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**Strengthening scientific and research capacity of the Institute of Economics, Zagreb as a cornerstone for Croatian socioeconomic growth through the implementation of Smart specialisation strategy**

# Policy Brief, SmartEIZ

## How to select and develop Key Enabling Technologies and policies to advance manufacturing in Croatia? Localising roles for innovation researchers and policy makers

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| List of key messages |
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| • Key Enabling Technologies as defined by the European Commission include: photonics, nanotechnology, advanced materials, micro/nano-electronics, biotechnology and advanced manufacturing technology.<br>• The up-take of KETs enables to advance manufacturing, productivity and growth; Without using KETs in manufacturing, inventing KETs does not generate growth, nor productivity, nor solves societal challenges.<br>• Technologies and policies which are 'key' and 'enabling' at EU level, may not be 'key' and 'enabling' for the actors, sectors and regions of Croatia.<br>• KETs research and policy practices developed at EU level might however be adapted to innovation research and policy making in Croatia.<br>• Sweden and Slovenia are leading in using sustainable and ICT-enabled manufacturing technologies. The position of Germany and Croatia is more modest. Policy lessons from Slovenia are likely to be more relevant.<br>• Challenges on the user-side of enabling technologies typically include: lack of understanding; conservatism of users; skills; fear for disruption in a systemic way; scale of investment/risks.<br>• Centres across Europe promote the up-take of KETs in manufacturing; activities include: Access to technology expertise and facilities; Demonstration; Proof of concept; Prototype development and testing; Pilot production and demonstration; Product validation & certification.<br>• Innovation researchers and policy makers can contribute to interactive learning among stakeholders in the (policy) innovation processes. Moreover, they can get empowered by orchestrating this discovery process. |

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## 1 Introduction

It is difficult to tell in advance which technologies and innovation policies will be best to improve the future of Croatia. Many kinds of stakeholders in innovation systems fulfil a role in the design, implementation and evaluation of system level strategies. Policy makers and policy researchers also fulfil a role. In the quest for the key enabling technologies (KETs) and policies there are local, co-ordinating and empowering roles for innovation (policy) researchers and policy makers in strategic (RIS3) processes. As producers and users of relevant knowledge both the 'policy researchers' and 'policy makers' should actively engage in the collective learning among stakeholders of how to improve the innovation system in which they operate.

This policy brief is written in the context of the first two Training Workshops of the SmartEIZ project at the Economic Institute in Zagreb. The first workshop was about innovation policy evaluation. The second workshop was titled 'Technology, Growth and Productivity, including KET'. It addressed a wide of range of theoretical, empirical and policy issues concerning the interaction between technology and productivity. The topic was discussed in four perspectives: the macro-economic perspective; the firm-level perspective; the Key Enabling Technologies and policy perspective; and the regional RDI policy perspective of Croatia. This policy brief highlights the topic of Key Enabling Technologies (KETs) and policies to advance manufacturing, but this topic will be embedded in other insights discussed at the workshops. This second policy brief is also a follow-up on the first one, which is a survey based assessment of the needs for research policy in SEE countries[1]. It showed amongst others: that views on needs differ by RDI sector and by stage of development; that current policy measures do not address the needs; that ICT is regarded as the highest R&D priority; that there is a need for policy research and training, e.g. in promoting Science-Industry linkages and Smart Specialisation. These results call for more local, more sector-, technology- and policy specific assessments linking the past to a future development path.

One of the objectives of the SmartEIZ project is to increase the capabilities of economic and innovation researchers to contribute to the Research and Innovation Strategy for Smart Specialisation (RIS3) which stimulates inclusive innovation and sustainable development in selected

[1] http://www.smarteiz.eu/publications/assessing-research-policy-support-needs-innovation-south-east-europe/

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technological domains. At all stages of the RIS3 policy cycle (including fore-sight, design, implementation, evaluation) EIZ could use and improve its capabilities to strengthen the RIS3 processes, e.g. by investigating and identifying specific Key Enabling Technologies (KETs) and public policies which improve the existing Systems of Innovation and Production at local, sectoral and national level. We have no intention to develop here a RIS3 guide for advanced manufacturing and specific KET domains in Croatia, but call on the involved policy researchers and policy makers to fulfil a role in 'localised learning' for all the six practical steps the RIS3 guide of the EC distinguishes[2]:

- Analysing the innovation potential
- Setting out the RIS3 process and governance
- Developing a shared vision
- Identifying the priorities
- Defining an action plan with a coherent policy mix
- Monitoring and evaluating.

