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November 2023

Meta-evaluation of the Swedish Strategic Innovation Programmes

As policy instruments for industrial competitiveness and systems innovation

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Series: Vinnova Report VR 2023:16

Published: November 2023

Publisher: Faugert & Co Utvärdering/Technopolis Sweden

Vinnova case no.: 2018-02397

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1 Summary

This report aims to draw policy lessons from the evaluations undertaken after six years of 17 Strategic Innovation Programmes (SIPs) funded by the Swedish Governmental Agency for Innovation Systems (Vinnova), the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas) and the Swedish Energy Agency since 2013. We consider their progress, first, through the lens of innovation and competitiveness and, second, using a framework based on the research literature on socio-technical transitions to consider how the SIP funding instrument could be modified better to tackle societal challenges and systems innovation.

1.1 The SIP initiative

The SIP initiative sought to improve conditions for research and innovation (R&I) collaboration through a bottom-up approach to create conditions for sustainable solutions to global societal challenges and to increase competitiveness in areas of great relevance to Sweden's economy. A SIP was to be open to any actor and its management was outsourced to actor consortia. Funding for up to twelve years was on offer provided evaluations every three years were favourable.

Four consecutive calls for proposals issued by the agencies resulted in four tranches of 17 SIPs. Most of them focused on manufacturing processes, transportation, health & health care, and urban planning, and most of them built on established networks from previous R&I programmes, while three completely lacked antecedent programmes.

A SIP is governed by a board and its day-to-day operations are managed by a programme office. Programme activities are based on an agenda that is implemented through competitive calls for R&I projects, strategic projects and complementary activities. The calls for R&I projects are developed in collaboration with the agencies, which administer calls, engage experts to assess proposals, take funding decisions and monitor projects. Strategic projects are used to address needs that are common to most of the programme's actors but that are inappropriate to realise through competitive calls. Strategic projects require negotiation with the agencies. Complementary activities may be realised either using coordination funding or through strategic projects. The bulk of most SIP portfolios is made up of R&I projects resulting from competitive calls, meaning that there are significant limits to a SIP's ability to tailor its project portfolio to achieve the objectives of its agenda.

The total resources for the entire SIP initiative will amount to SEK16b (if all 17 SIPs are funded for 12 years). Of this, SEK7.2b will be public funding while the remainder is expected to be co-funded by industry and other societal actors.

In 2018 the agencies assigned Technopolis Group, through its Swedish subsidiary Faugert & Co Utvärdering, to evaluate the SIPs after six years. This report summarises the 17 programme evaluations and analyses the SIPs from a transitions perspective to support policy learning.

1.2 Participants

The main beneficiaries of the public funding have been R&D performers (62%), i.e. higher education institutions and research institutes, followed by small and medium-sized enterprises (SMEs; 13%), large companies (10%) and public authorities (6%). Large companies have dominated as co-funders (51%), followed by SMEs (22%), public authorities

(10%) and R&D performers (10%). Funding trends illustrate a shift in focus from near-total orientation towards company needs in the SIPs of the first tranche to needs of the public sector gradually becoming more important in subsequent tranches.

Public funding has been heavily concentrated to the leading technical and medical R&D performers, meaning that most actors have received marginal amounts. Consequently, the regional distribution of public funding reflects where Sweden's main technical and medical R&D performers are located.

Co-funding is also concentrated, but considerably less so than the public funding. The concentration of co-funding by companies in Manufacturing & mining, Company services and ICT correlates very well with the same groups being responsible for most of Sweden's Business Expenditure on Research and Development. Companies in these groups contribute more than half of Sweden's value added. This indicates that most companies that invest heavily in R&D probably have participated in the SIPs. Eventually, all significant industry branches appear to have had their R&I needs satisfied by at least one SIP. The regional pattern of company co-funding also correlates with the distribution of the nation's value added by companies in the same groups. This suggests that the SIPs have engaged companies all over the country in approximate proportion to their contribution to the value added of the main industry sectors.

During their first six years the 17 SIPs engaged 2 700 unique actors, an increase of 70 percent compared to the first three years. While participation obviously has been dominated by industry incumbents and the main R&D performers, the 17 SIPs have been open to all types of actors and they have managed to engage most relevant actors, including ones without previous experience of R&I or of collaborating with others on R&I matters. The dominance of established actors is a feature of the SIP instrument's focus on areas of national strength in combination with competitive calls.

1.3 Impacts

The most common impact for project participants of all types was to establish long-term R&I collaboration with others, which arguably builds a foundation for additional impacts. Among the most common additional impacts for companies and public authorities alike were new projects with Swedish public funding and self-funded follow-on projects, thus indicating that participants have 'real projects' that require a sequence of projects to gradually approach their long-terms goals. Many projects produced prototypes but few resulted in patents or PhD recruitments, which is consistent with incremental development at intermediate technology readiness levels dominating the programmes. Expectations for future impacts were high overall. Several frequently reported impacts refer to using project results to improve products, services or processes. Together such intermediate impacts may prove important in the longer term, particularly since expectations for future achievements in these respects were high. While some companies reported that commercial impacts had already been achieved, most referred to expected future ones. Few implementation-related impacts were reported by public authorities, possibly in part since they are difficult to identify.

The additional impacts reported by R&D performers largely correlated with those of companies and public authorities. Among the most common ones were new publicly funded projects and development of prototypes, but there were few patents or postgraduate degrees, confirming the presence of real projects also among R&D performers, and that projects entailed more development than research. Many R&D performers reported increased international competitiveness with high expectations for further increases in the future.

Companies and public authorities agreed that they had developed more scientific working practices, while most R&D performers believed that they had adapted theirs better to serve industry and some of them better to serve public authorities. This bodes well for future R&I collaboration being mutually beneficial.

The 17 SIPs' achievements in engaging the relevant actors in formulating and realising common agendas and thereby invigorating their areas have brought substantial systemic impacts. While most impacts hitherto summarised refer to R&I projects, strategic projects have achieved system-level impacts by addressing common challenges and needs through international outlooks and benchmarking exercises, development of common platforms and infrastructure, as well as courses and graduate schools. Strategic projects have successfully addressed system-related weaknesses and have contributed to changed working practices, which has resulted in integration of R&I subsystems that are characterised by wide participation, relevance, quality and efficiency.

The SIP initiative's additionality is considerable, while its objective fulfilment is only partial. The latter is mainly due to the objectives being high-level societal objectives to which the SIP initiative and individual SIPs can at best contribute.

1.4 Systems innovation

The SIP instrument was originally designed as a more open successor to Branch Research Programmes, supporting industrial innovation and competitiveness. The government then decided that it should be used to help address societal challenges, creating an interesting kind of natural experiment that has allowed us to ask what changes would be needed in order to make it fully effective in the context of societal challenges, and systems innovation more generally. The wider policy context has also changed during the lifetime of the SIPs towards increased focus on sustainability, and this appears to have influenced the behaviour of the SIPs. Now, issues such as circular economy, sustainability more generally, but also the life sciences are being tackled at the national level in addition to the level of instruments like the SIPs. This has potential to develop into a system where certain prioritised themes are handled nationally through multi-level governance while others are delegated to agency programmes.

Systems innovations require instruments with more functionality than the SIP funding agencies can provide. However, SIPs could help co-produce them together with other actors that have the competence and ability to tackle needs outside the R&I sphere, such as scaling up, creating new markets, regulating and the 'creative destruction' of old sociotechnical systems (like fossil-fuel based production) that need to be superseded. The specific requirements for coordination will vary from case to case, but agencies will clearly need new coordination skills and processes.

A strength of the SIP instrument is that it can be used to involve implementers and the demand side to a greater extent than has been done in R&I policies so far. Probably, other demand-side instruments will be needed in addition, for example in demand aggregation. Reforms are clearly needed in some government organisations (notably, but not only, in healthcare) to increase their ability to understand and articulate their needs and to standardise and efficiently procure the innovations they need.

The SIP initiative has used actor consortia in public-private partnerships (PPPs) to run the individual SIPs and re-learnt the old lesson that the interests of those who control governance are reflected in what organisations do. Industry is the strong interest group in most of the SIPs. This has encouraged innovation to be incremental and technology-focused. To respond more fully to the need for socio-technical change, the demand side, including public

authorities, needs to be more involved. Adjustments need to be made, also, to find out how to govern individual PPPs in ways that prevent rent-seeking behaviour while allowing them effectively to implement strategy. For cases where multi-level governance is needed, new models will be needed to integrate the work at government and funding instrument levels.

We have in this study relied heavily on the new and fast-developing research literature about socio-technical transitions for ideas. There is very little policy experience to date from which we can learn, but nonetheless a great need to develop policy further. This is therefore a period in which policy experimentation – and sometimes failure – is very much needed. This means more research (specifically focused on policy implementation of socio-technical transitions) is needed, as is building capacity to design and use new policies and instrument.

1.5 Conclusion

Our overall conclusion is that the SIP instrument has proved effective as a technology programme to build national capacity and competitiveness. With some adjustments, it is likely to be effective also to tackle societal challenges by triggering socio-technical transitions. It does, however, need to be used within a wider policy and instrument mix that meets the needs of all three R&I policy generations – fundamental research, technological development and innovation, and transitions or systems innovation.

2 Sammanfattning

Denna rapport söker dra policylärdomar av de sexårsutvärderingar som har genomförts av 17 strategiska innovationsprogram (SIPar) finansierade av Verket för innovationssystem (Vinnova), Forskningsrådet för miljö, areella näringar och samhällsbyggande (Formas) och Statens energimyndighet (Energimyndigheten) sedan 2013. Vi studerar deras resultat dels i termer av innovation och konkurrenskraft, dels genom ett ramverk inspirerat av forskningslitteraturen om sociotekniska omställningar för att bedöma hur SIP-instrumentet skulle kunna modifieras för att bättre möta samhällsutmaningar och systeminnovation.

2.1 SIP-satsningen

SIP-satsningen syftade till att förbättra förutsättningarna för samarbete inom forskning och innovation (FoI) genom en *bottom up*-strategi för att skapa förutsättningar för hållbara lösningar på globala samhällsutmaningar och öka konkurrenskraften inom områden av hög relevans för Sveriges ekonomi. En SIP skulle vara öppen för alla aktörer och programledningen delegerades till aktörskonsortier. Finansiering erbjöds för upp till tolv år förutsatt att utvärderingar vart tredje år utföll positivt.

Fyra på varandra följande utlysningar från myndigheterna resulterade i fyra omgångar av 17 SIPar. De flesta av dem fokuserade på tillverkningsprocesser, transporter, hälso- och sjukvård samt hållbar samhällsutveckling, och de flesta byggde på etablerade nätverk från tidigare FoI-program, medan tre SIPar helt saknade föregångare.

En SIP leds av en styrelse och dess operativa verksamhet sköts av ett programkontor. Programmets verksamhet baseras på en agenda som implementeras genom konkurrensutsatta utlysningar av FoI-projekt, enskilda projekt och kompletterande aktiviteter. Utlysningar av FoI-projekt utvecklas i samarbete med myndigheterna som administrerar utlysningar, anlitar experter för att bedöma ansökningar, fattar finansieringsbeslut och följer upp projekt. Enskilda projekt används för att möta behov som är gemensamma för de flesta av programmets aktörer men som är olämpliga att realisera genom konkurrensutsatta utlysningar. Enskilda projekt kräver förhandling med myndigheterna. Kompletterande aktiviteter kan genomföras antingen med koordineringsmedel eller genom enskilda projekt. Huvuddelen av de flesta SIPars portföljer utgörs av FoI-projekt från konkurrensutsatta utlysningar, vilket innebär att möjligheterna för en SIP att anpassa sin projektportfölj för att nå målen i agendan är högst begränsade.

De sammanlagda resurserna för hela SIP-satsningen kommer att uppgå till 16 miljarder kronor (om alla 17 SIPar finansieras i 12 år). Av detta kommer 7,2 miljarder kronor att vara offentlig finansiering medan resten förväntas vara medfinansiering från näringslivet och andra samhällsaktörer.

År 2018 gav myndigheterna Technopolis Group i uppdrag att, genom sitt svenska dotterbolag Faugert & Co Utvärdering, utvärdera SIParna efter sex år. Denna rapport sammanfattar de 17 programutvärderingarna och analyserar SIParna ur ett omställningsperspektiv som underlag för policyutveckling.

2.2 Deltagare

De huvudsakliga mottagarna av den offentliga finansieringen har varit FoU-utförare (62 %), det vill säga universitet, högskolor och forskningsinstitut, följda av små och medelstora företag (SMF, 13 %), stora företag (10 %) och myndigheter (6 %). Stora företag har dominerat som medfinansiärer (51 %), följda av SMF (22 %), myndigheter (10 %) och FoU-utförare

(10 %). Trender i finansieringen visar på en förskjutning i fokus från nästan total inriktning mot näringslivsbehov i SIParna i den första omgången till att offentlig sektors behov gradvis har blivit viktigare i senare omgångar.

Den offentliga finansieringen har i hög grad koncentrerats till de ledande tekniska och medicinska FoU-utförarna, vilket innebär att de flesta aktörer har mottagit marginella belopp. Den regionala fördelningen av den offentliga finansieringen speglar således var Sveriges främsta tekniska och medicinska FoU-utförare finns.

Medfinansieringen är också koncentrerad, men i betydligt mindre utsträckning än den offentliga finansieringen. Koncentrationen av medfinansiering från företag inom Tillverkning och utvinning, Företagstjänster och IKT överensstämmer mycket väl med att samma grupper står för merparten av svenska företags utgifter för egen forskning och utveckling (FoU). Företag i dessa grupper bidrar med mer än hälften av Sveriges förädlingsvärde. Detta tyder på att de flesta företag som investerar mycket i FoU sannolikt har deltagit i SIParna. Efterhand tycks alla väsentliga näringsgrenar ha fått sina FoI-behov tillfredsställda genom minst en SIP. Det regionala mönstret av företags medfinansiering överensstämmer också med fördelningen av landets förädlingsvärde från företag i samma näringsgrenar. Detta tyder på att SIParna har engagerat företag i hela landet i ungefärlig proportion till deras bidrag till förädlingsvärdet i de viktigaste näringsgrenarna.

Under de sex första åren engagerade de 17 SIParna 2 700 unika aktörer, motsvarande en ökning med 70 procent jämfört med de tre första åren. Medan deltagandet tydligt har dominerats av etablerade företag och de främsta FoU-utförarna, har de 17 SIParna varit öppna för alla aktörstyper och de har lyckats engagera de flesta relevanta aktörer, inklusive aktörer utan tidigare erfarenhet av FoI eller av att samarbeta med andra i FoI-frågor. De etablerade aktörernas dominans är en funktion av SIP-instrumentets fokus på nationella styrkeområden i kombination med konkurrensutsatta utlysningar.

