# Smart specialisation strategy and the policy instruments

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## Abstract

This paper discusses the problem of designing and using innovation policy instruments and experimentations within the framework of a Smart Specialisation Strategy (S3). As a matter of fact, S3 cannot be reduced to one single policy instrument – such as R&D subsidies or tax credits or the patent system. It is a general approach to the problem of structural transformations of regional economies and, as such, is likely to include several instruments. Indeed, any structural transformation has multiple determinants and requires policy responses and experiments in various policy areas.

This paper is intended to help policymakers take stock of the variety of available policy tools and facilitate their understanding of what kind of tools fits certain types of problems or opportunities.

# 1 Introduction

One question that has been repeatedly addressed for the last 20 years in regional policy discussions is whether there was a better alternative to a policy that spreads R&D investments thinly across several frontier technologies and research fields, and, as a consequence, fails to make much of an impact in any one area. A more promising strategy can be for regions to identify the domains where new R&D and innovation activities will complement the region's other productive assets to create future domestic capability and interregional competitive advantage. Such strategy was termed “smart specialisation” (S3) by four economists (Paul David, Dominique Foray, Bronwyn Hall and Bart Van Ark) when they were members of the *Knowledge for Growth* expert group of the European Commission (EC) (Foray and Van Ark, 2008; Foray et al., 2009). It was then adopted by the European Commission as a central policy approach for regional and cohesion policy. According to this approach, every region was advised to: (i) generate a **vision** of its future domains of transformation and diversification, based on its specific capacities and opportunities; (ii) translate this vision into a few **priority areas**; and (iii) concretise these priorities in terms of projects, actions and policy initiatives as identified through a bottom-up **process of entrepreneurial discovery**.

## 1.1 Lessons from the first experimental period

The first phase of implementation started in 2014 until 2020. S3 was established as an *ex-ante* conditionality within the framework of EU cohesion/regional policies. This first period was a massive policy experiment for all European regions and countries and the feedback and learning processes derived from it allowed us to better understand what kind of policy design can be effective in generating structural transitions and strategic initiatives (Tsipouri, 2017;

Foray, 2019b). This allowed us also to highlight the problem of insufficient exploitation of the rich innovation policy toolbox in most cases of regional S3s. Indeed, S3 cannot be reduced to one single policy instrument. It is a general approach to the problem of structural transformations of regional economies and as such is likely to include several instruments since any structural transformation has multiple determinants and requires policy responses in various policy areas. However, using fully the innovation policy toolbox and proceeding to the effective matching of problems and instruments are challenging policy tasks. This is the main issue which is addressed in this paper.

### 1.2 S3 becomes mainstream

The new operational period of the Commission started in 2021. S3 is no longer an *ex-ante* conditionality but an enabling condition which "*plays a central role in strengthening regional innovation ecosystems so that they are better equipped to stimulate and sustain economic growth*" (EC, 2022). This is reflected in a large consensus in European policy circles that "*smart specialisation strategies are the EU's principal methodology for reinforcing national and regional innovation ecosystems*" (EC, 2022).

Although the rationale is intact and the general principles remain in place, the S3 design and implementation concept offers a simpler and more obvious process – which has been cleaned out of unnecessary complications – and that regions find easier to implement, with greater effectiveness. This concept is summarised in the next section.

## 2. Smart Specialisation Strategy: a Primer

The S3 approach is complex, and we learned from our many interactions with regional policymakers that it is not very effective to provide too many prescriptions and details of implementation that policymakers should follow scrupulously. More effective is to make sure that policymakers and stakeholders understand why and how an S3 can contribute to innovation and growth in regional economies. The idea is therefore to provide a script – "a set of rules similar to those given to an actor who is asked then to improvise on a particular theme". Based on the S3 script, regions then can "improvise" on the theme of structural transformations.

These rules involve prioritisation, operationalisation and, given the limited capacities of the Government to support innovation in very specific contexts, *entrepreneurial discovery process (EDP)*. These are the fundamental rules that are presented below[1].

### 2.1 Prioritization

Prioritisation allows for concentration: it aims to generate a certain density of actors and activities that are *related* as they are dedicated to the same priority – an imperative condition

[1] - A fourth and final rule is about evidence-based S3. It involves all procedures and methods for data and information gathering and analysis – which need to be deployed for establishing priorities, support the EDP and monitor roadmap's execution. This fourth rule will not be considered in this paper.

to benefit from the resulting synergies, complementarity and agglomeration, which are essential determinants of innovation, creativity and R&D productivity. Concentration achieves increased density in prioritised sectors with potential spillovers to the non-prioritized sectors.

A second rationale for prioritisation is that innovation support systems need to be very specific: MedTech innovations and entrepreneurship require different public inputs and coordination solutions than FoodTech innovations and entrepreneurship. This has been a constant argument by Hausmann and Rodrik (2006): the encouragement of innovation cannot limit itself to setting up generic infrastructures and capacities, valid for the entire economy and all companies: "*The idea that the government can disengage from specific policies and just focus on general framework conditions in a sector-neutral way is an illusion based on the disregard for the specificity and complexity of the requisite publicly provided inputs and capabilities*" (ibid.). But, as they argue, addressing all specific issues for all industries is just unaffordable. The Government cannot address all potential infrastructure needs or fix all coordination problems in all industries. '*It is not that choices are desirable, they are simply inevitable.'*

### 2.1.1 Principles of prioritisation

S3 practices have evolved since 2012 as lessons from the first period of implementation were drawn. However, the main principles to select and establish priorities remain intact.