The concepts of KETs, RIS3 and Advanced Manufacturing, originate from the policy world of the European Commission. Before emphasising the need to adapt and localise these concepts to the local situation (of the regional, technological, sectoral and policy sub-systems) of the innovation systems in Croatia, we first turn to the EU policy background of these concepts (2), and we give some examples of how to investigate the uptake of key-enabling- technologies (KET) in the EU (3). Some innovation strategies and policy instrument (of national, regional and sectoral systems) to advance manufacturing will be discussed (4).

Since Croatia cannot excel in each and every technology domain, it has to set priorities for the future. Since markets and governments may fail to predict which technology strategy would be best for the future of Croatia, it should be discussed, designed, implemented and evaluated in a systemic way involving a variety of local stakeholders (e.g. research organizations, firms, policymakers, agencies, communities). We conclude (5) with some ideas on roles for innovation (policy) researchers and policy makers in localised innovation and policy learning processes to advance manufacturing in Croatia.

[2] http://s3platform.jrc.ec.europa.eu/s3-guide

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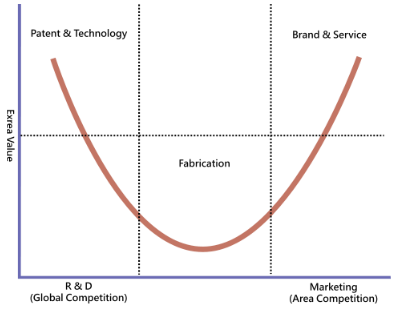
## 2 Policy background: The renewed policy interest in the up-take of technologies which advance manufacturing in Europe

KETs is an EU policy concept as can be derived from the title of the concerning communication of the EC (2009): "Preparing for our future: Developing a common strategy for key enabling technologies in the EU". Although the document recognizes that *"there are differences between Member States on what should be regarded as KETs, which might be explained by the strengths and limits of their research and industrial landscapes",* the remainder of the document takes a global view on technologies and a European view on the future. Moreover, the focus in the document and the early days of the KETs concept still came down to: *"enabling high-tech industries".* After the EU policy of 'the Barcelona target of 3% R&D' (as a generic, pre-competitive policy target for all economies in the EU) some have suggested to specify which technologies would be especially relevant to grow new high-tech sectors[3]. The innovation supply-side perspective has broadened, with more emphasis on the uptake of technologies (with innovation demand-side policies). In 2010 the EC therefore, identified Advanced Manufacturing Systems (AMS) as the sixth and crosscutting KET besides the original five Key Enabling Technologies (KET) of photonics, nanotechnology, advanced materials, micro/nano-electronics and biotechnology (EC 2010). What followed is an Industrial Policy Communication update (2012), which includes the target to reverse the declining role of Europe's manufacturing industry from around 16 percent of GDP in 2014 to 20 percent by 2020. To achieve this target, efforts have been made to boost the uptake of Advanced Manufacturing Technologies, including the original KETs. This renewed interest in manufacturing can also be witnessed in the many national strategies that followed (See Figure 2). All these programmes start with a re-validation of manufacturing, stating for instance that: it has one of the highest multiplier effects of all industry sectors; it is driving technological innovation; and providing skilled and well-paid jobs (Mazarro, 2012). Pisano & Shih (2012) stated that "America needs a manufacturing renaissance [...since...] when a country loses the capability to manufacture, it loses the ability to innovate". What once was referred to as the 'smiley curve' of value added (figure 1), had under-estimated the loss of important back-ward and forward learning effects between the various activities in the value chain. As was for instance pointed out by the 2014 report of the Task

**Figure 1 The idea of the 'smiley-curve' of value added and value-chains**




[3] With the RIS3 concept DG Regional Policy had suggested at about the same time that regions should specify their own strategy

Force on Advanced Manufacturing for Clean Production, Europe may be a global leader in supplying advanced manufacturing technologies and patents, but the new robots and machines are mainly sold to, and used in Asia, while for instance the demand in Europe for machine tools had dropped. Innovation and learning happens at and between different stages of the value chain at the same time, involving multiple sectors. In addition they stated that R&D seems to follow manufacturing locations. This perspective translated the 'smiley-curve' into many sad faces of policy makers Europe. As Lundvall (2010) has explained, the spill-overs from interactive learning between producers and users of knowledge is important for innovation systems. Without using KETs in manufacturing, inventing KETs does not generate growth, nor productivity, nor solves societal challenges.