2.3 Effekter

Den vanligaste effekten för projektdeltagare av alla typer var att etablera långsiktig FoI-samverkan med andra, vilket tveklöst lägger grund för ytterligare effekter. För både företag och myndigheter var de vanligaste ytterligare effekterna nya projekt med svensk offentlig finansiering och egenfinansierade fortsättningsprojekt, vilket tyder på att deltagarna har ”verkliga projekt” som förutsätter en serie av projekt för att gradvis närma sig sina långsiktiga mål. Många projekt resulterade i prototyper men få i patent eller doktorandrekryteringar, vilket överensstämmer med den inkrementella utveckling på mellanhöga teknikmognadsnivåer som dominerar programmen. Förväntningarna på framtida effekter var överlag höga. Flera vanligt förekommande effekter avser användning av projektresultat för att förbättra varor, tjänster eller processer. Tillsammans kan sådana mellanliggande effekter visa sig viktiga på längre sikt, särskilt då förväntningarna på framtida framsteg i dessa avseenden var höga. Medan några företag rapporterade att kommersiella effekter redan hade uppnåtts, hänvisade de flesta till förväntade framtida effekter. Myndigheterna hänvisade endast i ett fåtal fall till implementeringsrelaterade effekter, möjligen delvis för att de är svåra att identifiera.

De ytterligare effekter som framhölls av FoU-utförare stämde till stor del överens med företagens och myndigheternas bedömningar. Bland de vanligaste var nya offentligt finansierade projekt och utveckling av prototyper, men få patent eller forskarexamina, vilket bekräftar förekomsten av verkliga projekt även bland FoU-utförare liksom att projekten innebar mer utveckling än forskning. Många FoU-utförare framhöll ökad internationell konkurrenskraft och hade höga förväntningar på ytterligare förbättringar i framtiden.

Företag och myndigheter var överens om att de hade utvecklat mer vetenskapliga arbetssätt, medan de flesta FoU-utförare uppgav att de hade anpassat sina arbetssätt för att underlätta samarbete med företag och några av dem för att underlätta samarbete med myndigheter. Detta bådar gott för att framtida FoI-samarbete ska bli ömsesidigt gynnsamt.

De 17 SIParnas framgångar med att engagera relevanta aktörer för att formulera och förverkliga gemensamma agendor och därigenom stärka sina områden har resulterat i betydande systemiska effekter. De flesta hittills nämnda effekterna avser FoI-projekt, men enskilda projekt har uppnått effekter på systemnivå genom att ta itu med gemensamma utmaningar och behov genom internationella utblickar och *benchmarking*-övningar, utveckling av gemensamma plattformar och infrastrukturer, samt kurser och forskarskolor. Enskilda projekt har framgångsrikt åtgärdat systemrelaterade svagheter och har bidragit till förändrade arbetssätt, vilket har resulterat i integration av FoI-delsystem som kännetecknas av brett deltagande, relevans, kvalitet och effektivitet.

SIP-initiativets additionalitet är betydande, medan dess måluppfyllelse är ofullständig. Det senare beror främst på att målen är samhällsmål på hög nivå som SIP-initiativet och enskilda SIPar i bästa fall bara kan bidra till.

2.4 Systeminnovation

SIP-instrumentet var ursprungligen tänkt som en mer öppen efterföljare till branschforskningsprogrammen och skulle bidra till innovation och konkurrenskraft i näringslivet. Regeringen beslutade sedermera att det skulle användas för att hjälpa till att ta itu med samhällsutmaningar, vilket skapade ett intressant naturligt experiment som har gjort det möjligt för oss att undersöka vilka förändringar som skulle behövas för att göra instrumentet mer effektivt i samband med samhällsutmaningar och systeminnovation i bredare bemärkelse. Det bredare politiska sammanhanget har under SIParnas genomförande också förändrats mot ett ökat fokus på hållbarhet som verkar ha påverkat SIParna. Nu hanteras frågor som cirkulär ekonomi och hållbarhet i bredare bemärkelse, men även livsvetenskaperna, på nationell nivå i tillägg till SIP-instrumentets nivå. Detta kan utvecklas till ett system där vissa prioriterade teman genom flernivåstyrning hanteras på nationell nivå medan andra delegeras till myndigheters program.

Systeminnovationer fordrar instrument med större funktionalitet än vad myndigheterna bakom SIP-initiativet kan tillhandahålla. De skulle emellertid kunna hjälpa till med att producera dem tillsammans med andra aktörer som har kompetens och förmåga att ta itu med behov utanför FoI-området, för att exempelvis skala upp, skapa nya marknader, reglera och åstadkomma ”kreativ förstörelse” av gamla sociotekniska system (såsom fossilbränslebaserad produktion) som måste ersättas. De specifika kraven på samordning kommer att variera från fall till fall, men myndigheter kommer helt klart att behöva nya kompetenser och processer för samordning.

En fördel med SIP-instrumentet är att det i större utsträckning än vad som hittills har gjorts inom FoI-policy kan användas för att engagera aktörer för att implementera FoI-resultat och för att representera efterfrågesidan. Sannolikt kommer ytterligare instrument på efterfrågesidan därtill att behövas, exempelvis för att samordna efterfrågan. Reformer behövs tveklöst i vissa statliga organisationer (särskilt, men inte bara, inom hälso- och sjukvården) för att öka deras förmåga att förstå och formulera sina behov och för att standardisera och effektivt upphandla de innovationer som de behöver.

SIP-initiativet har använt aktörskonsortier i offentlig-privata partnerskap (OPP) för att leda de enskilda SIParna och har därmed återupptäckt den gamla insikten att de ledande

aktörernas behov återspeglas i vad organisationen gör. Näringslivsaktörer dominerar i de flesta SIPar, vilket har bidragit till inkrementell och teknikfokuserad innovation. För att bättre möta behovet av socioteknisk omställning måste efterfrågesidan, inklusive myndigheter, engageras i större utsträckning. Förändringar måste också till för att förhindra att aktörer bara ser till sina egna intressen utan att för den skull förhindra OPPer att effektivt implementera sina strategier. När flernivåstyrning krävs kommer nya modeller för att integrera insatser på både regerings- och finansieringsinstrumentnivå att behövas.

Vi har i denna studie i stor utsträckning inspirerats av idéer från den nya och snabbväxande forskningslitteraturen om sociotekniska omställningar. Det finns än så länge mycket lite policyerfarenhet att lära av, men inte desto mindre ett stort behov av att fortsätta att utveckla policy. Behovet av policyexperiment – och ibland misslyckande – är således omfattande. Detta innebär att det finns ett behov av mer forskning (speciellt om implementering av policy för sociotekniska omställningar), men också av att bygga kapacitet för att designa och implementera nya policyer och instrument.

2.5 Slutsats

Vår övergripande slutsats är att SIP-instrumentet har visat sig effektivt som ett teknikprogram för att bygga nationell kapacitet och konkurrenskraft. Med vissa förändringar kommer det sannolikt att vara effektivt även för att möta samhällsutmaningar genom att bidra till sociotekniska omställningar. Instrumentet behöver dock användas i en bredare policy- och instrumentmix som tillgodoser behoven från alla tre generationer av FoI-politik – grundforskning, teknisk utveckling och innovation, samt omställningar eller systeminnovation.

3 Introduction

In 2018 the Swedish Governmental Agency for Innovation Systems (Vinnova), the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas) and the Swedish Energy Agency assigned Technopolis Group, through its Swedish subsidiary Faugert & Co Utvärdering, to evaluate 17 strategic innovation programmes (SIPs) after six years. The purposes of the evaluations was to identify results and early impacts as foundation for the agencies' decisions on continued funding, and to support the agencies and the programme offices in further developing and improving the programmes. Five SIPs were evaluated in 2019, six in 2020, five in 2021 and the 17th SIP in 2023. Each of the first three tranches of evaluations were summarised in annual meta-evaluations highlighting results and impacts of the SIPs, and collated experiences of their implementation as foundation for continuous development of the SIP initiative.

This report summarises findings and experiences of the full five-year assignment, taking the 17 six-year evaluations and the three annual meta-evaluations as primary points of departure and analysing the SIPs from a transitions or systems innovation perspective to support policy learning.

3.1 Assignment

The overall objectives of this study were to:

- Document participation in and impacts of the 17 SIPs.
- Analyse the 17 SIPs from a systems innovation perspective.
- Draw forward-looking recommendations.

The study set out to answer the following questions:

1. Which actors and what actor types have participated in the 17 SIPs?
2. What impacts have the SIPs contributed to for actors, system and society?
3. What is the additionality of the SIP initiative?
4. To what extent have the SIP initiative contributed to fulfilment of its high-level objectives?
5. To what extent does the SIP initiative promote systems innovation?
   a. What are the barriers to success?
   b. What are the success factors?
6. How can the functions, processes and transition management roles proposed in the literature on transitions and missions be used to:
   a. Design and implement funding instruments intended to promote systems innovation?
   b. Evaluate and improve such instruments?
7. What recommendations can be drawn for future instrument and policy designs and evaluation practices?

3.2 Methods

The answers to questions 1–4 essentially are mainly based on empirical evidence from the 17 programme evaluations and the three annual meta-evaluations, while the answers to questions 5–7 to a greater extent rely on collection of new empirical evidence.

3.2.1 *Document analyses*

The documents analysed included:

- 17 programme evaluations[1]
- Three annual meta-evaluations[2]
- The SIPs' proposals for funding of a third stage[3]
- The SIPs' action plans in response to the recommendations in the six–year-evaluations[4]
- The SIPs' new or revised agendas and programme logics[5]
- The literature on transitions and missions

3.2.2 *Registry analyses*

The registry analyses entailed merger and analysis of quantitative data (from all 17 programme evaluations) on:

- Project participation, including public funding and participant co-funding
- Project contribution towards sustainable development goals (SDGs)
- Proposal success rate, including gender distribution
- Web surveys of project participants[6]

3.2.3 *Interviews*

Given that some time had passed since the six-year evaluations on which this study is based, representatives of each SIP were interviewed to update our understanding of the SIPs and their context and identify relevant documentation such as agenda updates that we should take into account.[7]

3.2.4 *Case studies*

A case study was prepared for each SIP based on document analyses and interviews. Programme managers were given the opportunity fact-check case study drafts.

3.2.5 *Transversal analysis*

A transversal analysis of the 17 SIPs based on case studies and registry analyses was made in terms of:

- Context and pre-history
- Industrial structure and maturity

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1 Full references to the 17 six-year evaluations are provided in Appendix A.1. Each programme evaluation acquired empirical evidence through document studies, self-evaluations, registry analyses, funding analyses, social network analyses, bibliometric analyses, in-depth interviews, web surveys, and topic expert assessments, and employed presentations of observations, preliminary conclusions and preliminary recommendations to programme representatives for validation.

2 Full references to the three meta-evaluations are provided in Appendix A.2.

3 At the time of this evaluation, only the first 16 SIPs had submitted proposals for a third stage.

4 At the time of this evaluation, only the first 16 SIPs had submitted action plans.

5 Where applicable.

6 Web survey response data are provided in Appendix B.

7 Interviewees are listed in Appendix C.

- Degree of directionality
- Role of reflexivity
- Role of incumbents
- Extent of interaction with, and participation of, demand-side actors

3.3 Implementation

The assignment was conducted in the period January–November 2023 by Tomas Åström (project manager) and Erik Arnold. The team was supported by Vera Stafström and Sebastian Eriksson-Berggren. During an interpretation seminar on 29 September the team received valuable comments from representatives of the three agencies.

The 17th SIP evaluation (reported separately) was carried out in parallel with this assignment.

3.4 Report contents

Following on this brief introductory chapter, **Chapter 4** recapitulates the policy background to the SIP initiative and briefly introduces the 17 SIPs. **Chapter 5** summarises the overall funding perspective, including actor types and main actors, and provides an overview of some project characteristics. **Chapter 6** summarises project participants' motives for participation and the impacts experienced. **Chapter 7** considers impacts at the level of system and society, while **Chapter 8** summarises the SIP initiative's additionality and objective fulfilment. **Chapter 9** analyses trends in the recommendations given by the evaluation teams and considers the extent to which they have been heeded by the programmes and by the agencies. **Chapter 10** briefly reviews relevant literature on transitions and missions in order to develop an analytic framework for considering the usefulness of the SIP funding instrument as a basis for future programmes promoting systems innovation, and subsequently analyses the 17 SIPs and the SIP instrument from a transitions perspective. In **Chapter 11**, the overall findings of the assessment are distilled into recommendations for future instrument and policy designs and evaluation practices, while **Chapter 12** summarises the main findings of the report.

Appendix A includes references to the 17 programme evaluations and the three meta-evaluations. Appendix B provides web survey response data while Appendix C lists the assignment's interviewees. Appendix D summarises the abbreviations used in this report.

4 Background

This chapter first provides a brief review of the historical development of Swedish publicly co-funded instruments to foster R&I collaboration, whereupon the SIP initiative is presented. The end of the chapter briefly introduces the 17 SIPs and the extent to which they have predecessors among previous instruments.

4.1 An evolution of instruments for collaboration

In the early 1980s, the Swedish National Board for Technological Development (*Styrelsen för teknisk utveckling,* STU) introduced industry-oriented Framework Programmes for Knowledge Development (*Ramprogram för kunskapsutveckling*) and later Target Areas (*Insatsområden*), where the latter instrument introduced company participation as a novel feature. The Swedish National Board for Industrial and Technical Development (*Närings- och teknikutvecklingsverket,* NUTEK), which was formed in 1991 through a merger of STU with two other government agencies, continued to support technology development, at first through R&D Programmes (*FoU-program*) and later through Collaboration Programmes (*Samverkansprogram*). In R&D Programmes, working practices were tailored to specific industry sectors or technology areas, while in Collaboration Programmes, higher education institutions (HEIs) received funding provided that companies matched the public funding, preferably through in-kind contributions in joint R&D projects.

In parallel, STU and the Natural Sciences Research Council (*Naturvetenskapliga forskningsrådet,* NFR) jointly launched Interdisciplinary Materials Consortia (*Tvärvetenskapliga materialkonsortier*) in 1990, while NUTEK introduced Competence Centres (CCs; *Kompetenscentrum*) in 1995. These initiatives were inspired by international best practice, primarily the US Engineering Research Centers (launched in 1985) and the British Interdisciplinary Research Centres (launched in 1988). HEIs were the main beneficiaries in these (as well as in most subsequent) centre instruments.

When the Swedish Energy Agency (*Energimyndigheten*) was formed in 1997 by separating out the parts responsible for funding of energy-related R&D from NUTEK, the new agency inherited five energy-oriented CCs. The agency has continued to fund these centres and has later initiated additional ones. When Vinnova was formed in 2001 through a merger of the parts of NUTEK responsible for funding of technological R&D with two other government agencies, the new agency inherited the remaining 23 CCs, which were terminated after ten years (as originally planned; obviously in contrast to the Energy Agency's CCs). Vinnova subsequently introduced several other centre instruments focusing on industry needs, including VINN Excellence Centres, Institute Excellence Centres and Industry Excellence Centres. In 2015 Vinnova re-introduced the CC instrument, and the agency now funds 21 CCs.