First, encourage regions to identify priorities and thereby build new competitive advantages *on the basis of their specific strengths, potentials and opportunities*, rather than doing just what the others do. The initial S3 idea was based on the observation of many cases of policy decisions which were taken with no relation to regional assets but just followed some trendy topics. Regions need to particularize themselves by selecting priorities, based on region-specific capacities and opportunities.

Second, priorities *are vertical – target specific industries/firms* – a logic of intervention which is opposed to horizontal interventions which concentrate on a few aggregate capacities and categories such as SMEs, corporate R&D, entrepreneurship, universities or business environment. A vertical logic concentrates on a particular industry or group of industries. While horizontal policies are always important to design and implement, vertical interventions are also key for two reasons:

> Some industries are more promising in region X in terms of capacities, potentials and opportunities (Zachmann and Bergamini, 2020). They should deserve a special treatment to accelerate transformations: electric vehicle technologies in Bavaria or solar energy tech in Apuglia.
>
> As already said, support systems for innovation need to be specific. But, by definition, a horizontal policy cannot capture such specific nature of public inputs, services, infrastructures or coordination problems. Vertical policies which target specific

industries can address the specific needs, gaps and opportunities of the concerned industries.

Third, priorities are vertical but not on sectors *stricto sensu* but on *the transformation of these sectors*. This principle is key for S3 to depart from the old style of industrial policy which targeted preferential interventions but at the same time gave rise to the usual problems of picking winners and supporting losers. S3 picks changers! Hence, each priority area includes one or several sectors as well as a transformational goal. If both elements are combined, they build a priority area, a cornerstone of a smart specialisation strategy.

Fourth, priorities need, in any case, *to be specific* – to send clear signals to agents, enhance coordination and support density and agglomeration around a specific objective of transformation.

## 2.2 Operationalization

Within the framework of an S3 priority, the policy will support innovative activities along three dimensions.

### 2.2.1 Provide specific public inputs

There are many public goods which are industry-specific such as specialised skills and competencies, new knowledge, technologies, services and infrastructures. This means that they are not part of the generic policy agenda, but, on the other, they can't be provided (or are underprovided) by private agents. Vertical interventions will support the provision of these industry-specific public goods.

### 2.2.2 Support concentration of resources and networks of actors

The policy will support concentration, and density because innovative activities have scale and agglomeration economies. For example, S3 programs need to target SMEs, attract large companies, and support partnerships and networks.

### 2.2.3 Solve coordination problems

Many transformations at the industry level raise issues of complementarity. The point is that many companies (start-ups, large firms, SMEs) are willing to contribute to the development of this industry and can propose new and innovative business models. However, these business models make sense only when other complementary models are already in place. If all technologies and systems were realised together, they would form a self-sustaining system with potentially important profits. But there are many obstacles dealing with asymmetries of information and the challenges of capturing surplus from such complementarities – where the success of a given project depends on the success of another. It is therefore important to identify and support *systems of complementarities.*

### 2.3 The big question: can the Government do all this?

Government has, by definition limited capacities to address the provision of public inputs and solve coordination problems at a very high level of detail and specificity. The Government that was driving centralised decisions on priorities and transformations can't predict what should be done by whom and with whom, and what are the coordination problems arising from shifting a particular sector towards new goals or targets. Therefore, encouraging innovation in a specific sector to achieve a certain transformation or transition – which is the characteristic of an S3 priority – requires such a detailed level of information concerning the necessary specific inputs and infrastructures that it is not realistic to think that a central planner can attain this level.

In acknowledging this inability, planners must recognise their limited roles, which implies a need to complement the planning logic with a bottom-up discovery process – one where firms and other innovation actors are called to assist the planner to learn about constraints, problems and opportunities and engage in strategic coordination to generate specific and tailored policy initiatives in response (Rodrik, 2004).

### 2.4 Entrepreneurial discovery process

EDP is a bottom-up process involving stakeholders to elicit information about the specific gaps, needs and opportunities within a given priority area and identify the relevant policy actions.

This bottom-up discovery process will uncover a collection of complementary activities (all being undertaken and pertinent in relation to the transformation's objective) – covering a multitude of dimensions. This roadmap could under no circumstances have been imagined or predicted by the government.

### 2.5 S3 process: a summary

A key operation of S3 is to put in place a process of strategic interactions between the government and stakeholders to discover i) priorities defined as specific transformational goals within broad fields, ii) the gaps, problems and opportunities which characterise such transformations and eventually, iii) the policy initiatives to be taken in response. The outcome of this process is a transformational roadmap which forms the basis for designing and implementing policy programs (such as call for proposals, procurement, prizes, the provision of new infrastructures, etc.). Section 5 will offer a case study in order to illustrate how regions (or countries) can put this process into practice.

## 3. S3 and the policy instruments

Driving transformations towards certain goals may require the deployment of several instruments and provide opportunities for running policy experiments and designing novel

policy initiatives. It also requires flexibility and constant adjustment of the instruments to meet the uncertainty of project implementation and performance.

## 3.1 Multiple problems and opportunities, multiple instruments?

It is important to highlight here the multi-dimensional nature of any "vertical transformation" – for example the development of a circular economy in the food industry or the generation of digital transformation in the healthcare industry. A vertical transformation has multiple determinants and policy levers. This is why the problems to be solved and the opportunities to be realised are many and proceed from different policy areas: human capital, R&D and innovation, infrastructure and services, technology diffusion, cluster and networks.