Figure 2: Programmes for Advanced Manufacturing in selection of EU countries


In a similar way the workshop in Zagreb on 'Technology, Growth and Productivity, including KET' also stressed the importance of the up-take of technology for Croatia. Firms, regions, sectors and countries do not have to invent every technology themselves. From a macro-economic research perspective it was shown that it is important to increase the capacity to absorb knowledge and technologies, and therefore invest in R&D, tertiary education and imports of machinery. Also at firm level there are many determinants of productivity growth which highlights the heterogeneity in firms' capabilities and the importance of different sources of technological upgrading. Also for firms in Croatia there are many things which can explain differences in growth and productivity, not only R&D but also ICT, creativity and for instance the local consequences of the war. All this diversity and specificity in capabilities and constraints call for an (inter) active approach from policy makers and innovation researchers in their search how to assess and improve the innovation mix and innovation policy-mix in Croatia. The first TW concluded in this respect that there is not a simple, single, one-size-fits-all (representative) policy instrument or target to enhance innovation, e.g. the mainstream

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supply-side form of R&D subsidies which make it cheaper for R&D-performing firms to do more of the same (Wintjes et al. 2014). Also other, new modes of innovation, other sources for productivity and upgrading, a wider range of challenges and targets, and other policy instruments may be relevant; as ‘experiments’ and ‘discoveries’ from policy makers and innovation researchers involved in RIS3 could show.

## 3 Research on the production and use of Key Enabling Technologies in Europe

When selecting and developing appropriate technologies and policies for Croatia, we should therefore be aware that what may work for the EU or other Member States may not work for the actors, sectors and regions of Croatia. The practices developed at EU level might however be adapted to innovation research and policy making in Croatia.  We briefly discuss some European studies for inspiration.

The first is called ‘KETs Observatory’[4]. After a feasibility study in 2011-2012, and a study in 2013-2015, a more recent follow-up is in progress. This project follows the EC in its assessment of the six technology fields which are considered key. Figure 4 provides a part of the more detailed taxonomy. Several data-bases with standardised international codes are used to link various activities (including: PATSTAT for patent applications, PRODCOM for production and demand, UN/COMTRADE for trade, and ORBIS for business development) along what they call ‘the deployment value chain’ (Figure 3). The result is an international framework of indicators addressing the invention, production and use of KETs in European countries.

Figure 3: Indicator framework for the ‘deployment value chain’ of the EU KETs Observatory

| “Deployment Value Chain” | | | | | |
|---|---|---|---|---|---|
| *Technology generation and exploitation* | | | | *Technology diffusion* | |
| *New Technology* | *Competitive Innovations* | | *Commercialisation* | *Application* | |
| **Patents** | **Production** | **Trade** | **Turnover** | **Production & Demand** | **Employment** |
| IPC | PRODCOM | HS | NACE/IPC | PRODCOM | PRODCOM/NACE |
| KETs-related inventions | KETs-based components and intermediary systems | | KETs-related firm activities | KETs-related value creation | |