Many of STU's and NUTEK's instruments were clearly oriented towards the needs of the manufacturing industry, but industry pundits nevertheless argued that too much public R&D funding benefited HEIs while industry needs were not sufficiently catered to. This may be traced back to the 1942 Malm commission whose conclusions were further supported by a 1979 government inquiry that concluded that HEIs should carry out most sector-oriented R&D and thus function as 'research institutes for all of society'. Industry lobbying nevertheless resulted in two Branch Research Programmes (*Branschforskningsprogram,* BFPs), one on aeronautics and one on vehicle research, being launched in 1993. These two BFPs were eventually followed by several additional ones in 2004–2005 focusing on other traditionally strong Swedish industry sectors. Most of the later BFPs ended in 2010, whereas the ones in aeronautics, space and vehicle research live on to this day in one form or another.

From a SIP perspective, CCs and BFPs are important since most SIPs have antecedents in one of these funding instruments, and some in both. While both instruments have gone through several modifications to their rulebooks over the decades, the following traits generally have applied:

- CCs are (and were) led by HEIs, which must convince companies to participate. The funding model is usually one third public funding, one third private co-funding, and one third co-funding from HEIs (of course also mostly of public origin, but from the HEIs' institutional funding). The (additional) public funding generally funds R&D conducted by the HEIs, while private actors mostly contribute in kind.
- BFPs are (and were) *de facto* led by industry consortia and participating companies typically select the R&D performers (HEIs and institutes) with which they want to establish – or further develop – relationships. The public funding generally benefits R&D performers, while companies are expected to contribute the same amount, usually in kind.

4.2 The SIP initiative

Historically, participation in both CCs and BFPs was generally not open to any organisation, and only rarely to companies outside the traditional industry sector in question. With time, R&I policy attempted to mitigate the weak demand-side focus of CCs and the principal-agent lock-in of BFPs. The first major attempt to introduce such an instrument, the Strategic Research Area (*Strategiska forskningsområden,* SFOs) initiative introduced in the government's 2008 R&I Bill, was not particularly successful in incorporating the demand-side. The initiative, which aimed to support broad research efforts in medicine, technology and climate, provided funding to 20 Strategic Research Areas that were considered strategically important for Sweden's international competitiveness. It was eventually criticised because collaboration between HEIs (the beneficiaries of the public funding) on the one hand and industry and society on the other hand did not live up to expectations. This was ultimately recognised in the 2012 R&I Bill, which introduced the Strategic Innovation Area (*Strategiska innovationsområden,* SIOs) initiative to improve conditions for long-term and in-depth collaboration between HEIs, institutes, industry, public sector, civil society and other actors. This new challenge-driven initiative was to create conditions for sustainable solutions to global societal challenges and to increase competitiveness in areas of great relevance to Sweden's economy. The Bill argued that SIOs had to be long-term to encourage risk-taking and innovation, and emphasised areas within life sciences, but also other areas wherein Sweden was leading, including forestry, mining and urban planning.

Vinnova, Formas and the Swedish Energy Agency were tasked with realising the initiative. In 2012 and 2013, the agencies announced funding for development of Strategic Innovation Agendas (*Strategiska innovationsagendor,* SIAs), which in practice aimed to identify challenges and objectives for possible future SIOs. In 2015, support was announced for additional SIAs focusing on energy and climate. The purpose of these calls was to involve companies and societal stakeholders already active in the areas identified in the Bill but, unlike in BFPs, the agencies sought broader stakeholder groups to support the entire sequence from research to implementation, thus explicitly encouraging a bottom-up perspective. The calls yielded 290 proposals of which 136 were granted funding to develop SIAs within a wide range of themes, but most related to global competitiveness, climate-efficient and sustainable access to energy, as well as sustainable raw materials supply and biodiversity.

The agencies subsequently issued four consecutive calls for Strategic Innovation Programmes (*Strategiska innovationsprogram,* SIPs), two in 2013 and one each in 2014 and

2016 (in the first two calls they were still called 'SIO programmes', but this terminology was later dropped). The calls offered funding for up to twelve years in four three-year stages, where decisions on funding of the next stage would be contingent on evaluations of the previous stages. The four calls yielded the 17 SIPs introduced in Section 4.3.

The SIPs were together expected to contribute to five high-level objectives:

- Increased sustainable growth.
- Improved competitiveness and increased exports for Swedish industry.
- To make Sweden an attractive country to invest and conduct business in.
- Sustainable societal development to secure employment, welfare, environmental and energy policy objectives.
- Create conditions for sustainable solutions to global societal challenges.

In practice, the SIP initiative introduced the following main novelties compared to CCs and BFPs:

- A SIP was to focus on demand from users – mostly meaning companies (private and public), but eventually also public authorities (at national, regional and municipal levels) – which was to form the foundation for its SIA.
- SIP management was outsourced to actor consortia (although project funding decisions remained with the agencies).[8]
- A SIP was to be open to any legal entity registered in Sweden (regardless of type and sector).
- SIP funding was to be long-term (up to 12 years).

The funding agencies required the SIPs to employ the same organisational setup and operations. A SIP is therefore governed by a board elected at an annual members' meeting, while its day-to-day operations are managed by a programme office that receives earmarked coordination funding from the agencies. Programme activities are based on the SIP's SIA and are implemented through calls for R&I projects, strategic projects and complementary activities. Calls for R&I projects are developed in collaboration with the agencies, which administer calls, engage experts to assess proposals, take funding decisions and monitor projects. Strategic projects are used to address needs that are common to most of the programme's actors, but that are inappropriate to realise through competitive calls. Strategic projects require negotiation with the agencies. Complementary activities – such as international outlooks, investigations, workshops, courses, graduate schools, networking events and programme conferences – may be realised either using coordination funding or through strategic projects. The bulk of most SIPs' portfolios thus is made up of R&I projects resulting from open calls, which means that in practice there are significant limits on the SIPs' ability to tailor their project portfolio to achieve the objectives of their agendas. The available possibilities are to restrict calls for R&I projects to specific areas or actor types, strategic projects and complementary activities; several SIPs have discovered that restricted calls render too few qualified proposals and have therefore ceased using such.

In the 2016 R&I Bill, the government presented the Collaboration Programme for Research and Innovation initiative (*Samverkansprogram för forskning och innovation*), focusing on what the National Innovation Council (*Nationella innovationsrådet*) had identified as three central

[8] Most programme offices are formally hosted by industry associations, HEIs and institutes, others by university holding companies and science parks.

future challenges for Swedish society: digitalisation, life science, and environmental and climate technology. The Programme aimed to strengthen ties to industry and innovation. In contrast to the SIP initiative, the Collaboration Programme had a pronounced policy-driven, top-down design where the government's objectives set the agenda. Vinnova was tasked with realising the intentions of the Bill and mainly did so by providing additional funding to selected SIPs. In practice, the Programme thus complemented and provided some of the SIPs with additional resources, but through R&I projects that the SIPs themselves did not chose.

The three agencies estimate that the total resources for the entire SIP initiative will amount to approximately SEK16b (if all 17 programs are funded for 12 years). Of this, SEK5.9b will be public funding through the SIP initiative and SEK1.3b public funding through the Collaboration Programme. The remainder is expected to come from industry and other societal actors.

All SIPs were evaluated after three years (in 2016, 2017, 2018 and 2020) and all of them were granted funding for a second stage. All SIPs were evaluated again after six years (in 2019, 2020, 2021 and 2023) and this report constitutes a meta-evaluation of the 17 individual six-year evaluations, including a follow up of some aspects of how the SIPs have developed since then. The first 16 SIPs were granted funding for the third stage; the decision for the 17th SIP will be taken in late 2023. In 2022, the first tranche of five SIPs was evaluated after nine years, and the second tranche of six SIPs is being evaluated in the course of 2023.

The 2020 R&I Bill introduced the next generation innovation programme initiative, then provisionally called SIP 2.0. Although the Bill provided some additional funding, the overall idea was that most of the resources for SIP 2.0 would be released as the original 17 SIPs gradually are phased out during their fourth stage (which for the first tranche begins in 2023). In September 2022, the agencies launched a call for preparatory projects for the new initiative, now called Impact Innovation. In February 2023, they announced that 23 of 98 proposals submitted had been granted funding. Full proposals were submitted in autumn of 2023 and up to five Impact Innovation programmes were expected to commence operations in the beginning of 2024. A second call in 2025 is expected to result in two to four additional programmes starting in 2027.

4.3 The 17 programmes

This section briefly introduces each of the 17 SIPs in terms of scope and public funding history.

4.3.1 First tranche

The first five SIPs resulted from the first call for proposals in 2013. These SIPs are all administered by Vinnova.

4.3.1.1 Metallic Materials (MM)

The objective of the Metallic Materials SIP is to increase the capacity for innovation in metallic materials. The SIP engages Swedish companies in steel, aluminium, cemented carbide, cast steel, cast iron and cast non-ferrous metals, as well as companies that deliver post-processing solutions. The SIP is based on two related SIAs.

The Swedish National Research Programme for the Steel Industry, a BFP implemented 2007–2012, was the immediate precursor. In parallel, the Swedish Foundation for Strategic Environmental Research (MISTRA) funded a programme on sustainability in steel production. Due to the iron and steel industry's massive electricity consumption, the Energy Agency has since its establishment in 1997 funded many R&I programmes aiming to increase industry's

energy efficiency. The Energy Agency similarly funded the GeniAL network of aluminium companies in two stages (2012–2013 and 2014–2016), which also aimed to increase industry's energy efficiency. The Energy Agency and Vinnova have funded several programmes to develop production processes, including foundries, whereas the cutting and manufacturing industries have not enjoyed programmes addressing their needs.

4.3.1.2 Process Industrial IT and Automation (PiiA)

PiiA targets companies in the process industry, their suppliers of technologies and solutions in IT and automation, as well as HEIs and institutes. The SIP focuses on pharmaceuticals, metals, chemicals and petroleum, mining and minerals, power generation, food and forestry. The programme's vision is that Sweden should remain a leader in development and implementation solutions for process industrial IT and automation. The SIP is based on one SIA.

PiiA does not have a single direct predecessor, but many of the programme's leading stakeholders had for decades been active in several BFPs addressing needs of the automotive industry.

4.3.1.3 Swedish Mining Innovation (SMI)

Swedish Mining Innovation (SMI), originally named Mining and Metal Producing Industry (STRIM), gathers mining companies, technology suppliers, HEIs and institutes. The SIP aims to increase the competitiveness of the Swedish mining and metal extraction industry by supporting development of sustainable solutions. The programme is based on a single SIA for the entire industry and thus not one specifically for the SIP.

The Swedish National Research Programme for the Mining Industry, a BFP implemented 2006–2011, was a direct precursor to the SIP.

4.3.1.4 LIGHTer

LIGHTer, originally named Lightweight, focuses on lightweight solutions in all industry sectors to reduce transport weight and thus energy and resource requirements in order to reduce greenhouse gas emissions. The programme is based on a single SIA.

Just like PiiA, LIGHTer does not have a single direct predecessor, but many of the leading stakeholders had for decades been active in the aeronautics and various automotive BFPs, as well as in other Vinnova R&I programmes, including the Light Materials and Lightweight Constructions programme implemented 2003–2008.

4.3.1.5 Sustainable Production in Sweden (P2030)

Sustainable Production in Sweden focuses on digitisation and sustainability in manufacturing. The programme's overall objective is to increase the competitiveness of Swedish manufacturing industry through collaboration between companies, HEIs and institutes. The programme is based on a single SIA.

The Manufacturing Engineering Research Area programme, a BFP implemented 2005–2008, was a direct precursor to the SIP, but the leading stakeholders had for decades also been active in automotive BFPs. Several programmes by the Swedish Foundation for Strategic Research (SSF) had also targeted production industry's long-term needs, including Engineering Design Research and Education Agenda (ENDREA: 1997–2003), Production Engineering Education and Research (PROPER: 1998–2004), and ProViking (2002–2013).

4.3.2 Second tranche

Another six SIPs resulted from the second call for proposals in 2013. They are also administered by Vinnova.

4.3.2.1 BioInnovation (BioInno)

BioInnovation aims to foster development of the Swedish bio-based sector and to create sustainable solutions for global markets. BioInnovation's vision is that Sweden should have converted to a bioeconomy by 2050, and it focuses on innovations in the areas of forestry, chemicals and textiles. BioInnovation has a long and quite diverse background in previous public programmes since it is the result of a merger of no less than ten SIAs.

Since the early 1990s the Energy Agency and its predecessors has funded many R&I programmes targeting the energy-intensive **pulp and paper industry**. In 2011, the Agency also granted very large investment subsidies to companies for construction of demonstration facilities for bio-based raw materials (several of which were subsequently cancelled or discontinued).

The first major R&I programmes specifically targeting the **forest and wood industry** started around the turn of the century. The Forest Framework Programme (*Skogssatsningen*) comprised five separate R&I programmes that were implemented in 1999–2007. The Swedish-Finnish Wood Material Science and Engineering Research Programme (WMS) was realised in 2003–2007, where Vinnova and Formas funded the Swedish parts of the bilateral projects (while the Academy of Finland, the Ministry of Agriculture and Forestry and Tekes funded the Finnish parts). The WMS programme was followed by the Swedish National Research Programme for the Forest-based Sector, a BFP implemented in 2006–2012 that was the most immediate precursor to BioInnovation.

The first Swedish R&I investments in **bioenergy** commenced in 1975 following the global oil crisis of 1973. More recently the Energy Agency (and its predecessors) have funded a series of bioenergy R&I programmes, as well as investment subsidies to companies for demonstration facilities (the same initiative as mentioned above for the pulp and paper industry).

The Swedish Textile Research Foundation has funded technical-scientific research into **textiles** since 1943. In recent years, textile-related R&I programmes have been implemented by Vinnova and MISTRA, but at much smaller scale than for the other industries mentioned above.

4.3.2.2 Innovair

Innovair develops Sweden's preconditions for innovation in aeronautics. The programme aims to contribute to reduced fuel consumption and emissions from large passenger aircraft, to further develop military aircraft systems, to contribute to growth in industry and to develop R&I structures that utilise other sources of funding to contribute to development of Sweden's aeronautics industry's capacity and international competitiveness. The programme is based on a single SIA.

Innovair clearly builds on the National Aeronautics Research Programme (NFFP), one of the two initial BFPs, on-going since 1993, as well as a series of demonstrator programmes (also BFPs), on-going since 2006. NFFP initially mainly focused on military needs, but later stages of the programme have focused on civilian applications. Innovair is in practice dominated by the current stages of NFFP and a parallel demonstrator programme through a government

assignment to Vinnova, with some additional funding from the SIP initiative (amounting to 17% of Innovair's total budget during the first six years).