In the same vein, innovation as a key engine of any S3 needs to be understood in a broad sense: this means that, for many regions, S3 will not be deployed to invent at the frontier but rather to generate "innovational complementarities" in existing sectors (Trajtenberg, 2010) which involve innovation-related activities such as technology adoption, training and skills development, the creation of new organisational structures and/or business models in companies, the implementation of novel management practices or the provision of specialised business services and infrastructures for product and process development.

Then, as policy actions need to be formulated to address all the issues (solving problems, filling gaps, and realizing opportunities), the so-called *Tinbergen assignment theorem* applies (Tinbergen, 1967). As there are a number of policy goals and often an array of specific concerns, one will need to have as many separate policy instruments as there are targets. This is why EDP is crucial to identify these specific problems and opportunities and is also instrumental in exploring the rich toolbox of innovation policy to propose a relevant instrument for every issue that needs to be addressed.

## 3.2 Uncertainty in implementation and the need for operational flexibility

The implementation of a transformational roadmap - including several programmes and actions - is characterised by a high level of uncertainty regarding how each of these actions will evolve. Launching the various activities is like starting a *voyage of discovery* – to use Hirschman's expression (2015). By definition, discoveries involve success, failures and surprises, and it is critical to include in the design of an S3 *feedback mechanisms, monitoring principles and flexibility* to maximise the informational effects and spillovers of all considered activities which are implemented and allow stakeholders to re-assess initial funding decisions after a first period of operations.

## 3.3 Poor use and design of instruments, lack of flexibility

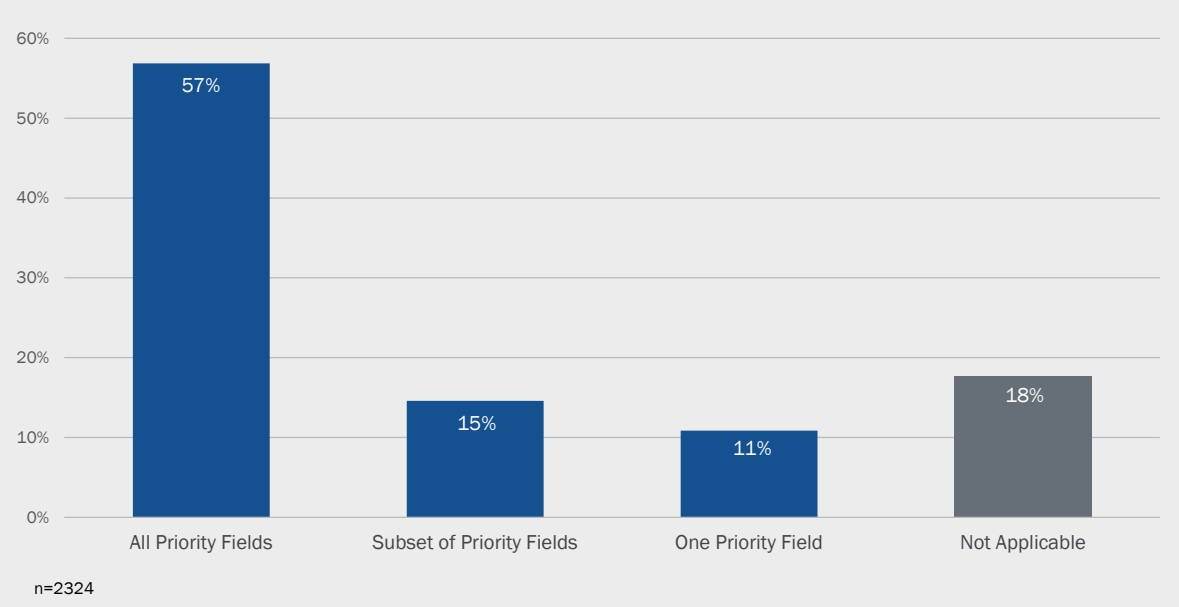
This is the theory. The S3 practice tells us a different story. In many cases, while the EDP was effective in identifying specific problems, gaps and opportunities, the suggested policy responses were poorly formulated and the EDP participants overlooked the diversity of the

policy tools which are available and were not able to respond to new problems and opportunities arising during the roadmap development.

### 3.3.1 Evidence

The limited scope and poor design of the potential instruments are reported by Gianelle et al. (2017 and 2019) and Prognos and CSIL (2023). For instance, Prognos & CSIL observe the dominance of one instrument – which is the *call for proposal* – and argue that this instrument is, in most cases poorly designed. Indeed, they show that the **majority of the S3-related calls for proposal address all priority areas at the same time** (see table 1).

*Figure 1 Priorities areas addressed by calls for proposals – source Prognos & Foray, 2023*




These results provide EU-wide confirmation of previous indications by Gianelle et al. (2019), who analyse calls for proposals in seven Member States (Italy, Poland, Portugal, Czechia, Hungary, Lithuania, and Slovenia) and find that the majority of these calls address all priorities jointly. Clearly, by addressing all priorities at the same time, calls do not consider sectoral and technological specificities, as the very logic of smart specialisation would advocate (Gianelle et al., 2019).

### 3.3.2 Tentative explanations

As a priority has been established, there are two possible logics of implementation: through the first one, the public agency makes explicit the priority thematic area and then allows researchers and innovators to freely explore it through some kind of broad call of proposals. There is little monitoring and oversight which makes this way rather easy to implement. The second logic starts similarly with the identification of priority thematic areas. However, the priority is described in much greater detail (involving milestones and targets) and program staff are deeply involved in the architecture and the execution of the program. Such a logic is

much more demanding in terms of the EDP capacity to get into great details, targets, and objectives and of the program staff management capabilities. It is obvious that the former is easier to implement but has little driving power and doesn't go very far in the task of matching problems and gaps with specific policy instruments. The latter is more difficult to implement, has high driving capacity and will make a better use of the variety of the policy toolbox. However, the former has been the predominant mode of translating a priority into concrete activities.