4 https://ec.europa.eu/growth/tools-databases/kets-tools/about

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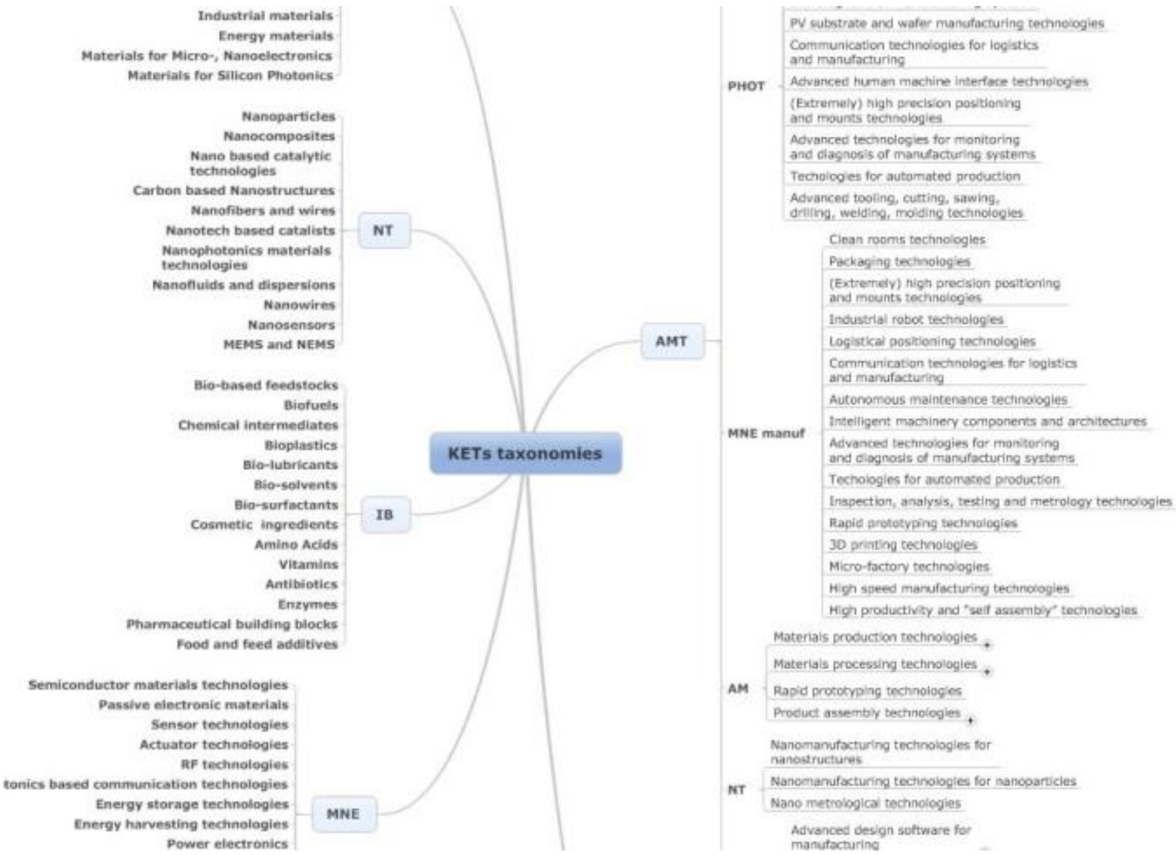
**Figure 4: Part of the detailed KETs taxonomy**




A second example is the Regional Innovation Monitor. Using a slightly different taxonomy they for instance map the patenting activity at sub-national level in Europe. In terms of patents Germany is the lead country in advanced manufacturing technologies, since firms in Germany contribute nearly half to all European patent activity in the field for the period 2003-2012[5].

A third study addresses the use of Advanced Manufacturing Technologies in product and process innovations in manufacturing industries. The results are based on the European Manufacturing Survey. The difference between KETs and AMT (Advanced Manufacturing Technologies) concerns the level of 'ready-ness': KETs may not be widely used yet, while AMT refer to technologies which are already used in practice (kroll et al., 2015). The three categories which are distinguished in several EU policy studies, are also followed in this one:

- Sustainable manufacturing technologies, i.e. technologies to increase manufacturing efficiency in the use of energy and materials and drastically reduce emissions;

[5] Regional Innovation Monitor Plus 2015 Thematic Paper 1: "Mapping advanced manufacturing networks and exploring new business opportunities"

