed electronics
Visualization and simulation – involving visualization of complex data, interaction with virtual models, interactive media, games
Advanced materials - involving coating for metals and plastics, nano-structured materials such as graphene and bio-compatible materials.

1.2 Advanced Materials as Smart Specialization Area

Advanced materials is one of strength priority areas in Region Östergötland. Advanced materials can be described as new materials or modified traditional materials which have substantially better, new or multifunction properties. These create new or additional values by market competitive technologies or products. Advanced materials field has a cross-over potential impact in a wide range of fields, while it is at the same time challenged by a long-term implementation scheme from novel materials approaches to system integration.

New or multifunctional properties of advanced materials create a variety of applications which lead to innovation and technological advancements. The multigenerational nature of advanced materials creates a potential for transforming the industrial sector and for achieving climate, environmental and resource-efficiency targets at a faster rate. Materials sectors are relevant in most fields for the transition to a smarter industry. These are also a foundation to boost so called 'key enabling technologies' (KETs) which have longer term impacts, as well as enabling preservation and long-lasting industrial transition at a global level.

Advanced materials are expected to generate more technological developments and knowledge intensive production. Novel innovative approaches push the industrial development by tailoring material properties to specific functions which add value. Value Added Materials is a group of advanced materials that have strategic importance for economic growth, industrial competitiveness or address the Grand Challenges of our times4. The market for value added materials was 101.7 billion Euro in 2008 and has the potential to grow more than 10 times over next 40 years.

The transition over the next 40 years includes to consider specific challenges related to:

Patent protection:
Only well protected material innovation assures the competitive advantage on the market in the long run.

Duration of product development and scalability:
Knowledge intensity makes value added materials hard to develop to pilot prototype and subsequently scale into industrial products and applications, which is one reason for a long time-to-market (typically claimed to be around 20 years).

Market maturity of products using material, and value:
The market must be mature and ready to use a given value adding material. The demand for a new material is largely dependent on its value related to cost and fabrication aspects. The implementation of use (or not) will therefore critically depend on the combination of factors like price, dimension of scalability, complexity of production etc.

Market (in)stability:
A main challenge is related to the capital market. There exist peculiarities of the capital market that is seeking short term profits by channelling the innovation focus to the service sectors instead of technologies since the time to market in service sectors is much shorter

Need of adaptation along with industry transition:

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[4] 'Technologies and market perspective for future Value Added Materials', European Commission - Directorate-General for Research and Innovation 2012, B. Romanow and M. Gustafsson, Oxford Research AS, ISBN 978-92-79-22003-6

The smart industry transition offers potential synergies which could be developed. Improved material properties have no value if the products do not match the modern industry. In parallel to continuous emergence of innovative materials concepts, there is a transition from traditional to modern industry. This makes it difficult to predict which routes are the best for the long-term impact. Some considerations in this respect are that stakeholders (companies) should:

- move from manufacturing to competence company
- compete based on competence instead of price
- think process and value creation instead of product
- consider the need of innovators and early adapters

The long-term considerations of time to market and market maturity provide substantial strain on advanced materials transition. The smart industry transition is based on innovations. The actors and regional players which create or pick up / adapt innovation concepts are often in academic research or SMEs. Large industries do not have the same fast responding to innovation exploration capacity since they are focused on their traditional markets. However, actors and regional players can not aim at commercial stage which is several years from now. In order to survive, they must focus on daily research or business issues more than future potentials.

In Östergötland, advanced materials as a strength area is characterized by a strong competence base, but limited business activities. The region can boast with a world-class research and development of metals, semiconductors, composite materials and biobased polymers at Linköping University. The market actors with a high demand for advanced material in the region include leading businesses such as SAAB, HTC, Siemens Industrial Turbomachinery, Thin Film Electronics. The challenges, however, are commercialisation of the research and development results.