Another explanation, which concentrates on the lack of flexibility and adjustment capacity, as the roadmap development unfolds, deals with the design of the ERDF as a funding structure. At its core, S3 needs to create the conditions for a continuous discovery process. The "discovery" element of the process towards a transformational roadmap implies a high level of flexibility. A transformational roadmap is not a static plan but should always be understood as a dynamic concept to be continuously adapted and amended along the way to transformation. In particular, a continuous EDP involves greater flexibility in terms of content and partners, smaller « stages » with shorter work cycles and more frequent testing, customer involvement, trial-and-error and, if it makes sense, fresh starts with new objectives and orientations. But the ERDF logic contrasts strongly with the spirit of EDP. ERDF structures and processes still function according to the canonical model of R&D project funding – in which resources are allocated at the very beginning of a project based on a detailed project plan and the funding is rarely stopped before completion. More flexible allocation of resources and greater flexibility will have definitive benefits for an S3 viewed as a living document.

# 4 Exploring the innovation policy toolbox

The reality is that there is a large variety of instruments available; each of them is suitable for certain types of problems, gaps, and opportunities. It is, thus, useful to think of some kind of **organisational principles** to get a better picture of the appropriate S3 toolbox.

## 4.1 Organizing the toolbox

Policy instruments are designed and deployed to support innovation through different logics.

Under a **push logic**, the instrument addresses essentially the cost of innovation activities. This includes the direct provision of research through government labs, directed grants and subsidies to R&D; R&D tax credits; subsidies to transfer of technologies or to support innovation adoption.

Under a **pull logic**, the instrument addresses essentially the reward for a successful activity. The most important pull policy is patent protection but, in many sectors, and circumstances ex-ante prizes and advanced market commitments are gaining in importance. Public procurement for innovation can also be considered as a pull instrument.

Under a **coordination logic**, the instrument addresses potential coordination failures which arise from the strategic complementarities among actions or investments. Strategic complementarities mean that supporting one action or investment will increase the return to support another. Under such principle, policy instruments are designed to capture such complementarities (e.g., support different types of investments simultaneously).

Under an **institutional design logic**, the instrument proposes a new organisational design for complex innovation problems – which cannot be addressed by the more conventional instruments. This is typically the case for the development of partnerships between SMEs and Universities or the support of entrepreneurship through multiple actions.

The final logic includes instruments which are usually used for interventions in other policy areas such as **human capital supply**.

Push and pull policy tools can be defined as « conventional » instruments – i.e., instruments which are well known and have proven effects, they are used in many national policies, and their effects have some levels of external validity. They can be subject to fine-tuning and setting and can be evaluated through a causal approach. Unconventional instruments are more of an *ad hoc* type, can have limited external validity in terms of causal effects and are difficult to evaluate since the policy process which is triggered by the instrument is complex, there are no pure treatment effects and no obvious counterfactual. Unconventional instruments can be experimental and can be tried, including ones where there is some uncertainty about whether they will succeed. If the evidence shows that they do not work, they can be modified or stopped.

We proceed first to the analysis of the conventional tools with a particular focus on public procurement for innovation and then turn to the less conventional instruments.

## 4.2 Push or pull? Conventional instruments

A first issue is that some of these instruments are essentially neutral. They address innovation costs or rewards for any potential innovator and cannot really be used for preferential interventions. This is typically the case of the patent system or the R&D tax credit[2]. These are neutral instruments which are not considered as S3 policy tools and are in any case available to any innovator. For the instruments which can be used in a non-neutral way, such as R&D subsidies or an *ex-ante* prize, the question is then to decide what should be used, given the problem to be solved.

Table 2 presents the case of a public agency which is willing to support innovators in the area of hydrogen fuel technology. The agency can either address cost (through R&D subsidies) or reward (thanks to an *ex-ante* prize). The pros and the cons related to each option are presented below.

[2] The expression *neutral instruments* means that the beneficial properties of the instrument (such as low administrative and monitoring costs) are conditional, in that they are used in a neutral way. Using them for preferential interventions in specific fields would greatly increase all these costs. For instance, if someone would like to turn an R&D tax credit into a non-neutral instrument – for example a green R&D tax credit – all of the dimensions of the policy would become much more difficult and costly (Foray, 2019).

Table 2 – Push and pull instruments – our own elaboration based on Kremer and Williams (2010)