4.3.2.3 Swelife

Swelife aims to strengthen the Swedish life science sector by coordinating expertise and resources to ensure that the sector remains sustainable, growing and internationally competitive. Swelife also aims to provide Swedish citizens with innovative, cost-effective and individualised solutions for improved health based on international best practice. Swelife is the result of a merger of three related SIAs. The programme is based on three related SIAs.

The sector has been the subject of public investments in R&I since long before the concept of life science was established in Sweden, but most of the public funding traditionally has benefitted individual research projects. A couple of CCs of the first generation, several SRAs and two BFPs (SAMBIO and SAMPOST; 2007–2012) are nevertheless precursors to Swelife. Moreover, life science researchers receive substantial funding from several charities and (mostly) private foundations.

4.3.2.4 Smarter Electronic Systems (SES)

SES aims to increase Swedish industry's global competitiveness within electronic components and systems (ECS) by facilitating collaboration between R&D performers and companies that manufacture electronics systems and ones that embed such systems in their products. The programme is based on seven related SIAs.

The ECS field has benefitted from considerable public R&I funding since the late 1970s, often through broader programmes focusing on the needs of manufacturing industry. Some CCs of the first generation, at least one SRA and two BFPs (the Swedish National Research Programme for IT and Telecom and the INSICT Programme targeting small and medium-sized enterprises (SMEs)) are precursors to SES.

4.3.2.5 SIO Grafen (Grafen)

SIO Grafen promotes increased use of graphene in Swedish industry with the overall objective of Sweden becoming one of the world's top ten users of graphene. The SIP is based on a single SIA.

SIO Grafen has no precursor and graphene had previously only been investigated in a handful of individual R&I projects prior to the establishment of the SIP. Though not a precursor, SIO Grafen has benefited hugely from Chalmers coordinating the EU Graphene Flagship, and the Flagship may be seen as a prerequisite for the approval of the SIP proposal (the Flagship was launched only one year before the SIP). The FLAG-ERA ERA-Net, wherein Vinnova and the Swedish Research Council (VR) participate, complements the Flagship by funding multilateral international R&I projects. Vinnova currently funds Chalmers' 2D-Tech CC focusing on two-dimensional materials, including graphene.

4.3.2.6 IoT Sverige (IoT)

IoT Sverige initially targeted the entire Swedish 'eco-system' for IoT, which eventually proved too broad a scope. Since 2016, IoT Sverige therefore focuses on IoT solutions for the public sector, but the programme welcomes companies and R&D performers with the knowledge and products needed to develop such solutions. The SIP is based on a single SIA.

IoT Sverige had no precursor, but it is likely that there had been individual R&I projects in the field before the establishment of the SIP.

4.3.3 Third tranche

The next five SIPs resulted from the 2014 call for proposals. RE:Source is administered by the Energy Agency, Smart Built Environment by Formas, and the remaining three SIPs by Vinnova.

4.3.3.1 Drive Sweden (Drive)

Drive Sweden's vision is to take a leading role in creating future mobility solutions for people and goods that are sustainable, safe and accessible to everyone, and based on a systems perspective that includes both societal and infrastructure aspects. The SIP is based on a single SIA.

Drive Sweden builds on the BFP Intelligent Vehicle Safety Systems (IVSS; 2003–2008), as well as – though less directly – on the largely parallel BFP Vehicle-Information and Communication Technology (V-ICT; 2005–2008), both funded by Vinnova, Nutek and the regional council of Västra Götaland. Drive Sweden also has close links to the Strategic Vehicle Research and Innovation programme (FFI) that is on-going since 2009. The FFI BFP is the result of the merger of one of the initial two BFPs, the Vehicle Research Programme (ffp), and several other BFPs targeting the automotive industry (including IVSS and V-ICT).

4.3.3.2 InfraSweden2030 (Infra)

InfraSweden2030's vision is that by 2030 Sweden should have a competitive transport infrastructure sector for climate-neutral transports that addresses society's economic and social challenges. The programme has three overarching objectives: to develop innovations for transport infrastructure, to create an open, dynamic and attractive transport infrastructure sector, and to reduce the environmental and climate impact of construction, operation and maintenance of infrastructure. The SIP is based on a single SIA.

Most early public R&I investments by the Swedish Rail Administration and the Swedish Road Administration did not have a branch perspective but instead funded basic research, but in the 1990s, the agencies started funding HEI-based CCs. The Swedish Transport Administration (formed through a merger of, among others, the rail and road agencies) has since the 2010s funded two BFP-like programmes.

4.3.3.3 Medtech4Health (MT4H)

Medtech4Health's vision is that by 2030 Sweden's medical technology industry should be an international leader supported by a unique R&I system, where HEIs, healthcare providers and companies collaborate and contribute to improved health. The vision is to be achieved through increased utilisation of medical technology innovations in healthcare, through increased awareness and knowledge of the benefits of medical technology, as well as through increased internationalisation. The programme is based on three related SIAs.

Medtech4Health's R&I funding history resembles that of Swelife in the second tranche, i.e. most public investments in the field traditionally benefitted individual projects. A couple of CCs of the first generation, likely some SRAs and parts of two BFPs (SAMBIO and SAMPOST; 2007–2012) are precursors to the programme.

4.3.3.4 RE:Source (RES)

RE:Source focuses on sustainable use of resources from a circular perspective. During the first years, the programme's focus was mainly on waste issues, but since then it has opted for a broad approach spanning from technology to policy, and from handling of raw materials to consumer behaviour. The programme is based on two related SIAs.

The Waste Refinery programme funded by the Energy Agency 2007–2013 is a partial precursor to RE:Source.

4.3.3.5 Smart Built Environment (SBE)

Smart Built's vision is a sustainable built environment and maximum user benefit through efficient information management and industrial processes. The ambition is to achieve both incremental and systemic transformations in urban development. The programme is based on three related SIAs.

The built environment sector has been the subject of several public R&I programmes with private co-funding since the early 1990s, as well as a CC.

4.3.4 Fourth tranche

The seventeenth SIP resulted from the 2016 call for proposals. It is administered by the Energy Agency.

4.3.4.1 Viable Cities (Viable)

Viable Cities focuses on the transition to climate-neutral and sustainable cities in line with Agenda 2030 and the Paris Agreement. The programme's mission is climate neutral cities 2030 with a good life for all within planetary boundaries. Viable Cities' work is closely linked to the EU mission 100 Climate-Neutral and Smart Cities by 2030. The programme is based on a single SIA.

Viable Cities had no precursor.

4.4 Varying preconditions

A majority of the SIPs obviously build on established networks from BFPs, others on networks from CCs, and a few trace their ancestries to both types of instruments. Additional SIPs build on other types of public R&I programmes, but only three completely lack antecedent programmes.

Such differing histories mean that the 17 SIPs had very different preconditions at the outset. The consortia that were successful in the first call (resulting in the first tranche of SIPs) invariably were all well prepared to quickly get organised to develop SIAs, since the key actors had decades of experience of collaborating with each other in BFPs. Subsequent calls yielded some SIPs where actors had little or no history of collaboration, but most SIPs resulting from later calls nevertheless also built on networks from BFPs.

Most SIPs thus hit the ground running since:

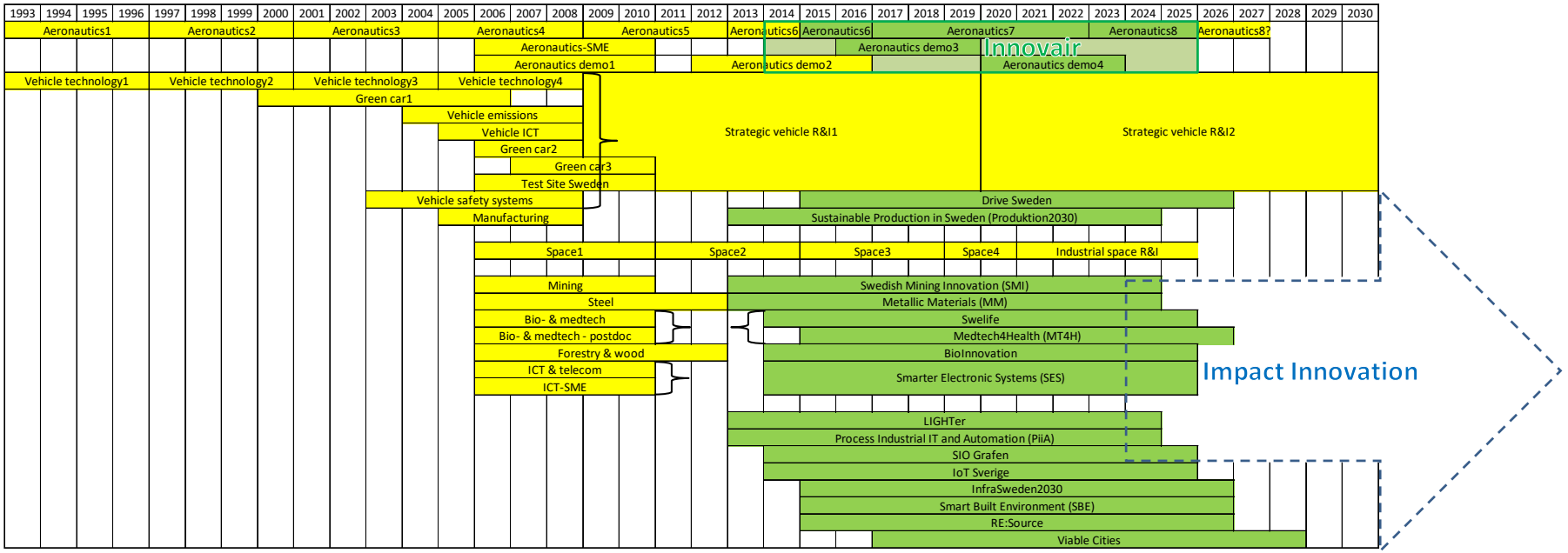
- They built on decades of R&I collaboration.
- Their networks included powerful and influential companies.
- They already had an 'agenda' (though not necessarily written down).

Other SIPs struggled since:

- Their stakeholders had little or no history of R&I collaboration.
- They found it challenging to formulate programme scope and focus.
- They lacked influential actors to facilitate and drive developments.
- They found it difficult to get organised, and a couple had to start anew with amended scope and focus after a few years.

In practice, this meant that in most cases the SIP calls offered actors an opportunity to continue building on Swedish industrial strengths, whereas in other cases the calls provided 'seed funding' to new and promising areas. Figure 1 summarises the more obvious relationships between the SIPs and their antecedent BFPs (as horizontal lineages). Impact Innovation is the next generation innovation programme initiative, i.e. the SIP initiative's successor.

Figure 1 Relationships between BFPs (yellow) and SIPs (green).



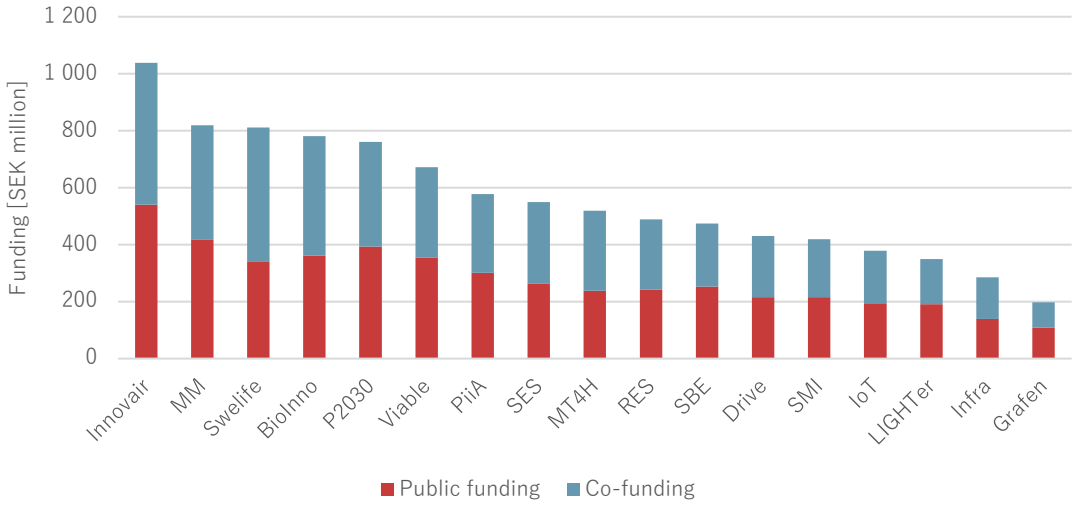
5 Programmes, participants and projects

In this chapter, we use project participation data from Vinnova, the Energy Agency and Formas to understand the 17 SIPs' overall funding and to explore what organisation have participated in the programmes. In the last section of the chapter we explore certain project characteristics. All figures in this chapter include both projects from open, competitive calls and closed calls for strategic projects. For practical reasons we use the (often unsanctioned) abbreviations of SIP names defined in parentheses in the sub-headers of Section 4.3.

5.1 Programmes

During the 17 SIPs' first six years the agencies granted a total of almost SEK4.8b in public funding, including funding to the SIP programme offices for coordination, to 2 313 projects. Project participants matched the public funding by co-funding projects with marginally more (still rounded to SEK4.8b). Both amounts include funding to multi-year projects lasting beyond the first six years, but where funding decisions were made during the first six years. Figure 2 reveals that the SIPs had quite different resources at hand, from SEK540m in public funding for Innovair (SEK1 038m including co-funding) to SEK108m for Grafen (SEK198m in total); the average is SEK280m per SIP (SEK562m in total).[9] There is no obvious trend between the four tranches in terms of funding per SIP.

Figure 2 Total public funding and co-funding in calls during the first six years.



Source: Vinnova, Energy Agency and Formas.

Success rates in open, competitive calls for proposals for R&I projects have varied widely, both between calls and between SIPs.[10] The average success rates at the level of SIPs have ranged from 17 to 76 percent (Swelife and Innovair, respectively) and the overall average for all 17 SIPs is 45 percent. Since the three agencies have quite different missions and target

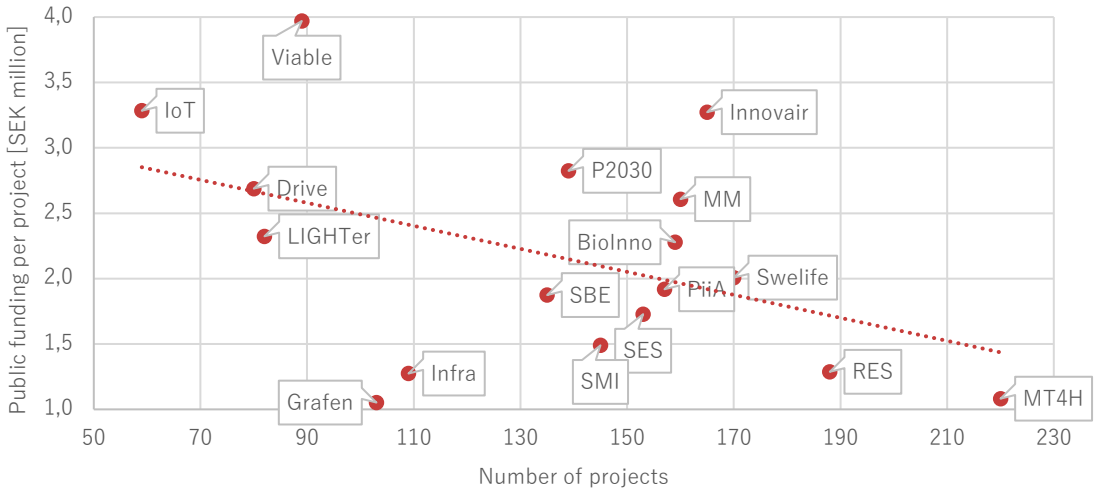
[9] As mentioned in Section 4.3.2.2, Innovair is dominated by two subprogrammes through a government assignment with some additional funding from the SIP initiative. If one were to only consider funding specifically from the SIP initiative, Innovair would be comparable to Grafen in terms of resources.