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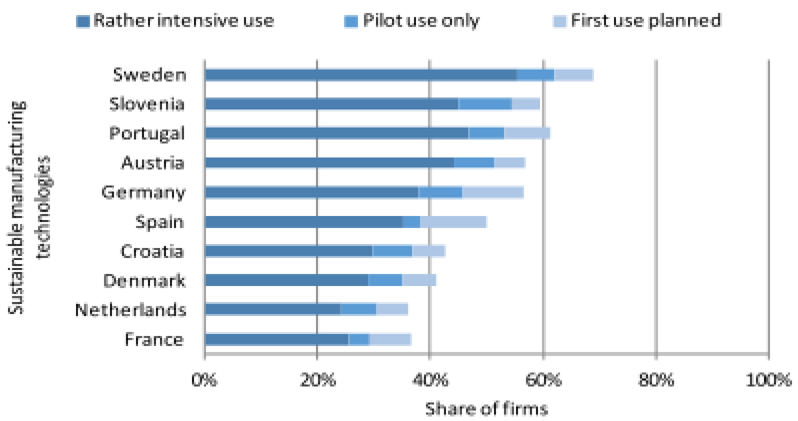
- ICT-enabled intelligent manufacturing, i.e. integrating digital technologies into production processes (e.g. smart factories);
- High performance manufacturing, combining flexibility, precision and zero-defect (e.g. high precision machine tools, advanced sensors, 3D printers).

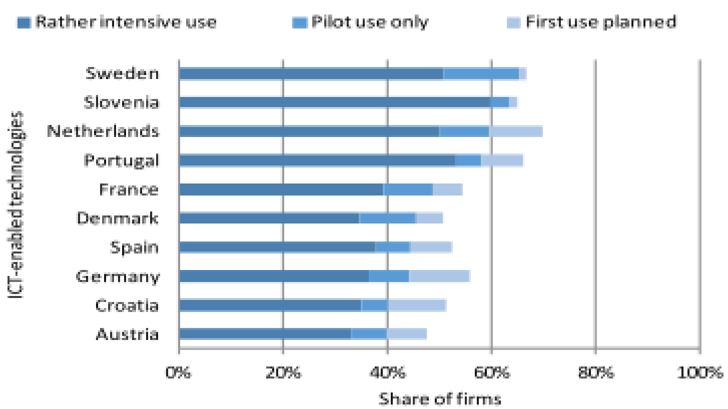
In terms of using advanced manufacturing technologies in processes and products, a much more distributed picture across countries emerges, see Figure 5 and 6. Sweden and Slovenia are leading in the graphs concerning sustainable and ICT-enabled manufacturing technologies. The position of Germany and Croatia is more modest. We have to note that there are also differences between sectors and between large and small firms, which to some extent explains the differences between countries.

Figure 5: Shares of firms using sustainable manufacturing technologies, by country




Source: Kroll et al. (2015) based on European Manufacturing Survey 2012

Figure 6: Shares of firms using ICT-enabled manufacturing technologies, by country

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Source: Kroll et al. (2015) based on European Manufacturing Survey 2012

The analysis based on the European Manufacturing Survey is complemented with qualitative information from company case studies concerning the drivers and barriers for the up-take of advanced manufacturing technologies among producing and using firms. This information is especially relevant for policy making. This qualitative approach is also applied by Wintjes (2013; see table 1). Challenges on the user-side typically include: lack of understanding; conservatism of users; skills; disruptive in systemic way, for many actors; scale of investment/risks. These challenges call for policies addressing the innovation-demand-side, rather than for mainstream policy promoting R&D (innovation supply-side policies). Specific challenges in the situation of Croatia should be identified. Adoption and standardization of questions on these issues in surveys would allow for future quantitative analyses.

**Table 1: Challenges of users of advanced manufacturing technologies**

| Trends | Challenges of users of Advanced Manufacturing Technologies |
|---|---|
| | |
| 1 Environmentally friendly technologies and energy efficiency | Limited understanding of the technological solutions; Clients having a lack of understanding of the new value chains and the technologies being employed; Environmentally friendly technologies may disrupt value chains and production lines. In doing so, they might require the fundamental rethinking and redesigning of the client's manufacturing structures and production flows. Financial considerations as significant upfront expenditures and long investment horizons are typically required; Adoption can lead to both increases and decreases in staffing levels; Clients also need to be ensured of the reliability, viability and sustainability of both the technology and the company supplying the technology. |
| 2 New Manufacturing Engineering | Adjusting to a higher skill level of employment demand in manufacturing.<br>Build good and early cooperation with supplying companies. |
| 3 Mass customisation | Mass customisation enables clients to develop their own business.<br>Integrating an MC strategy implies carefully managing various kinds of change, mostly organisational change. Management challenges include: supply-chain management, Inventories management, sales projections and risk management. |
| 4 Measurement Technologies and Robotics | Automation solutions are often capital-intensive and best suited for large-volume production, and secondly they are often complex systems with a single function that makes them highly inflexible. Moreover potential SME clients have difficult access to finance, poor awareness of the benefits of the solutions; and low technical competence outside core business. |
| 5 Smart Value Chains | The solutions offered were considered to be potentially disruptive to the value chain.<br>Requires significant capital expenditures to invest.<br>The uptake of smart value chain manufacturing solutions requires companies to attract highly skilled human capital. |