The business climate has changed considerably and is characterized among other by: competition based on competence instead of price; selling of services instead of raw materials; going from manufacturing company to competence company, or a hybrid of both; process logics rather than product logics. Analysts have concluded that Swedish industry needs innovators and early adopters. The mapping of the regional strength areas found that the challenges of the region in the advanced materials focused on (Region Östergötland, 2014):

- Retaining and reinforcing the regional attractiveness for start-up companies
- Increasing visibility and knowledge of the home-based materials industry inside and outside the region
- Overcoming the regional “Valley of Death” effect for the start-ups
- Creating arenas for addressing problems connected to research, development or commercialization of the advanced materials.

1.3 The research problem, aim and research questions

New collaboration forms among a wide range of actors are especially sought and highly valued: industry, large businesses, SMEs, the national, regional and local governments and the wider public sector. Such collaborations are directly related to the companies' willingness to invest in R&D. However, maintaining a potent collaboration environment, and creating driving forces for innovation and mobility across sectors, proves still to be an important challenge.

Traditional forms of collaboration need to be rethought, enhanced and renewed. Some ways to address this challenge is to study insufficiency and tensions in collaborative structures engaging companies, academia, public and national authorities; platforms that enable new cooperation efforts and the exchange taking place in these platforms that aim at creating new opportunities. Such exchanges are tension laden fields where different stakeholders' interests, stakes and logics are at play. Such tension dynamics can involve a living field of actors and networks that is reconfiguring its structures of collaboration and materialization of knowledge and interests. If and when the actors of such networks succeed in revising their connections in the light of their needs and interests, new collaboration structures will emerge.

The project aim was to employ analyses of the tension fields that arose when new governance structures emerged as an effect of renewed investments in regional growth focusing on strength areas. The study was based on the following three research questions:

- What tensions arise in the development of the network?
- How can these tensions be understood?
- What practical knowledge for the different actors (industry, SMEs and public authorities) results from a tension perspective?

2 Innovative Materials Arena

The Innovative Materials Arena (IMA) was initiated as a strategic measure in the context of the region's smart specialization policy in the focus area "advanced materials". The initiative aimed to strengthen the competitiveness of businesses in advanced materials by building a sustainable business environment. The strategy is to diminish the gap between research and innovation to commercialization through bringing together and promoting new cooperation structures between academic research, SMEs, large companies, research and the regional authority. The arena should act to increase knowledge in products and services and new and values creating cooperation that enables new innovations in line with the regional economic growth.

The arena emerged from an initiative to understand the stakeholders in the area. Initially, the Region Östergötland set up a working group of materials experts to focus on advanced materials market in the region. It consisted of one representative from Region Östergötland, one coordinator and two materials experts. During 2016-2017 the team mapped advanced materials stakeholders categorized as academic, SME and large industry. Even though the mapping was not complete, it created a nucleus of network. The expert group initiated one workshop in June 2017 with main aim to explore interest for a collaboration arena. As the workshop participants response was positive, an application for funding from EU structural funds was initiated and submitted for such arena. It was granted by the end of 2017. The project owner (Sankt Kors Fastighet) recruited a project leader and a project group as well as advisory board were established. The value of the project team was that the coordination efforts were to be shared, as one person would not suffice for the job but important as motor.

2.1 What is new and special?

IMA has to be understood as a part of systemic innovation policy and complementary measures, carried by Region Östergötland in interconnected alliances of actors.

The peculiarity about the Advanced Materials focus area, as was discussed in the work group and the interviews, is that it is no or to a very limited extent an area which generates finished products that companies immediately can sell to the end-users. Rather the R&D is producing enabling solutions (coatings, composites etc) to be added to the exiting materials or totally new materials functionality. The end product, that would be composed of advanced materials, exists currently or in the future in other companies or a consortium of companies. Therefore, this R&D has to be organically connected to other focus areas and industries that are covered by

other strength areas focused in the Smart Specialization effort and also in the overall regional development strategy.

The main purpose of IMA therefore lies in becoming a natural meeting place for the different stakeholders, where knowledge is shared and produced, where it can generate sub-networks of companies focusing on development and production of marketable solutions, solutions that the regional authorities see to that are contributing to solving challenges of future welfare, and of course regional growth. There is a strong challenge-driven and needs–value-based perspective in the idea of IMA, which is reflected both in the work group discussions during their meetings and in the interviews.