[10] The success rate is the number of projects granted divided by the number of proposals submitted.

audiences, their overall success rates (i.e. not only in SIP calls) vary significantly, with the Energy Agency having the highest and Formas the lowest, but success rates have declined for all three agencies over the years for which we have data. All SIPs but three have had success rates higher – generally significantly higher – than the average for the agency that has had the main administrative responsibility for their calls. The exceptions are the two life-science-oriented SIPs – Swelife in the second tranche and MT4H in the third – which have had notably lower success rates than Vinnova's overall success rate, and RES that has had lower success rate than the Energy Agency's overall.

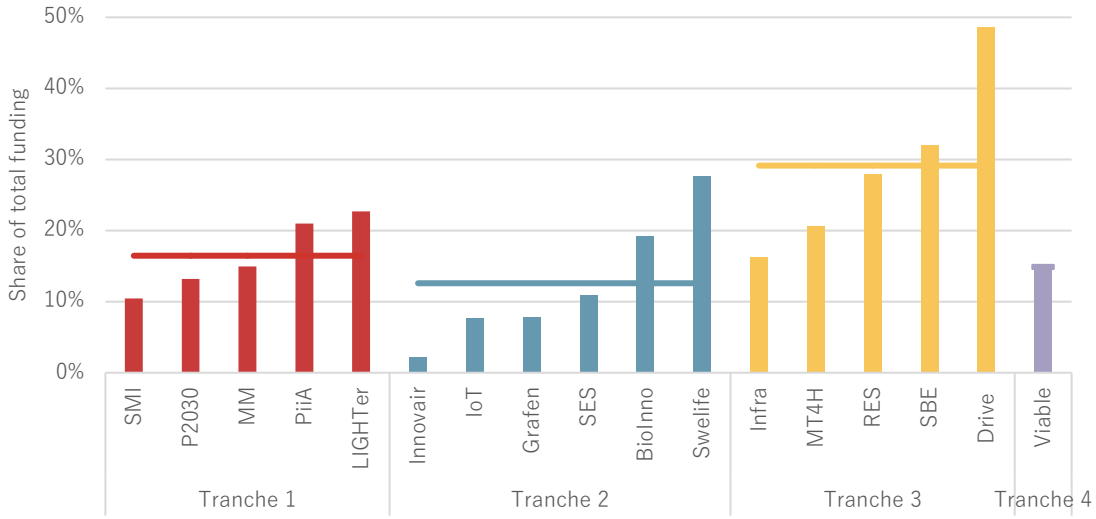
As described in Section 4.2, a SIP may influence how its public funding is spent by how calls for proposals are formulated and by initiating strategic projects. Figure 3 shows that the SIPs have chosen quite different strategies in terms of size of projects, from just over SEK1m in average public funding per project for Grafen and MT4H to almost four times as much for Viable. Figure 4 illustrates that the use of strategic projects also has varied greatly. There does not seem to be any trend between tranches in either respect.

Figure 3 Number of projects and average public funding per project in calls during the first six years.



Source: Vinnova, Energy Agency and Formas.

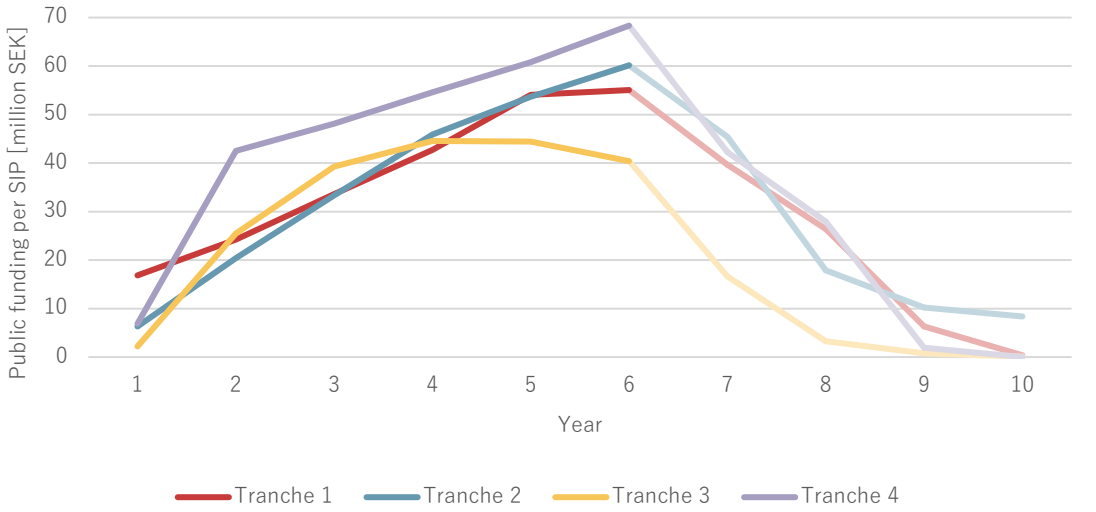
Figure 4 Share of public funding to strategic projects in calls during the first six years and average share per tranche.



Source: Vinnova, Energy Agency and Formas.

The agencies' model for SIP funding provides 100 percent funding years 3–10, 33 percent year 1 and 12, and 67 percent years 2 and 11. Figure 5 illustrates that on average the SIPs did not manage to ramp up operations that quickly; in practice it took at least 4–5 years to reach what may be some form of steady state. The difference between available budget and granted amounts is largely explained by it taking time to formulate and publish calls, write proposals, assess proposals and make decisions; the agencies (and the government) tend to ignore such repeatedly occurring delays to their plans. The shaded lines following year 6 only include funding to multi-year projects decided upon during the first six years; given that all SIPs but one have been granted a third stage when this is written, subsequent funding decisions will have resulted in considerably larger funding for years 7 and on than this figure indicates.

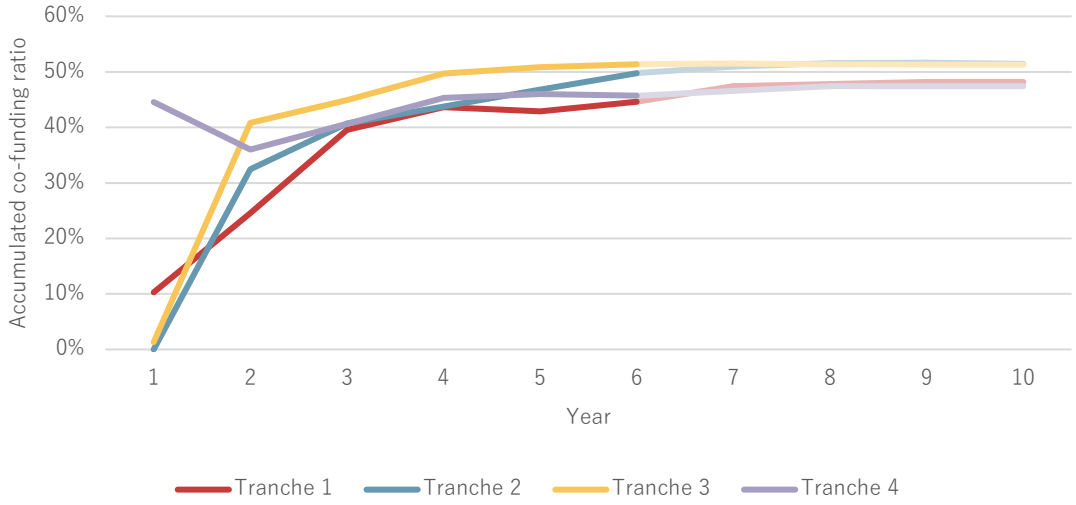
Figure 5 Average public funding per year and tranche in calls during the first six years.



Source: Vinnova, Energy Agency and Formas.

In the long term, the agencies expect 50 percent co-funding at programme level (but not necessarily in each project). Figure 6 reveals that the degree of co-funding initially was considerably lower, but that it has increased with time. Few, if any, calls for proposals were published in the SIPs' first year and the early projects granted mainly concerned coordination. The main reason for co-funding lagging behind public funding also for another few years is likely that project co-funders, mostly companies and public authorities, tend to do most of their work towards the end of multi-year projects when research results – often developed by R&D performers – are ready to be further developed and possibly commercialised or otherwise implemented. As mentioned in the beginning of the chapter, total co-funding in all 17 SIPs pretty much matched the public funding after six years, but Figure 6 shows that the SIPs of the first and fourth tranches on average still had a way to go in this respect, while the others had secured enough co-funding after six years (the SIPs of the third tranche already after four years).

Figure 6 Degree of co-funding per year and tranche in calls during the first six years.



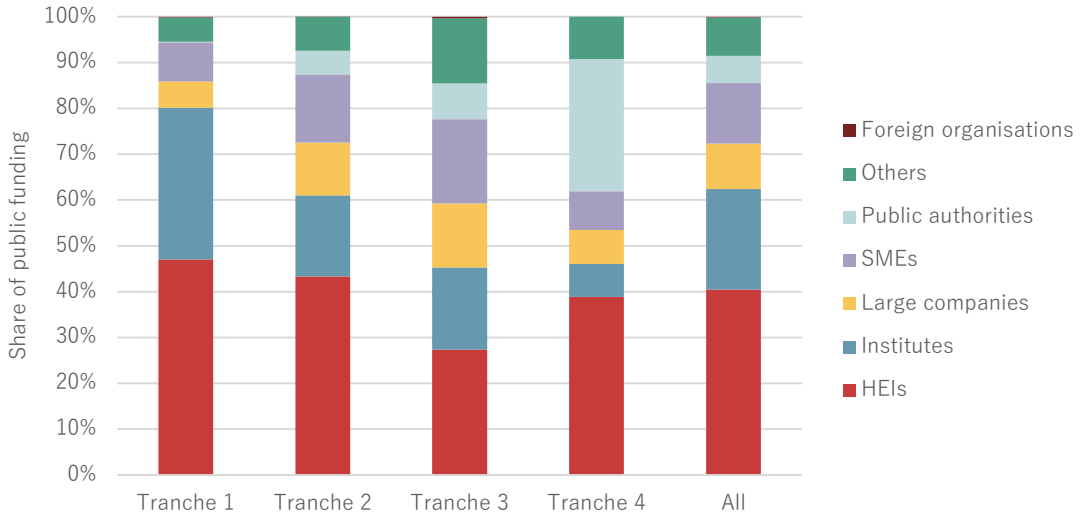
Source: Vinnova, Energy Agency and Formas.

5.2 Participants

Figure 7 shows that most of the public funding was granted to R&D performers, i.e. HEIs and institutes, although their share decreased significantly with the SIPs of the second and third tranches, while the share to companies, both large and small, increased considerably. The share going to public authorities also increased notably with each tranche. Overall, 62 percent of public funding benefited R&D providers, 23 percent companies and 6 percent public authorities. The prominence of the 'Others' category, 8 percent of the total, is mainly explained by several programme offices being hosted by such organisations. Funding granted to foreign organisations is not discernible in the figure since the amounts were marginal (0.1%). While the SIPs are national programmes and the three funding agencies are national authorities, they may grant funding to foreign organisations provided it benefits Swedish project participants – but such decisions apparently have been quite rare. Most foreign

organisation thus have participated with own funds, possibly supported by public funding from their own countries.[11]

Figure 7 Recipients of public funding in calls during the first six years by actor type and tranche.[12]



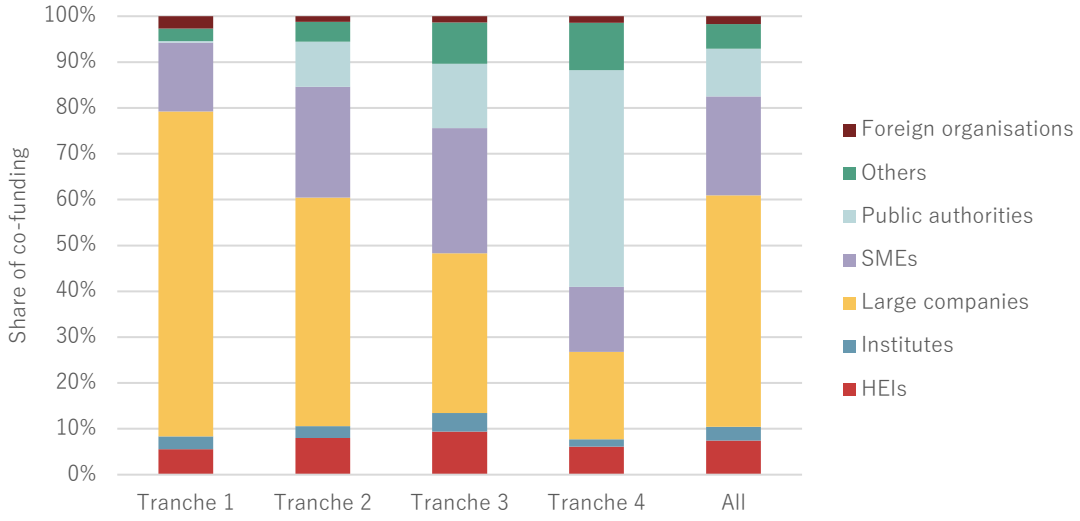
Source: Vinnova, Energy Agency and Formas.

Figure 8 illustrates that companies heavily dominated as co-funders, but the dominance of large companies decreased with each tranche, while co-funding from SMEs increased until the third tranche. Co-funding from public authorities increased from close to nil in the first tranche to nearly half in the fourth (that consists of a single SIP, whereas the previous tranches comprise five, six and five SIPs, respectively). Overall, large companies have contributed 51 percent of co-funding, SMEs 22 percent, public authorities and R&D performers 10 percent each, others 5 percent and foreign organisations 2 percent.

[11] Foreign-owned organisations that are legally registered in Sweden are eligible for funding; they are consequently included in the other actor types.