*Table 1 Push and pull instruments – our own elaboration based on Kremer and Williams (2010)*

| **Issues** | **Push – subsidies for R&D hydrogen fuel technology** | **Pull – a prize for the first inventor of a new hydrogen fuel technology** |
|---|---|---|
| **Directionality**<br><br>**Does the instrument allow for determining a direction?** | Yes – subsidies can be allocated to preferential fields | Yes – obviously – the prize's specification gives a clear direction |
| **Principal-agent (PA) problem – innovation is highly uncertain, and innovators are difficult to observe and monitor - this generates unhedged uncertainty. This is a market failure.** | The agency pays for the inputs with no certainty whether a useful output will be discovered, and it is not easy to monitor both levels of effort and direction – mechanisms to mitigate unhedged uncertainty involve reputation, midterm review, and multiple-stage funding. The PA problem can be mitigated but not eliminated. | The agency pays for the output – so no problem of uncertainty and no monitoring costs – but high risk for potential inventors who will not win the prize – risk of disincentives - (need to combine the reward mechanism with partial reimbursement as firms achieve milestones) |
| **Information requirement**<br><br>**What is the agency supposed to know for decisions?** | Logically low problem – but monitoring and evaluation issues | *Ex ante* specification of the desirable innovation creates high information problem for technology distant target. Evaluation of the results (who will get the prize in case of multiple winners?) is also an issue |
| **Allocation of risk** | The public agency bears most of the risk and must pay for failure | The private innovators bear most of the risk – the agency pays only for successful outcomes |
| **Reward *vs* access**<br><br>**What counts ultimately is diffusion – how to solve the tension between reward and diffusion?** | Logically no issue – but if inventors can patent their innovation (although it was publicly funded), this is detrimental to access | *Ex ante* prize is given in exchange of making the innovation freely available. Also possible to link reward and diffusion (ex post metrics) |
| **Competition**<br><br>**Does the tool freeze or stimulate competition ?** | No clear evidence | Prizes stimulate competition but too detailed ex ante specification of the expected results can discourage entry and deter competition |
| **What is the best fit ?** | To support research advances | To support product development |

## 4.3 Public procurement for innovation (PPI)

Public procurement is an important pull instrument, which can affect innovation and adoption in various ways[3]. Government and other public agencies can act as "lead customers", making large purchases of a new technology or product at an early stage in its development. Such lead customer generating substantial early purchases can generate several benefits for the whole industry: economies of scale in production, learning effects and reduction in production costs and prices, improvement in product quality, learning in use, etc. Collectively, these benefits can accelerate improvement in price/performance ratios, supporting broader adoption by non-government users (see Simcoe and Toffel, 2012, Tsipouri and Athanassopoulou, 2014, Urraya et al., 2020).

## 4.4 Instruments to fix coordination failures

Beyond the push and the pull logics, a third logic proceeds from the argument that in many cases, investments to provide public inputs for innovation need to be done simultaneously: determinants of innovation and of transformation are multiple and the complementarities among them are key (Milgrom and Roberts, 1990). For example, the mission of establishing a circular economy in a set of sectors of a regional economy (materials, constructions, food, wood, etc.) is characterised by such strategic complementarity problems (see above 2.2.3). It is therefore important to identify and support *systems of complementarities* involving investments to develop alternative materials, promote a repair sector, establish infrastructures for the collection and management of waste, support sharing platforms and library of things or increase modularity in product design.

There is thus a need for policy instruments which can capture strategic complementarities. This is the story of the US ARPA model and its featuring principles such as general organisational flexibility, bottom-up program design, discretion in project selection and active project management (Azoulay et al., 2018). An ARPA mechanism helps to capture complementarities, support various lines of investments for which the success of one is depending on the success of another and drive a systemic transformation of an industry.

Another type of instrument that should be classified in this category is what concerns the building of the entrepreneurship ecosystem according to the S3 priorities. Once priorities have been established, it is important to stimulate start-ups and venture capitalists (VCs) within the considered priority area to lever and channel entrepreneurship's vitality and creativity towards the targeted transformation. Government programs can provide greater access to financing and venture capital, as well as to other types of services such as business expertise which can support the start-ups on the key operations of sales, marketing, and management.[4] One policy approach involves co-location of many high-tech firms in a high-density accelerator or an incubator. In an S3 logic, the concerned entity will be 'specialized' (in fields corresponding to the priority area). Having many entrepreneurial projects within the

[3] There is a small number of examples of the use of civilian PPI in the fields of energy as well as public buildings (building to comply energy efficient and environmental standards).

[4] It is well known that in many cases, start ups are created to meet a technological challenge and show a strong internal culture of science and technology but they are poorly prepared for the commercial challenges (Arora et al. 2022).

same priority area is likely to generate positive synergies and emulation while the support systems of services can be highly specific and relevant.

## 4.5 Towards new institutional design and experiments

The idea behind new institutional design is that complex innovation problems require some institutional "tweaking" and incremental modification of existing conventional instruments. For instance, it is possible to support university-SMEs transfer of knowledge through conventional tools such as subsidies. However, access to new technological knowledge by SMEs is a complex problem since small companies and the academic world find it hard to communicate and implement partnerships. Thus, some sophisticated organisational design can be proposed to solve the various problems arising from university-SMEs uneasy relationships. It seems that intermediary institutions are usually necessary to support the production of adequate (practical) knowledge and the transfer of technology that will enable small companies to undergo transformation. Recent case and econometric studies by Foray and Woerter (2020) and Foray et al. (2022) provide interesting examples of such institutional "tweaking" to deal with complex transfer problems.

A special case for institutional experiment deals with the so-called « institutional reparation ». Quite regularly, the EDP makes the point that some publicly funded or subsidised entities to support the innovation process already exist in the considered industries. However, these entities might prove to be dysfunctional – often because of small-scale implementation and poor resources leading to poor performance.[5] Specifically, this is often claimed for centres/platforms/institutes providing specialized services to SMEs, but can apply to other policy instruments as well, e.g., incubators and accelerators or certain R&D infrastructures.