Since the regional authority is centrally involved, by initiating and by following it up, the challenge and value for society (usefulness and impact) is fundamentally backed up. As the interviewed public official responsible for the regions five areas, explained:

'We cannot foresee and control the companies or what might come out of these alliances, directly. They can choose or not to be part of any alliance and work on their inventions as they consider right and profitable. Any kind of invention may result in IMA-brokered consortia, but if we see that we can't connect their solution to any of our challenges, we won't contribute with new funding. They can continue doing it with other means'.

3 Tensions & challenges

The results of this study show that indeed the birth of a new collaborative structure was rife with challenges and that a tension approach put the light on the 'pulse' of such a process. The challenges characterizing the initial stage of the collaboration concerned issues of infrastructure and physical location of the research; the ambiguous relation between academia and the research institutes; configuration of the different utilities and interests in the network; and transition of the idea from an expert group to a project with operational team.

3.1 High-tech and advanced infrastructure and the issue of research location

An access and the quality of the infrastructure would be beneficial for the research. It was raised that IMA could invest in a cutting edge infrastructure as part of its physical building since that facilities to attract both companies and research,. Advanced equipment for research is costly, scarce and not always available. Resources need to be pooled. IMA invited the university to share infrastructure, both at IMA and at established laboratories at university premises. For the specific researchers and their projects, lab-related costs are usually very high and any possibility to decrease these costs by accessing new labs should be important. At the same time, the close availability is a criteria for researchers.

Today there is also an increased cost for lab space at university. There is an interest from both research groups and spin-offs to use such a lab at IMA, as shown by the stakeholders at the workshops. The university, on the other hand, is interested to have the cutting-edge research based on the campus, according to the interviewed member of the project-team. By encouraging research to move out to external labs, there is a certain fear that the university may lose prestige, project funding and other support in terms of overheads.

3.2 Competition between university and new research institutes

The smartest research ideas and results can lead to creation of research institutes (basically non-profit companies). There are over 400 such research institutes currently registered in Sweden (allabolag.se) 3. Tension can arise between the individual researchers starting the institutes and the university when research moves out of the university, according to the interviewed researcher (member of the project team). When the smartest ideas with high potential for further R&D move out, he explained, the research institutes can apply for R&D funds - they become

competitors to the research groups from the university for funds. IMA is already in its first year discussing the possibility of creating institutes in order to compete for R&D funding, which poses pressure on the university to rethink collaboration strategies.

Another tension arises when it comes to academic and SME exchange. The universities have strong tradition in their field and has built the base at the laboratories at the university premises. The cluster activity has focus on creating impact and use of results to create market growth and value. In the cluster view, the exchange between research and industry should preferably be positioned around the cluster. A tension is then appearing when the research focus is moved to the cluster, or even further when the discussion about moving research teams to a physical cluster area outside university premises.

3.3 Different utilities for the actors create tensions

The actors in IMA have different needs and utilities. The needs could be lab space, reduced overhead costs, funding, competence, etc. The regional authority, on the one hand, needs to create economic growth and attractiveness of the region while the SMEs on the other hand need to survive, be self-sustainable or grow. The research institutes need to finance their R&D, and the industry needs new ideas and innovations or solutions to difficult problems. The value of a collaboration exchange like IMA – builds on working with such needs. However, the larger actors such as the public authority and the large industry are having a longer-term perspective for the collaboration. The public authority is acting in the interest of public good, while the industry is driven by market principles and interests. The industries have their business today, and aim more for future. The SMEs perspective is much shorter and focused on 'here and now' to have a sustainable business. How to coordinate such different positions and perspectives poses a difficult challenge for coordination at this initial stage of IMA.

The materials field, even after smart specialization mapping of stakeholders, is extremely broad. The actors need a more concretized language both in terms of correlating it to their respective needs and in terms of dialog. 'You need to talk more concretely', one of the interviewee explained. Also, the smart specialization concept is not understood by many stakeholders. They need more accessible descriptions which can be understood easily. For example, one interviewee specified: 'a description of developing composite materials to have several functions instead of one is more naturally understood than smart specialization related to materials for creating value chain in Clean Sky projects in Europe'.