[12] HEIs = Higher education institutions (universities and university colleges), Institutes = research institutes, Large companies = effectively companies larger than SMEs (including publicly owned companies expected to make profit), SMEs = companies with less than 250 employees that are not controlled by a larger company (including publicly owned companies expected to make profit), Public authorities = national government agencies, regional councils and municipalities participating in projects (i.e. not incl. funding agencies and publicly owned companies expected to make profit), Foreign organisations = organisations legally registered in other countries, Others = any other organisation based in Sweden (in practice, this category is dominated by industry confederations, technology parks, HEI holding companies, technology transfer offices, foundations and non-governmental organisations (NGOs)).

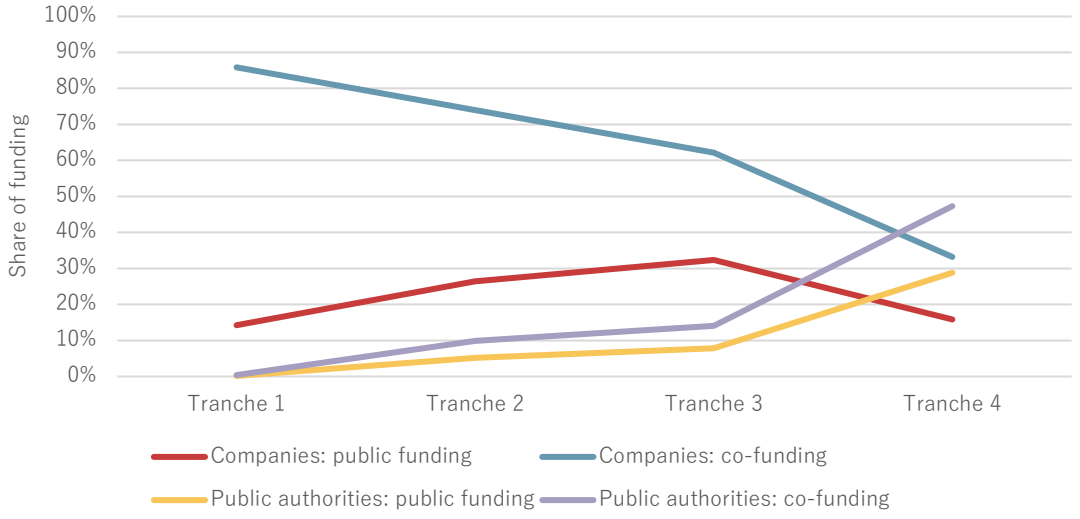
Figure 8 Source of co-funding in calls during the first six years by actor type and tranche.



Source: Vinnova, Energy Agency and Formas.

Together, Figure 7 and Figure 8 illustrate a shift in focus from near-total orientation towards company needs in the SIPs of the first tranche to needs of the public sector gradually becoming more important in subsequent tranches. Another way of illustrating these trends is Figure 9 which illustrates that companies' share of co-funding (blue line) decreased sharply with each tranche while their public funding (red line) increased until the third. However, it should be noted that co-funding from and public funding to SMEs increased until the third tranche; it is large companies that dominate the overall company trends. Conversely, co-funding from and public funding to public authorities (purple and yellow lines, respectively) both increased for each tranche.

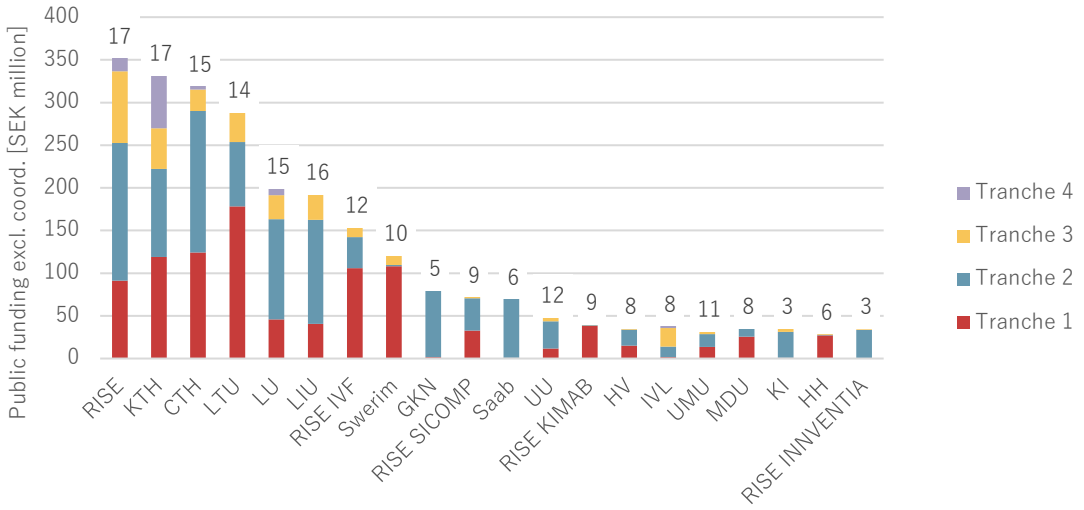
Figure 9 Shares of public funding and co-funding in calls during the first six years by selected actor types and tranche.



Source: Vinnova, Energy Agency and Formas.

The 20 largest recipients of public funding (excluding coordination) out of a total of around 2 700 unique actors are shown in Figure 10. The figure illustrates that only RISE and KTH have received funding from all 17 SIPs, although another ten organisations have received funding from ten or more SIPs (including two outside top 20).

Figure 10 Twenty largest recipients of public funding excl. coordination in calls during the first six years by tranche, and number of SIPs they received funding from (number above bar).[13]



Source: Vinnova, Energy Agency and Formas.

As expected, 18 of the recipients are R&D performers, 11 HEIs and seven institutes. The 20 organisations in the figure together received SEK2.6b (58% of total public funding excluding coordination), and the top 10 organisations SEK2.1b (49%). To a significant extent, this concentration is due to most technical and medical R&D in academia being concentrated to a small number of Sweden's 30 HEIs; Sweden's main technical universities found in places 2–6 together received SEK1.3b (31%). On the same note, in the institute sector almost all technical R&D now has been consolidated into the RISE Group. The RISE Group was not fully consolidated when the first SIPs were launched, but adding up the funding to all previously independent institutes (also the ones outside top 20) one gets SEK0.7b (16%). Public funding is thus heavily concentrated to a small number of organisations, meaning that most actors in the very long tail of 2 700 organisations received marginal amounts.

The fact that two large companies – GKN and Saab – received large allotments of public funding is due to certain peculiarities of Innovair in the second tranche. One is the fact that Sweden only has two large companies in aeronautics, another the long tradition from Innovair's BFP predecessors of the companies enrolling their own employees as PhD students (and keeping them on their payrolls), and a third that Innovair includes a large demonstrator sub-programme where the companies are the main beneficiaries.

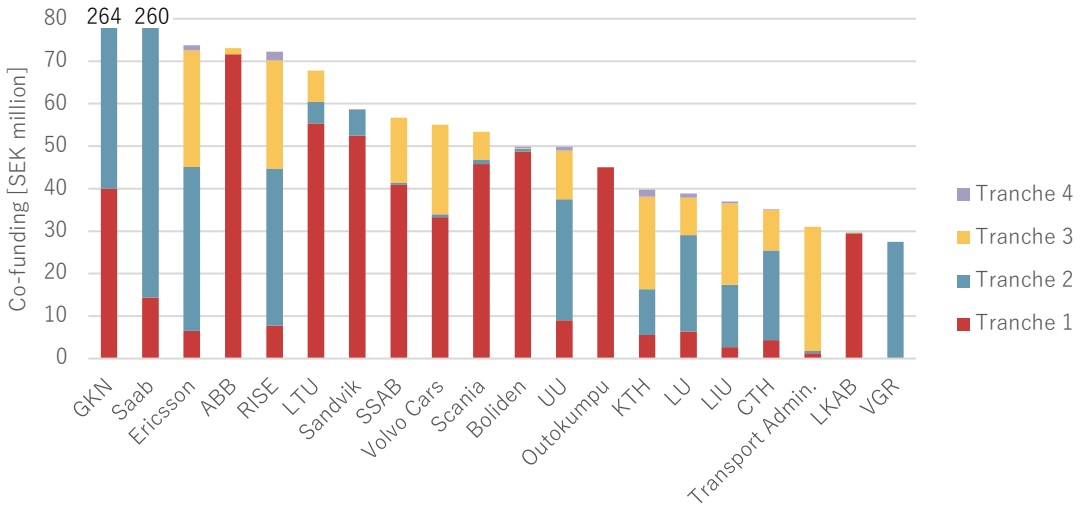
In total, SEK414m in public funding was granted to the SIPs' programme offices for coordination. The organisations in Figure 10 together received SEK210m in funding for

[13] RISE = Research Institutes of Sweden, KTH = Kungl Tekniska högskolan, CTH = Chalmers tekniska högskola, LTU = Luleå tekniska universitet, LU = Lunds universitet, LIU = Linköpings universitet, GKN = GKN Aerospace Sweden, UU = Uppsala universitet, HV = Högskolan Väst, IVL = IVL Institutet för Vatten- och Luftvårdsforskning, UMU = Umeå universitet, MDU = Mälardalens universitet, KI = Karolinska institutet, HH = Högskolan i Halmstad.

coordination (not included in the figure), SEK65m of which each to RISE and KTH, but substantial amounts also to LTU, UU, RISE IVF and LU.

Figure 11 similarly shows the top 20 co-funders. Eleven of them are companies that are among Sweden's biggest, and two are public authorities. The remaining ones are an institute and six HEIs, all of which are also among the top 20 recipients of public funding.

Figure 11 Twenty largest co-funders in calls during the first six years by tranche.[14]



Source: Vinnova, Energy Agency and Formas.

The co-funding of GKN and Saab is so much larger than that of all others that their bars have been truncated. The reason for their co-funding being more than three times as high as Ericsson's, in third position, is the peculiarities of Innovair mentioned above (55% of the two companies co-funding is due to the demonstrator sub-programme). The co-funding of the 20 organisations in the figure amounted to SEK1.4b (30% of total co-funding), while the co-funding of the companies in top 20 amounted to SEK1.0b (21%). Despite GKN's and Saab's massive co-funding (11% in total), co-funding is overall notably less concentrated than the public funding.

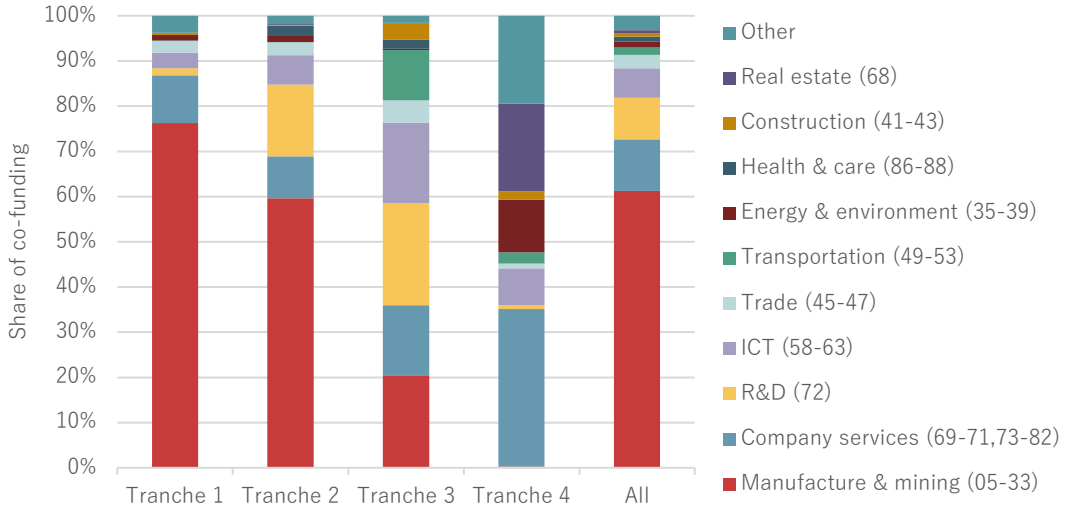
Figure 12 shows that co-funding of companies in Manufacturing & mining decreased dramatically for each tranche, while companies providing various support services (including R&D) and companies in ICT, Trade, Transportation and Real estate have taken their place. The four largest NACE groups in the figure – Manufacturing & mining, Company services, R&D and ICT – together accounted for 88 percent of total co-funding from companies, which correlates very well with the same groups being responsible for 90 percent of Sweden's Business Expenditure on Research and Development (BERD) in 2021. In 2021, companies in the same groups contributed more than half (53%) of Sweden's value added.[15] The figure thus indicates that most companies that invest heavily in R&D probably have participated in the SIPs. The sharp decline for Manufacturing & mining with each tranche does not suggest that the branches of this NACE group have become less important, but rather that all significant

[14] Transport Administration is a national authority and VGR the regional council of Västra Götaland.

[15] The BERD share does not include mining (05-09), so it is an underestimate. The value added share also includes education, health and health care and parts of personal and cultural services (85-96) meaning it is an overestimate. Data from Statistics Sweden.

branches eventually had their needs satisfied by at least one SIP (large companies generally have participated in more than one SIP).

Figure 12 Share of company co-funding to projects in calls during the first six years by NACE group and tranche.[16]

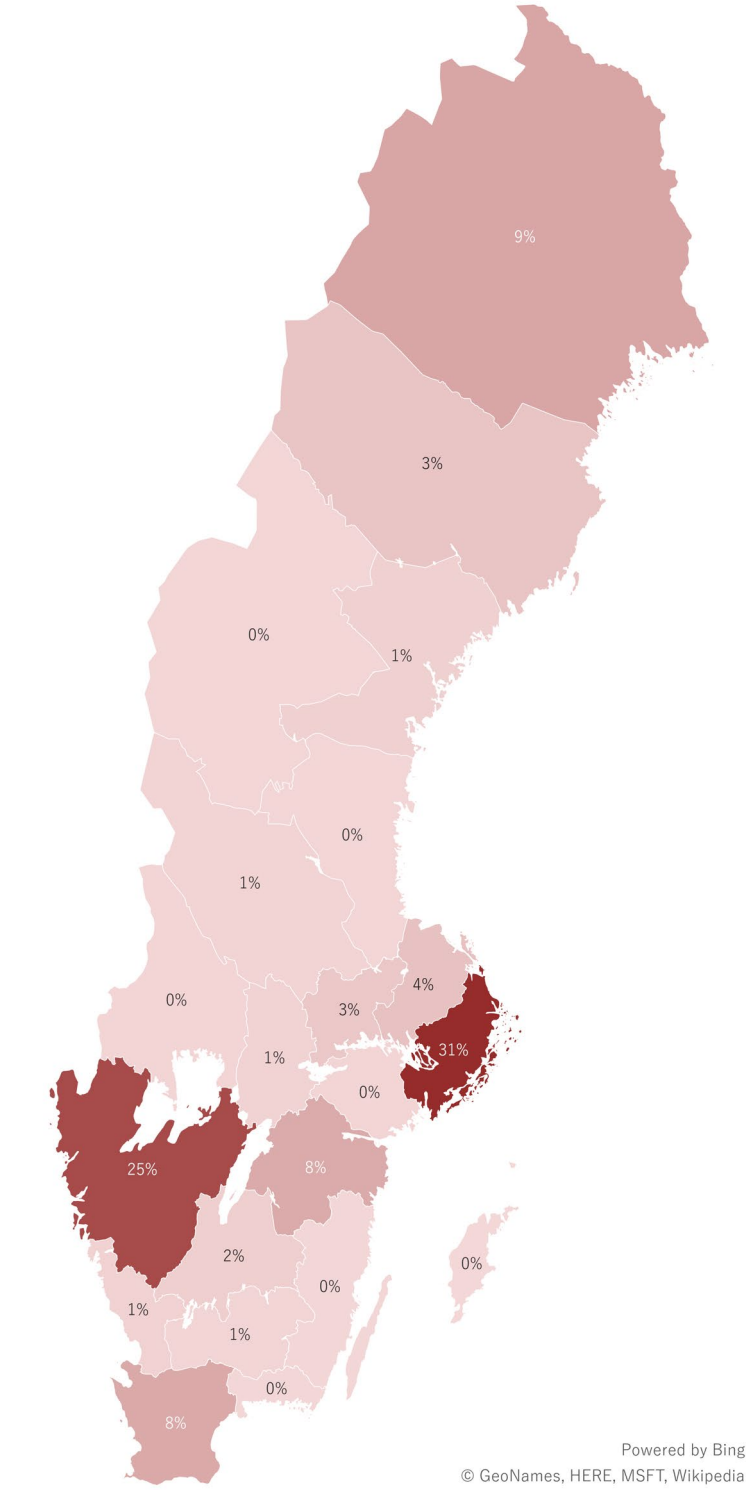


Source: Vinnova, Energy Agency and Formas.