A policy instrument to achieve an "institutional reparation" for such dysfunctional structures involves a pilot – empowering one or a small number of such entities with more resources (in terms of manpower, infrastructures, and other resources). They should be selected in areas (fields and regions) with a perceived high potential of firms to be supported. These scale changes in terms of public resources for these pilot entities will allow to exploit the full potential of the policy instrument and prove its usefulness (or disprove it). But the policy instrument does not only include more resources. To achieve an "institutional reparation" the governance structures must be reconsidered and improved as well.

## 4.6 – Instruments in other policy areas: human capital supply

Many policy tools are available that can increase the supply of (highly) skilled workers in the specific domains of the considered S3. These tools concern several targets such as:

- Increasing the number of people able to generate frontier innovations (in the concerned industry). The point here is to increase the number of individuals with training in science,

[5] Specifically, this can often be the case when such entities are spread throughout the whole economy or innovation system, splitting the available resources along geographically or thematically boundaries into small parts for each entity.

technology and engineering who then will innovate in the concerned industry(ies) as well as people with entrepreneurial skills and mindsets.

- Increasing the number of individuals with the appropriate new skills and competencies related to new technologies (e.g., digital) or to new missions (e.g. circular economy, energy efficiency). The point here is to offer vocational training programs related to the concerned industry as well as offering continuous education programs.

If these goals are adopted, then policy proposals will help to achieve them. These programs involve the provision of training grants to undergraduate institutions that are designed to increase the number of frontier innovators; the provision of training grants to VET institutions that support the creation of new training programs for a given industry; the provision of training grants to continuous education institutions; the funding of system of objective, achievement-based tests that measure undergraduate and other levels mastery of various areas of science, technology and engineering which are crucial for the considered S3.

# 5 Matching policy instruments to problems and opportunities: towards good S3 practices

## 5.1 Matching problems and instruments

Any activity included in an S3 roadmap associates the identification of a gap or an opportunity with an instrument as a policy response. I propose a few examples of activities below.

If the problem is the need for more R&D in a specialised field, the appropriate instrument should be R&D subsidies – the allocation of which can be operated through a well-designed call for R&D proposal based on certain specifications.

If the problem is arising from human capital supply in a specialised field where the targeted transformation will require some specific engineering skills, the appropriate instrument should be the provision of training grants to specialised programs at the regional university or a VET institution to increase the fraction of students receiving an adequate training according to the regional S3. The instrument could also involve the creation and funding of a new class of portable fellowships, offered to students who are willing to start graduate training within an S3-relevant domain of specialisation (see Romer, 2000).

If the problem is about developing jointly complementary investments (in R&D, training, and technology adoption in SMEs), the appropriate instrument should be an ARPA mechanism which will *by design* capture the strategic complementarities between the various needed investments.

If the problem is a technological bottleneck in the case of a regional priority (we can think of cases in agriculture or renewable energy), the appropriate instrument could be an *ex-ante* prize. However, the prize should be designed so that any potential inventor, outside of the region, can contribute, while the outcome will be made freely available to the regional operators.

If the problem is about creating or strengthening a market for a specific innovation or transformation, the appropriate instrument could be a public procurement scheme to generate substantial early purchases, production-related learning effects and learning in use. Collectively, these benefits can improve price/performance ratios of the innovative product or process, supporting then broader adoption in the private markets.

This list of examples could be largely extended. However, the point is not to provide a systematic matching of problems/opportunities – instruments. Indeed, **the EDP provides significant leeway and flexibility for participants to propose the best associations between problems/opportunities – instruments**, given the specific regional context and current policy practices and capabilities. This is a matter of a robust and transparent EDP where the interactions between the relevant stakeholders (business, research, social innovator, society) and the policy makers will generate a rich collection of relevant activities. This argument shows how important is for the S3 CoPs to build strong EDP capacities.

## 5.2 A case study of good practices: Skåne

The Region Skåne (Sweden) has putting in place a process to design and implement its S3 which follows quite well the logic described in section 2. The process covers the identification of broad priorities (stage 1), the selection of specific transformational goals within each priority area (stage 2) and the development of a roadmap (stage 3) for each specific transformational goal.