The actors talked different 'languages' and on different levels. To generate more action in practice, the SMEs need to see their immediate value with IMA-collaboration and match it with their own resources and needs. It was difficult to

realize how they could perceive or create utility based on their mutual interests with collaboration. In connection to this challenge, one of the interviewed team members reasoned: 'each and every one of us is interested in different things and have different goals. How does IMA help me to publish and get resources to my research? And what is IMA? One of the largest companies, we talked with, is interested to have researchers sitting at IMA, to have front-edge knowledge and infrastructure based there'.

Our results showed that the value of cooperation in networks such as IMA is also influenced by the publication culture dominating the academia. An informant from academia explained that while collaboration outside the academia (science outreach) is highly emphasized in university policies, in practice cooperation does not show too many activities. This is partly due to the dominating publication culture in the academia, according to him. This is slowly changing. It is gradually becoming a question of what the researchers must do, and not what they want to do, according to the informant. The question is not *if collaboration will take place*, but rather '*where to plant the carrots* for enhanced collaboration on smart specialization to happen'.

At the same time informants from academia admitted perceiving a value with IMA. They could see a strength of IMA by having its own 'brokers' who would act as bridges between the different demands coming from the industry and SMEs, and the researchers who could contribute with knowledge and their infrastructure.

The SMEs on the other hand were interested to see what large industry was connected to IMA, seeking possibilities to connect to future clients, get access to their knowledge and infrastructures and get the longer time perspective on future needs and direction concerning the market of advanced materials. It seemed that each of the actors needed the other one to be involved in the network in order to anticipate an added value. They perceived the utility of the collaboration through specific actors who were connected to the network.

Concludingly, translating strategy goals, ex. creating and facilitating conditions for research, enterprise development, to match SMEs and industry needs which in their turn shall perceive or create affordance for developing their businesses - is a difficult and tension laden process, that need further analysis.

3.4 Project group organization, structure, function and roles – a tricky process

The transition of IMA from an idea that was developed by a work group of experts, to a project with a new team and new ownership structure turned to be a difficult process, where new roles, mandates and work methods needed to be re-negotiated and contained. The informants from the work group expressed confusion as it was highly unclear then how the group would continue to work in a project group. The

members of the work group had been working together at least two years with the idea of IMA, discussing and deciding what should be done. In the project, the operational group was partially the same, but the project manager was recruited on the market. The project leader was not an expert in advanced materials but had experience in project management. The regional authority stepped back and acted as an advisor in a reference group, rather than being part of the operational team. At the initial stage it was unclear what mandate the project manager had in the team and how she related to the experts in the work group. While ownership and organization structure has changed, some experts were highly hesitant about contributing to further work on operational level. The team still needed to translate the goals into specific activities, while most of the members of the project team worked with IMA only on a limited basis. 'We need more structure in our meetings and clearer steps forward,' it was admitted by one informant.

The challenge was connected to the team members – old and new - realizing their new roles, expectations and learning about their different strengths and expertise and how they could work together in a project set-up. At the same time, there was a lot of information for the project manager to grasp, from early history and ongoing activities to the formal reporting of project, in agreement with application with its aims on growth (numbers, values etc). For example, the original members could foresee areas where an activity seemed viable to initiate early, while it was not clear to the project coordinator since that person was having less knowledge about the area at starting stage of project. On the other hand, such blank experience in materials could provide a fresh and umbrella mindset to the team, as was admitted by on informant.

From the observation of the meetings, the project group continued to update each other on IMA-s participation and position towards other networks, other on-going projects and conferences. No difference from previous discussions on 'what should be done' could be discerned. The project group moved along a detailed list of activities that should be implemented during the project time frame. It was visible that the team did not identify itself as IMA, yet. IMA did not exist yet as a real structure, as it had not generated any activities yet, by that time. The buildings where IMA would be located were under construction.

4 Conclusions

The project aim was to employ analyses of the tension fields that arose when new governance structures emerged as an effect of renewed investments in regional growth focusing on strength areas. In pursuing this aim the study focused on the tensions that arose in the development of the network and built knowledge both in terms of research papers, research applications and a dialogue with practitioners where the insights were presented and discussed.