Figure 13 shows that almost a third (31%) of all public funding was granted to organisations with operations in the Stockholm region and a quarter (25%) to organisations in the region (county) of Västra Götaland (which includes Gothenburg).

[16] NACE = Nomenclature statistique des activités économiques dans la Communauté européenne, i.e. Statistical classification of economic activities in the European Community.

Figure 13 Share of public funding to projects in calls during the first six years by region.



Source: Vinnova, Energy Agency and Formas.

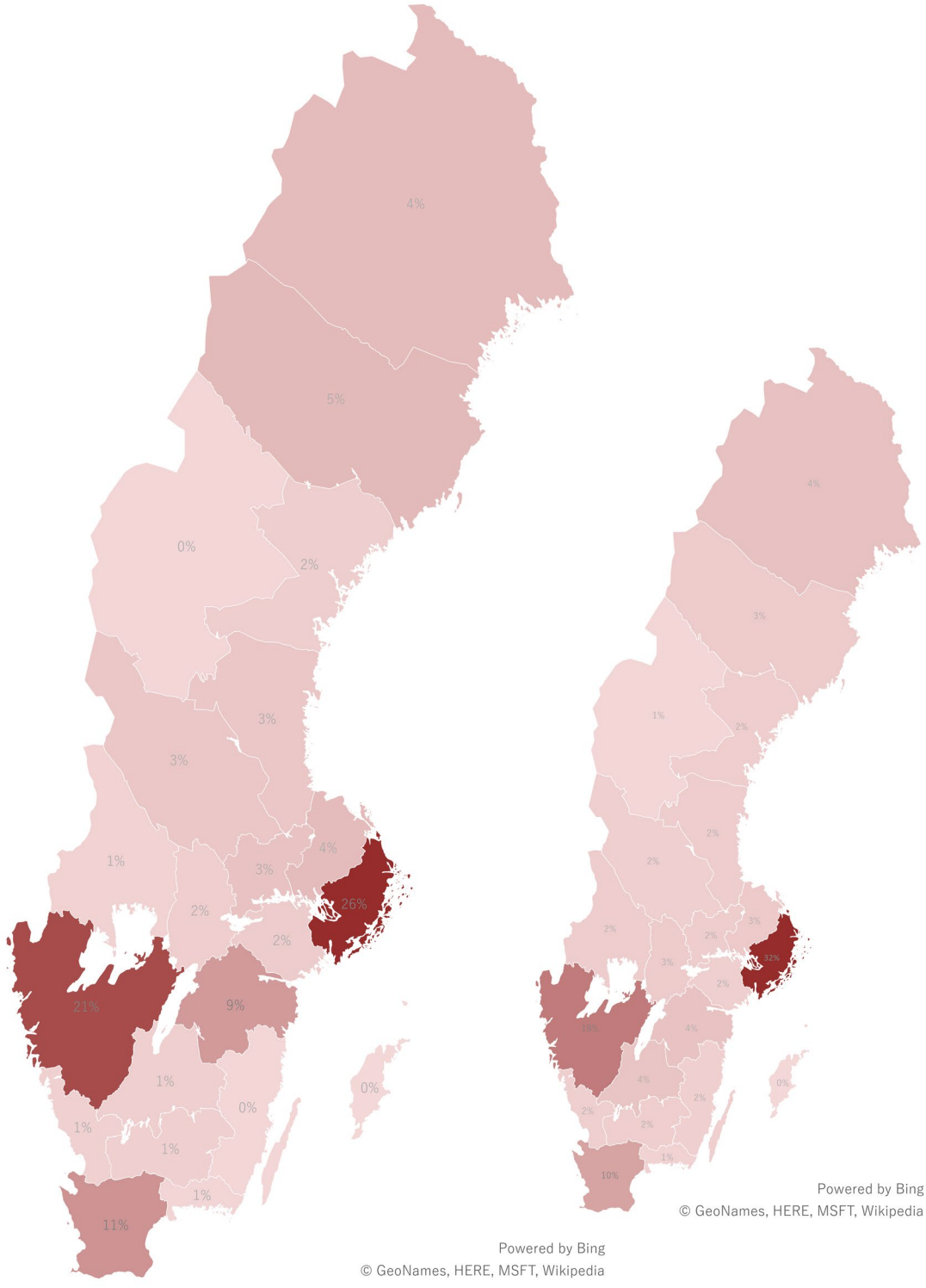
Figure 10 may assist in understanding the regional distribution of public funding. The concentration to Stockholm region is to a significant degree due to the institutes RISE (which has some of its operations in the region), RISE KIMAB, IVL and RISE INNVENTIA, and to the HEIs KTH and KI. The concentration to Västra Götaland is mainly due to the institutes RISE

(which has many of its operations in the region) and RISE IVF, to the HEIs CTH and HV, as well as to GKN. Sweden's northernmost region of Norrbotten's third place is largely due to the HEI LTU and the institutes Swerim and RISE SICOMP, while Sweden's southernmost region Skåne's fourth place is mainly explained by the HEI LU, and the region of Östergötland's fifth place by the HEI LIU and Saab. The remaining regions have received considerably less public funding, but ultimately the regional distribution reflects where Sweden's main technical and medical HEIs and institutes are located.

The main map in Figure 14, which shows the regional origin of co-funding, obviously resembles Figure 13, but the concentration is not quite as pronounced, thus illustrating that participating companies and public authorities are more evenly spread across the country than the R&D performers. An earlier figure again may assist in understanding the regional distribution, in this case Figure 11. However, since co-funding is not nearly as concentrated to a small number of organisations as public funding, interpretation is less straightforward. That said, the concentration to Stockholm (26%) is to a significant extent explained by Ericsson, RISE, Scania and KTH, while that to Västra Götaland (21%) largely by GKN, RISE, Volvo Cars and CTH. The presence of LU is nowhere near sufficient to explain Skåne's third place (11%), but several large companies, e.g. Ericsson, ABB and Sandvik, have operations in several Swedish regions including Skåne. In contrast, the location of both Saab and LIU in the region of Östergötland (9%) goes a long way explain the region's fourth place.

The smaller map in Figure 14 shows the distribution of the nation's value added by companies belonging to the top four NACE groups in Figure 12 (Manufacture & mining, Company services, R&D and ICT; data for 2021 from Statistics Sweden). The correlation with the main, co-funding map is quite good, thus indicating that the SIPs have managed to engage companies all over the country in approximate proportion to their contribution to the value added of the dominant industry sectors.

Figure 14 Share of co-funding to projects in calls during the first six years by region (large map) and Sweden's value added by companies in top four NACE groups by region (small map).



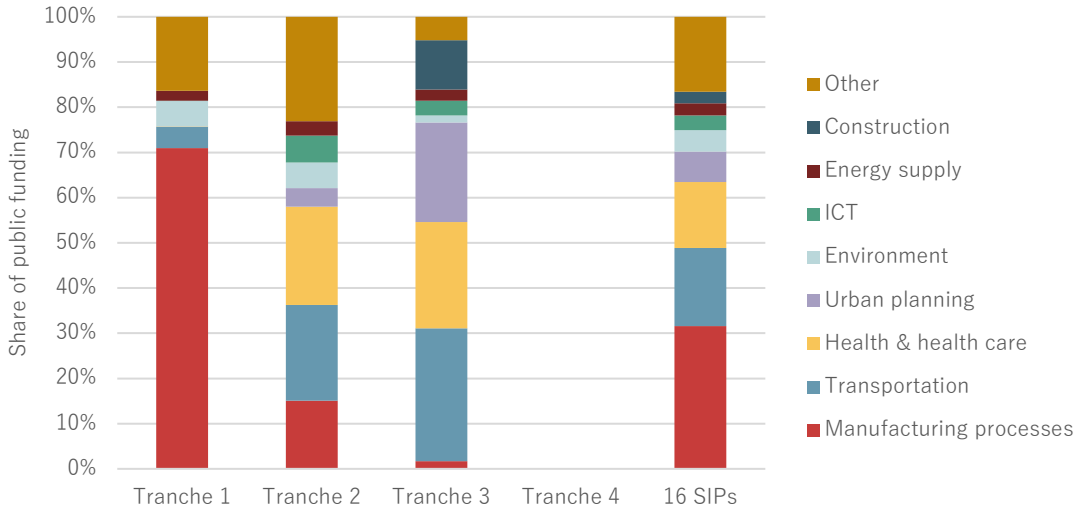
Source: Vinnova, Energy Agency, Formas and Statistics Sweden.

5.3 Project characteristics

In their first six years, the 17 SIPs' open, competitive calls for proposals resulted in 1 781 R&I projects, 538 of which were led by women (30%).[17] At SIP level, the share of female R&I project leaders ranged from 14 to 51 percent (SES and Viable, respectively). For all 17 SIPs, the success rate was 6 percent higher for female proposers than for male, but at SIP level this difference ranged from 20 percent higher (LIGHTer and Viable) to 8 percent lower (P2030).

Figure 15, which shows public funding to R&I projects by topic area, illustrates that the heavy dominance of the needs of the manufacturing industry in the first tranche was replaced by transportation and health & health care in the two subsequent tranches. (Data was not available for Viable of the fourth tranche.) The apparent emergence of health & health care is nevertheless limited to two SIPs, Swelife of the second tranche and MT4H of the third. Urban planning emerges in the second tranche and increases in the third. There is little doubt that, had we had comprehensive data for Viable, a large part of the bar would have been taken up by urban planning. While these developments bear a certain resemblance to the trends in Figure 12, the trends in public funding by topic area are considerably more dramatic than the trends in company co-funding by NACE group. For 16 out of the 17 SIPs (i.e. excluding Viable), almost a third (32 %) of public funding went to projects on manufacturing processes, followed by 17 percent to transportation and 15 percent to health & health care.

Figure 15 Share of public funding to projects in calls during the first six years by topic area and tranche.



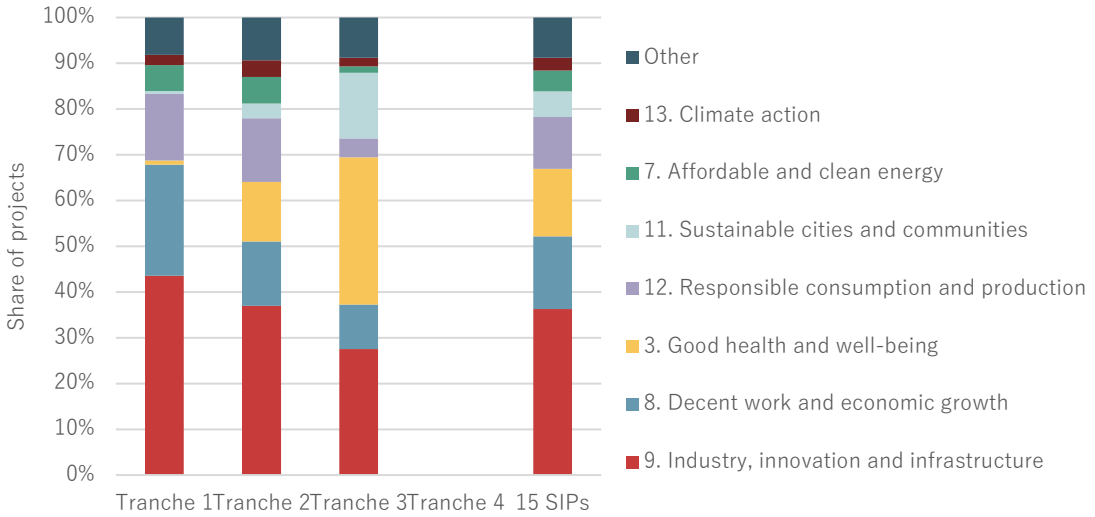
Source: Vinnova, Energy Agency and Formas.

Figure 16 shows the share of projects that address the seven most commonly occurring Sustainable Development Goals (SDGs), which together account for more than 90 percent of all project classifications. (Data was not available for RES of the third tranche and for Viable of the fourth.) The apparent increasing importance of Good health and well-being (SDG3) and Sustainable cities and communities (SDG11) at the expense of the declining importance of Decent work and economic growth (SDG8) and Industry, innovation and infrastructure (SDG 9) mirror the trends in Figure 15. Again, had we had data for Viable, Sustainable cities

[17] Out of 2 313 granted projects, 1 781 have resulted from open calls for R&I projects.

and communities no doubt would have dominated the bar.[18] For 15 out of the 17 SIPs (i.e. excluding RES and Viable), 36 percent of projects addressed SDG9, 16 percent SDG8, 15 percent SDG3 and 11 percent SDG12.