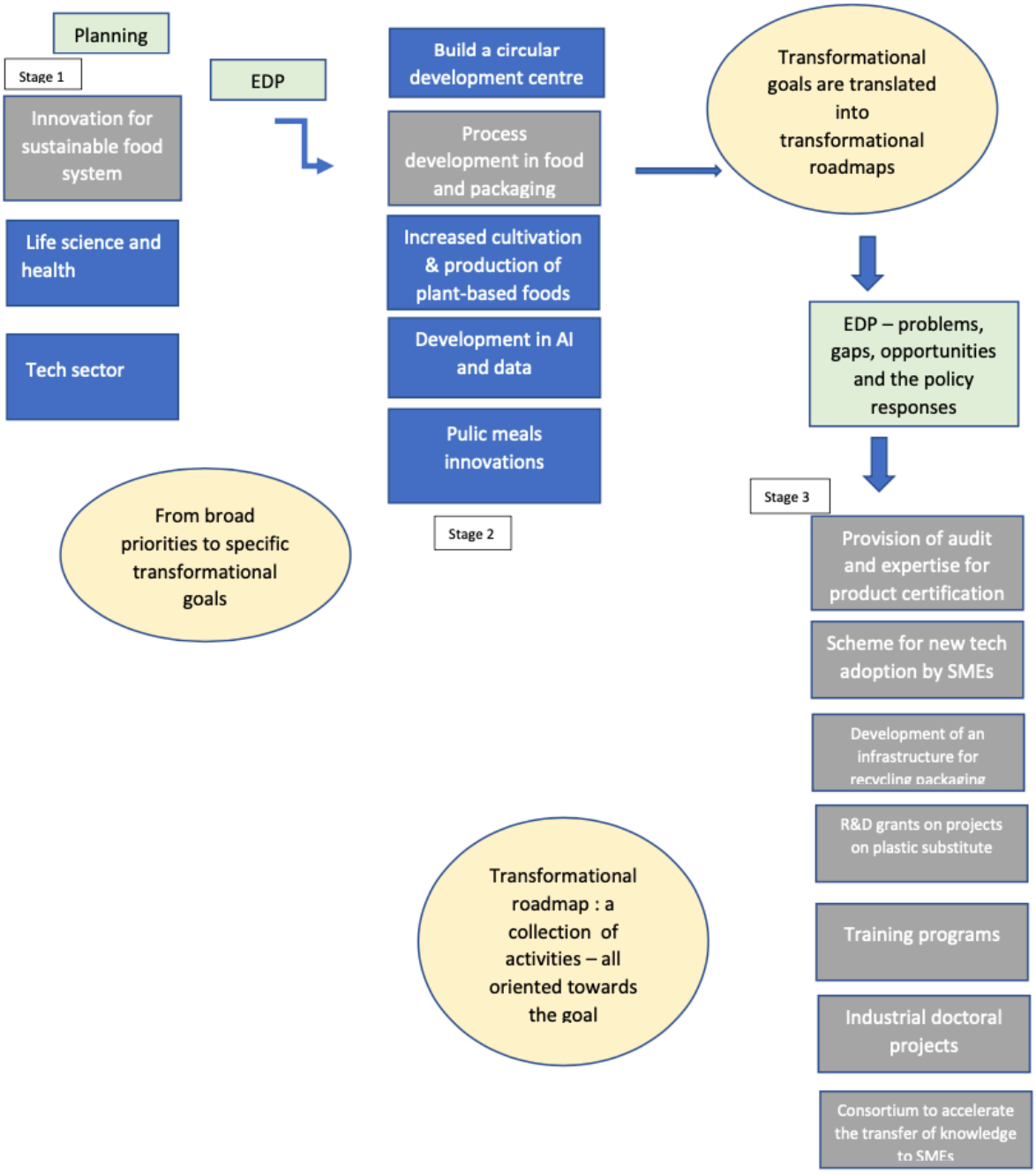
At the first stage, large priority areas have been identified. At this stage, the logic of centralised and top-down decisions is dominating, even if all relevant stakeholders are involved in the decision process.

At a second stage, each of the three large priority areas is explored through an EDP and is eventually sub-divided into more specific transformational goals. For instance, within the large priority area of innovation for a sustainable food system, five sub-goals were identified.

Finally, at a third stage, the entrepreneurial discovery process is activated again to identify problems and gaps which need to be addressed to reach each transformational goal and the tailored policy initiatives in response. The collection of activities (stage 3) is the transformational roadmap. It involves conventional instruments falling into the push logic category: R&D grants, provision of business services, provision of infrastructures, adoption grants, and industrial doctoral project grants. It also includes the support of a network of cooperative R&D as well as the development of a consortium to accelerate the transfer of knowledge. This roadmap covers multiple issues and reflects well on the multiplicity of factors which were important to consider in achieving the transformational goal.

The Skåne example provides an excellent illustration of the right way of thinking about the logic of S3: a mix between a **planning process** -centralised decisions on strategic focus – and a **discovery process** – one where firms, researchers and the government learn about constraints, problems and opportunities within a very specific area and engage in strategic coordination to generate unique and tailored policy initiatives in response.

*Figure 2 Figure 1 – S3 process in Skåne (source Tillväxtverket, 2021)*




# 6 Opening another toolbox

With regard to important and urgent societal problems, of course, public sectors, Governments and social donors have a central role to play in funding projects. However, as the problems our society is facing are not just about financing R&D and start-ups but about financing *transformation and transition*, some new financial instruments need to be involved.

Undertaking structural transformations involve changing infrastructures, developing social programs and supporting systems of coordinated investments in numerous complementary activities.[6]

Financial instruments are more difficult to implement than grants (a conventional innovation policy instrument presented above) but have more potential to solve complex funding problems and can help to greatly change the scale of funding (EC, 2016, p.26; ESPON, 2019, p.21-23). While the literature on « financing innovation » typically recognises the specific features of such projects (for example, R&D or start-ups) and analyses the appropriate institutional responses (e.g. subsidies, venture capital) given these features - the FI literature proposes a different line of solution which is about changing the properties of the financial risk-return profile of the projects to make them attractive for potential investors. In this perspective DG Regio (supported by EIB) has pushed ERDF Management Authorities to exploit more fully the potential of FIs (ESPON, 2019).

Another argument for developing practical knowledge about the design and implementation of new financial instruments deals with the potential explosion of deep tech start-ups – that is to say, start-ups inventing and developing complex technologies rooted in science and advanced engineering[7]. Deep tech innovation is presented as a new wave of innovation which has become a priority to create an EU's leadership in technological innovations (EC, 2022). However, the funding of deep tech start-ups is far from obvious: contrasting with biotech or software start-ups which fit well the classical VC model, deep tech start-ups are characterised by long time horizons between idea and commercialisation, high capital intensity and high costs for experimentation and scale up. All these features make them less attractive to the classical VCs (Lerner and Randa, 2020; Mills and Dang, 2020). Hence the need for enriching the financing innovation toolbox.