Source: Trend Report Business Innovation Observatory (Wintjes 2013)

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**4 Policies promoting the up-take of KETs in manufacturing**

This section will mention some examples of KETs based strategies and Innovation policy (mixes) for manufacturing at firm, cluster, and national level.

In this respect, the KETs Observatory also maps KETs Technology Centres, which in their words: “help companies cross the 'Valley of Death', that is to say to go from lab to market, for new KETs-based products. They help companies reduce the time-to-market for new innovation ideas”. The centres can be public and/or private, some focus on competences, others refer to excellence, some cover specific technological fields, others address more general skills. Typically they provide the following services:

- Access to technology expertise and facilities for validation;
- Demonstration;
- Proof of concept / lab testing
- Prototype development and testing;
- Pilot production and demonstration/ pilot lines / pre-series
- Product validation / certification.

Sirris, in Belgium,is an example of a collective technology centre. Twenty percent of income is from member companies. They carry out more than 4,000 industrial interventions per year in more than 1,800 different companies of whom 80% are SMEs. Experts visit companies on site, offer them technological advice, launch innovation paths, and provide guidance until they reach the implementation phase. The aim is to find concrete solutions to the real challenges faced by companies.

Especially in southern Europe there many sector specific ‘collective centres’ which are often related to regional clusters and cluster-policies. Other initiatives are organised by universities which want to reach out to and learn from regional users, e.g. concerning 3-D printing or super-computing. Relevant initiatives may also concern a group of companies that visit each other’s factories, showing and questioning on-site how they deal in real-life with the abstract relation between technology and productivity. Learning may also be the incentive for policy makers and innovation researchers to participate in such initiatives, since the raised issues may serve to improve their work, e.g. to think of new policies, new survey questions, or indicators for monitoring and evaluation.

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We can't cover in this brief the large diversity in the mix of policy instruments, infrastructures, regulations and programmes concerning KETs and advanced manufacturing[6], but limit ourselves to a list of possible ingredients which emerged from another EU study:

- Advice, information, organise network events;
- Promote contract research and service provision by technology institutes;
- Improve quality of service provision;
- Provide and share infrastructure for testing and demonstrating;
- Improve financial instruments to invest in and import existing state of the art technology;
- Vouchers for solving problems raised by firms or others;
- Subsidies for innovation projects which include process, market and organisational innovation;
- Promote collaborative research and innovation;
- Multi-disciplinary teams of students, fast proto-typing of solutions to business or societal challenges;
- Innovation assistance: subsidised hiring of a person to run an innovation project;
- Provide training and adapt school curriculum;
- Develop apps to improve access to equipment, expertise and resources in existing labs.

> The **Smart Specialisation Platform for Industrial Modernisation (S3P-Industry)** aims to support EU regions committed to generate a pipeline of industrial investment projects following a bottom-up approach - implemented through interregional cooperation, cluster participation and industry involvement. The S3P-Industry co-developed and co-led by the regions themselves ensuring an active participation of industry and related business organisations such as clusters, as well as research institutions, academia and civil society.
>
> Source: http://s3platform.jrc.ec.europa.eu/industrial-modernisation

Common challenges that regions with industrial RIS3 strategies face, open up the possibility for cooperation with other regions, e.g. neighbouring regions. The S3 platform includes a corner where such regions can find each other, and discover ways in which they can cooperate and learn from each other.