IMA has to be understood as a part of systemic innovation policy - called in practice Smart Specialization, aiming to diminish the gap between research and innovation towards commercialization by promoting new cooperation structures between researchers, SMEs, industry and public authorities. Our results show that indeed the birth of a new collaborative structure was rife with challenges and that a tension approach put the light on the 'pulse' of such a process. The challenges characterizing the initial stage of the collaboration concerned issues of infrastructure and physical location of the research; the ambiguous relation between academia and the research institutes; configuration of the different utilities and interests in the network; and transition of the Idea of IMA from an expert group work to a project team.

This study highlights the need to deeper understanding of the complex processes involved in re-structuring collaboration patterns to mobilize exiting resources and create new opportunities for innovation for both market actors and society. The insights of practitioners are extremely important.

5 Work activities

5.1 Mapping the actors' strategic needs, identifying the bridge builders & tensions

- **Work activity 1**: Participation and data collection in IMA workshops 1 & 2. Workshop 1 (June 2017) aimed to explore interest of actors for an arena. This was confirmed. An application for funding IMA was submitted (and accepted). Workshop 2 (Feb 2018) aimed to collect needs of actors for next steps. Participation at Production 2030 (March 2018) conference to understand modern industry translation.
- **Work activity 2**: Literature study on new governance collaborations and tensions characterizing them, as well as challenges and risks shown by collaboration on science, technology and innovation for economic growth - so called STIG-systems.
- **Work activity 3**: Document studies of EU, national and regional policy documents on smart specialization, internal IMA documents.
- **Work activity 4**: Participant observations in the strategic work group December 2017 and in the project group afterwards.
- **Work activity 5:** Interviews with key actors in IMA: initially Region Östergötland, Linköping university (large industries and SMEs in next phase)
- **Work activity 6**: Writing a conference paper by Gustafsson & Syväjärvi: 'The birth of a regional materials arena node: A case study on the entrepreneurial and governance dynamics of advanced materials networks': where initial results were presented, the network governance theoretical frame was described and the tension approach was explained.
- **Work activity 7:** Presented and discussed the conference paper at 21st Uddevalla Symposium 2018 on "Diversity, Innovation, Entrepreneurship – Regional, Urban, National and International Perspectives", in Luleå, June 14-16.
- **Work activity 8**: Participation in East Sweden Innovation Day: Mingling and discussing project results with stakeholders of Smart Specialisation, observation of demonstrations and discussion by IMA-counter in the poster area, in Linköping, November 5-11, 2018
- **Work activity 9**: Complementary data collection. Deep interview with IMA project leader on dynamics of IMA development by December 2018. Discussions with IMA members on development in

IMA, December 2018. Participation in several meeting of the project team.

- **Work activity 10**: Wrote and submitted an application for further research funding based on the projects accumulated maternal and results. The two researchers in this project made up a team of three who have co-authored the application. The application 'Sustainable production and innovation routes for crossover high temperature materials' (Dnr. 2019-00765) was sent to Formas, April 2019.
- **Work activity 11:** Presentation of project results, with the paper 'Using Buurtzorg model as innovation clustering model for regional capacity building in an entrepreneurial context', at Uddevalla Symposium, at Gran Sasso Science Institute (GSSI), L'Aquila, Italy, June 27-29, 2019
- **Work activity 12:** Finalizing the article manuscript: 'The birth of a regional materials arena node: A case study on the entrepreneurial and governance dynamics of advanced materials networks' to be submitted for publication in the journal 'Innovation: Organization & Management'.
- **Work activity 13:** Preparing abstract and conference presentation of 'Clustering dynamics in advanced materials domain related to regional growth' at EUROMAT2019, Stockholm, Sweden, Sep 1-5, 2019.

6 Project economy

An economy overview of the project resources is presented below. If more detailed information about the costs is required we will be happy to assist. For further questions kindly contact our economist Lisa Rosandher (lisa.rosandher@liu.se, 013-28 47 63)

	Period 170101-191130		
	Personalkostnader	215 678	
	Övriga direkta kostnader	34 442	
	Indirekta kostnader	49 881	
	Totalt	**300 000**	