## 6.1 Analysing funding problems for supporting sustainable transitions

To attract investors, projects must feature a large enough Sharpe ratio[8]. However, projects that could be implemented to achieve an S3 transformational goal may require large initial investments, have a low probability of success, and feature a long duration before producing any payoff. Others may be out of the economy, i.e., they do not produce a direct stream of cash flow, making it difficult to reward investors. As a result, because of the no/small expected return and/or the large risk characterising such investments, they feature a low Sharpe ratio and fail to attract the financing they need to be implemented. This is a market failure: projects which have potentially large benefits for society are not implemented due to the lack of

[6] This section draws upon Cornet and Foray (2023)

[7] Examples include bew energy technologies, new energy storage solutions, carbon capture technologies, synthetic biology based production technologies, etc..(Arora, et al.,2022).

[8] A widely used measure of the risk-return tradeoff is the **Sharpe Ratio**. It is defined as the excess expected return of the investment above the risk-free rate – the profit or loss an investor expects –, divided by its risk – by how much the realized return may differ from what is expected – which is measured by the standard deviation. The Sharpe ratio can therefore be interpreted as the expected excess return per unit of risk provided by an investment, and rational investors prefer investments with a larger Sharpe ratio.

private incentives they generate to attract the required financing. Financial engineering can help solve this market failure by modifying the risk-return trade-off of such investments.

The risk dimension is a fundamental characteristic to take into consideration because transformational goals are typically risky endeavours. An obvious way to mitigate such high risks is diversification: when risk is diversifiable, FIs build on this characteristic by allowing to invest in many projects to decrease risk at the level of the portfolio of projects, thereby increasing the Sharpe ratio. However, in some cases, the risk is not diversifiable. This is the case, for example when there is a single project or when the outcomes of several projects depend on the success of the others. In such cases, FIs may be used to reallocate risk between the different stakeholders. In the rest of this section, I will focus on funding mechanisms to support projects characterised by non-diversifiable risks and poor financial expectations.

## 6.2 Societal challenge and non-diversifiable risk: the case for social impact bond

The necessity for a local community to adapt climate change – for example, by developing infrastructures against flooding – is an interesting example of *societal problem with non-diversifiable risk.* Indeed, the development of new infrastructures does not produce any direct cash flow, but is highly socially desirable; additionally, projects in this case often involve the realisation of expensive, standalone investments where diversification is not possible.

***Impact bonds*** are a type of financial product that can be used by the public sector to finance social or environmental programs. Impact bonds are similar to bonds, but their payoff is linked to the realization of a desired outcome. Impact bonds are a good example of how financial engineering can help leveraging one important mission of financial markets, in that case, sharing risk. This is probably the most relevant FI for S3. Impact bonds can be used to finance projects that have no earnings such as a green infrastructure, because the bonds are issued and repaid by the government. The important point here is that money that is used to repay the bonds is independent from the projects themselves, as they don't produce any cash flows. The goal of impact bonds is not to finance a profitable business model but rather to facilitate and ease the financing of societal or environmental actions. It does so by providing a sort of insurance against the potential failure of the project: if objectives are not met, the interest the issuer of the bond has to pay is lower. If the project succeeds, the investor is rewarded by receiving a larger interest rate. This is risk sharing – a fundamental mission of the financial market.

The European Commission is putting a great emphasis on this FI through the deployment of *NextGeneratioEU Green Bond* which will be used for funding the transition to a green economy [9] (see for instance the Portuguese *social innovation initiative* (EIB, 2018).

The message of this section is that there is value in understanding the power of this specific approach to support the full deployment of sustainable strategies in regional economies. Obviously, this message has a lot of implications for the S3 CoPs, such as the importance of

[9] - https://commission.europa.eu/strategy-and-policy/eu-budget/eu-borrower-investor-relations/nextgenerationeu-green-bonds_en

building financial engineering capabilities in public administrations at both regional and national levels.

# 7 Conclusion

This paper provides a preliminary analysis of the types of policy instruments which can be used within the framework of S3. The starting hypothesis is that S3 practitioners and policymakers have not always made the best use of the rich toolbox which is available and not enough leeway in terms of flexible decisions and funding. The consequence is that even in the case of a strong EDP – leading to a clear analysis of problems, gaps and opportunities – the actions which were proposed as policy responses were rather poor (reduced in most cases into "calls for R&D projects" within broad thematic areas).

In this paper, we have introduced the S3 approach and its fundamental principles. The very nature of S3 – as an approach to support structural transformations or transitions in selected industries and sectors – implies the necessity to mobilise multiple instruments in various policy areas. And because any structural transformation has multiple determinants, we need as many policy instruments. Clearly, in most cases, S3 practices showed limited use of these policy instruments.

It was then necessary to present the innovation policy toolbox, using some organisational principles to get a clear picture of the various tools which are available. Finally, the case for using fully new financial instruments was made, in order to multiply the funding capacities associated with S3 development.

A lot of lessons should be drawn for the S3 CoP project. The feasibility of critical actions should be discussed – particularly (1) to improve the capacities and capabilities of regional and national policy makers and S3 experts in the area of the design and implementation of innovation policy and financial instruments; and (2) to improve the way the EDPs are designed and organised, as EDP is the essential locus of the critical interactions between stakeholders (industry and research) who can reveal specific problems, gaps and opportunities of their industries and policy makers who can propose the policy actions in response.

More concretely, the COP project could support policy makers and practitioners in designing and implementing key S3 policy tools which are not easy to use: calls for proposals, public procurement for innovation, and new financial instruments.

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