Such common inter-regional challenges and policy issues, include:

- Rapid deployment and up-scaling of advanced manufacturing technologies;
- The challenge of shifting to digital factories;

[6] See for instance https://ec.europa.eu/growth/tools-databases/regional-innovation-monitor/content/regional-innovation-monitor-plus

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- The need to adopt clean technologies and enhance resource and energy efficiency;
- The theme of new business models in manufacturing;
- Internationalisation and global supply chain management;
- Training and skills for advanced manufacturing;
- Technology standards and new regulations;
- Science-Industry co-operation & improving research and innovation infrastructure.

## 5 Engaging and empowering roles for innovation (policy) researchers and policy makers in RIS3 innovation and (policy) learning processes

In strategic processes to improve the (local, technological, sectoral and national) innovation and production systems of Croatia innovation researchers and policy makers have a role in localising the learning processes. In the past the EU doctrine of policy learning (Open method of coordination) was one of diffusing 'best practices', as if a sort of competition among practices would lead to a convergence into a single EU best practice policy mix (Nauwelaers & Wintjes 2008). With the RIS3 approach, which is rather aimed at diversification of the innovation and policy-mixes, regions have the opportunity to experiment with new technologies and policies and develop even more relevant practices. In order to develop innovation niches and specialised strategies the EU level taxonomies and landscape discussions should be localised: adapted to the ideas, challenges, capabilities and relations among actors in the innovation systems of Croatia. Both innovation researchers and innovation policy makers have a role to play in organising and co-ordination activities aimed at learning to innovate.

The question: "Which technologies and policies can be best applied and deployed in Croatia?", can be answered in many ways, and based on a diversity of methods: answers can come from applying scientific statistical methods, or from theory-based policy evaluations, the question can be answered with narratives framed around cases of success or failure, with results of political debates, with insights from 'fore-sight' exercises, with results from 'entrepreneurial discovery' as called for by RIS3 guidelines, etc. The variety of answers is also likely to differ according to differences among actors (who is answering and raising the question) and the differing (local, sectoral and historical) contextual situation in which they operate.

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Also the first Training Workshop emphasised the policy importance of the demand side of innovation and of an orchestrating role in policy learning. In prioritizing technologies and R&D policy and complementary demand-side innovation policies, the innovation ecosystems in Croatia can learn from global analyses at EU level, but the insights should be adapted to the specific situations and capabilities.

It is important that local technology producers and technology users communicate with each other, but their forward looking communication goes beyond trading patents and transferring knowledge for a price on global markets. It is difficult for any actor in innovation systems, to tell in advance what the value of knowledge, technologies or innovations will be in the future. Moreover, both the producers and users of new technology know more than they can tell (Polanyi 1966) and they know more than they can sell through licences. The fact that not all relevant knowledge is codified, or has a price, does not make it less valuable. The same is true for knowledge about KETs and advanced manufacturing policies. Not only the codified knowledge of standardised statistical data, existing school curricula and evidence-based ‘best practice’ policy recipes of the past are of value. Innovation researchers and policy makers may be more interested in codified knowledge and existing practices, but in order to get to new knowledge and even more relevant policy practices, they should actively engage in the codification processes.

Also innovation (policy) researchers have to develop new ideas and new research methods. This also implies ‘experimenting’ outside the mainstream neo-classical paradigm. The variety of stakeholders, the diversity of innovation modes, sources of productivity, and heterogeneity in policy interventions, and the multiple levels of governance, etc. also calls for a variety in research methods in a mixed-method approach to study innovation (policy) mixes.

Since both markets and governments may fail to predict which technology strategy would be best for the future, it should be discussed, designed, implemented and evaluated in a systemic way involving a variety of stakeholders (e.g. research organizations, firms, policymakers, agencies, communities). Answering the question raised in the title of this policy brief is therefore a joint discovery process (Rodrik 2004; Nauwelaers & Wintjes 2002). In the RIS3 concept this process is labelled as ‘entrepreneurial discovery’ (Foray 2011). The term sets it aside from ‘scientific discovery’, but in no way it excludes the involvement of innovation researchers and policy makers. In this respect the workshop concluded that for Croatia the coordination between public and private sectors and actors

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is a clear challenge for the near future. This policy brief highlights that innovation researchers and policy makers can contribute to this interactive learning and (policy) innovation process. Moreover, they can get empowered by orchestrating this discovery process.

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