Figure 16 Share of projects in calls during the first six years addressing SDGs by tranche.[19]



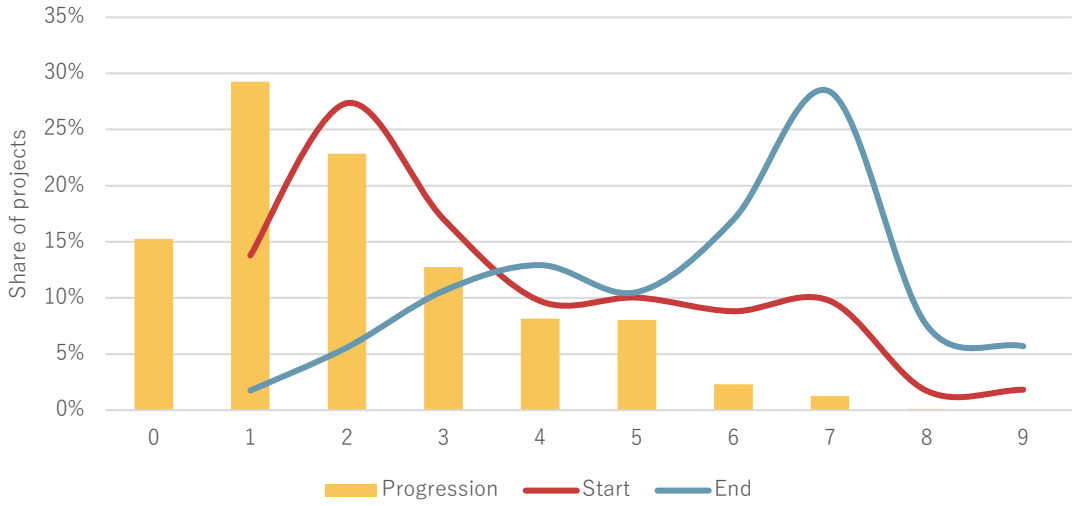
Source: Vinnova and Formas.

In the web surveys of individuals who had participated in R&I projects, respondents were asked to assess their projects' technology readiness level (TRL) at project start and end (unless still ongoing). It should be noted that all web survey responses only refer to R&I projects, i.e. projects that aim to develop new knowledge, and to assessments made by individuals who had participated in R&I projects. Figure 17 shows that company respondents judged that most projects had started at TRL1–3 and that they had ended at TRL6–8. However, the projects representing the starting peak at TRL2 were only very rarely the same ones that ended at TRL7 since the average TRL progression of individual projects was 2.1.

[18] Nine projects funded by Vinnova are mainly classified into SDG11 and SDG12, but they cannot be assumed to be representative for all Viable's R&I projects.

[19] Projects could be classified in up to three SDGs, meaning that there is an element of double counting.

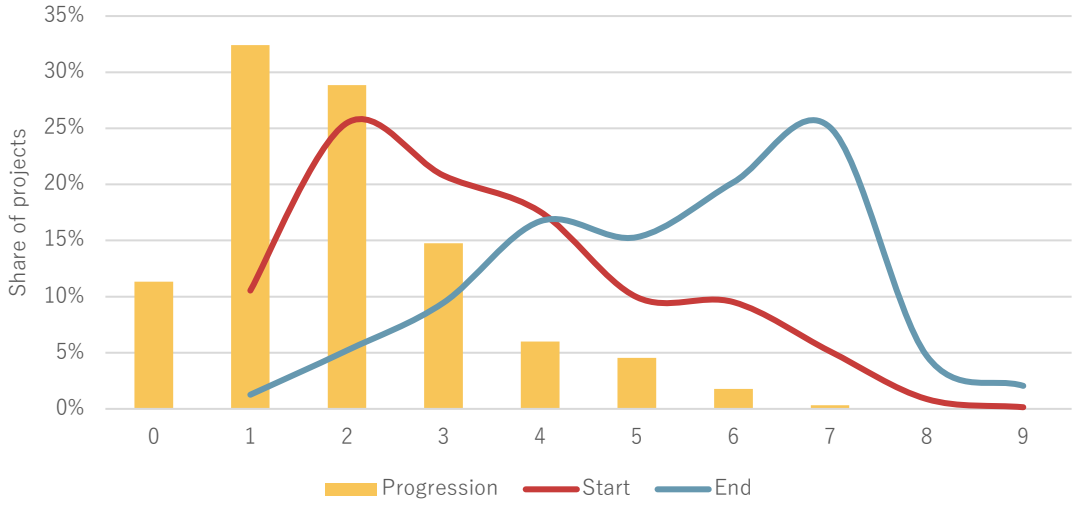
Figure 17 Share of R&I projects starting and ending at different TRLs according to companies, including TRL progression of projects (n=987).



Source: Web surveys.

Large proportions of public authority respondents found it considerably more difficult to assess their projects' TRL, meaning that answers were few and for this reason we do not show them. In contrast, R&D performers found these judgments easier. Figure 18 illustrates that their assessments seem to agree rather well with those of company respondents, i.e. that most projects had started at TRL1–3 and ended at TRL6–8, although their assessment of TRL progression was more conservative at 1.9.

Figure 18 Share of R&I projects starting and ending at different TRLs according to R&D performers, including TRL progression of projects (n=683).

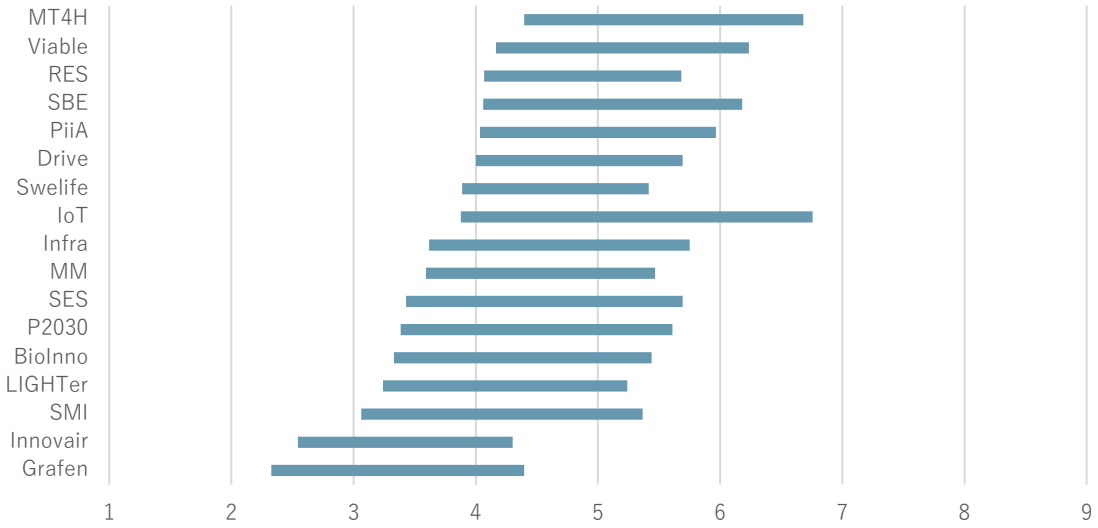


Source: Web surveys.

Considering only the average TRL assessments of all 17 SIPs fails to illustrate that their projects seem to have been quite different. Figure 19 shows company respondents' assessments for each SIP, thus illustrating that Grafen and Innovair operate at the

fundamental research end of the scale, while for example MT4H and Viable seem to be much closer to implementation, and IoT by far has the highest progression of the lot.

Figure 19 Average TRL progression by SIP according to companies (n=871).



Source: Web surveys.

Although Figure 17 and Figure 18 seem to indicate that company and R&D performer respondents generally agree on TRLs, it turns out that there is considerable disagreement at the level of some individual SIPs. Figure 19 thus should be taken with a grain of salt and it is mainly included to illustrate that the 17 SIPs are active at quite different parts of the TRL scale (R&D performer respondents nevertheless agree on Grafen and Innovair belonging at the fundamental research end of the scale).

6 Impacts for participants

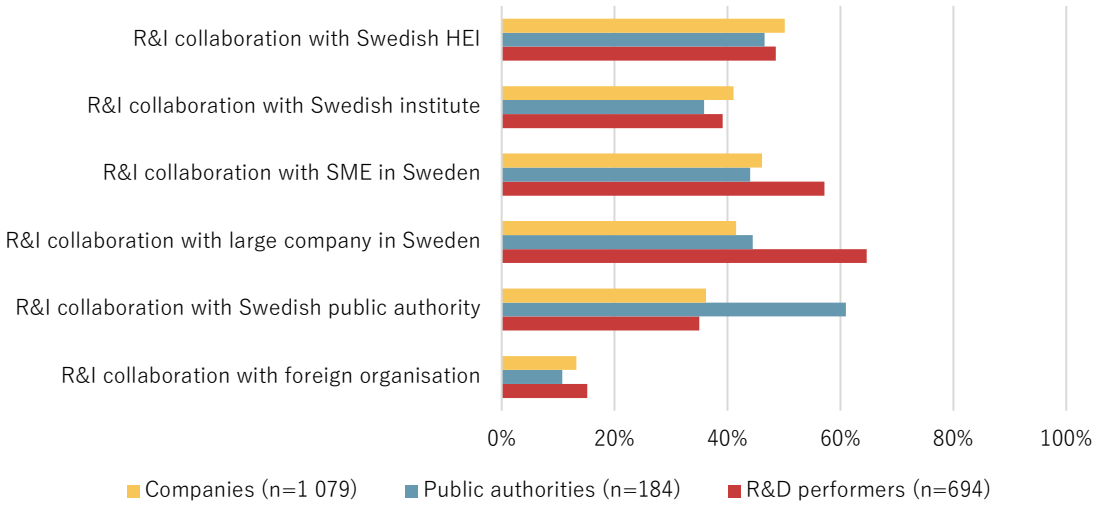
In this chapter, we first study participants' motives for engaging in R&I projects before we move on to the impacts that the projects have contributed to or are expected to contribute to for participants. The chapter is based on web survey responses and bibliometric analyses. Just as for the TRL figures of the previous chapter, web survey responses refer only to R&I projects and assessments by individuals who have participated in R&I projects (i.e. not strategic or coordination projects).

As we showed in Chapter 5, participation by public authorities gradually has increased from a very low level in the first SIP tranche to considerable proportions in latter tranches. Public authorities in SIPs with marginal participation of their kin in R&I projects did not receive an invitation to respond to a web survey. There was therefore no public authority survey in the five SIPs of the first tranche and not in three of the six SIPs of the second tranche, whereas there was such a survey in all SIPs of the latter two tranches. In practice, there were dedicated public authority surveys in nine out of the 17 SIPs.[20] The number of public authority respondents was nevertheless considerably lower than the other respondent categories.

6.1 Motives

Figure 20 shows the shares of the three survey respondent categories that agreed that they to a very large or large extent agreed that they engaged in their R&I project to collaborate with organisations of different types. On average, between 40 and 50 percent of all three respondent categories were motivated by the opportunity to collaborate with all types of Swedish organisations, but to a substantially lower degree with foreign ones. However, public authorities were the keenest to collaborate with (other) public authorities, and R&D performers notably the most interested in collaborating with companies.

Figure 20 Participants' collaboration-related motives for engaging in R&I projects in all 17 SIPs.

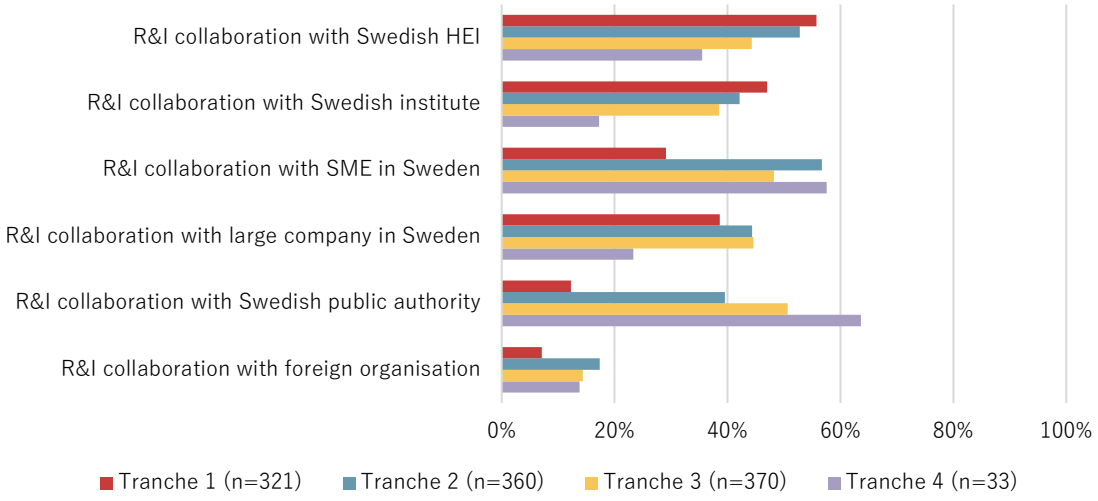


Source: Web surveys.

[20] Tranche 2: Swelife, IoT and BioInno; tranche 3: SBE, MT4H, Infra, Drive and RES; tranche 4: Viable.

The apparent near consensus of Figure 20 conceals the fact that motives evolved considerably between tranches. Figure 21 illustrates that in tranche 1, companies' collaboration-related motives were dominated by collaboration with HEIs, institutes and companies, and to a much lesser extent by collaboration with public authorities. Overall, companies' interest in collaborating with public authorities increased for each tranche, while collaboration with HEIs and institutes became a less important motive.

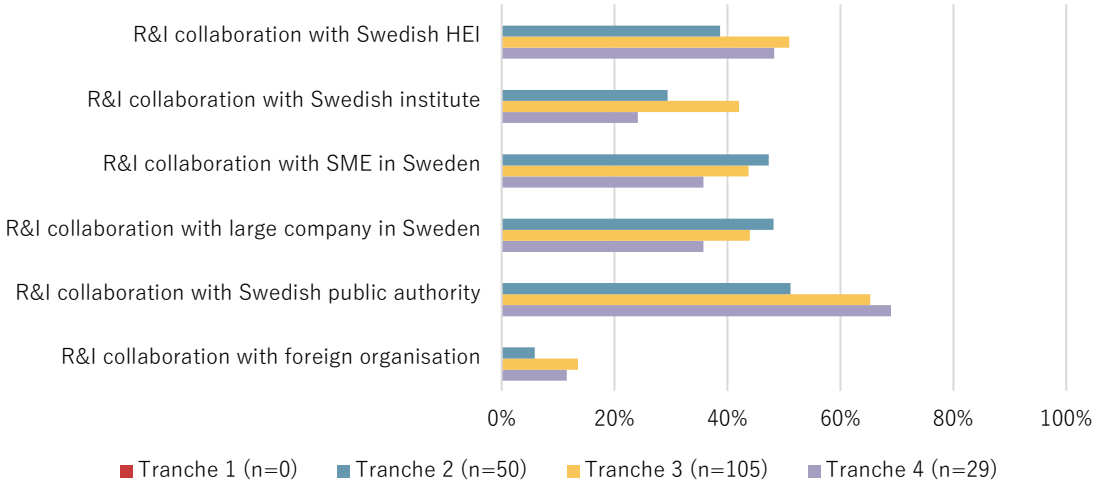
Figure 21 Companies' collaboration-related motives for engaging in R&I projects by tranche.



Source: Web surveys.

Figure 22 shows the equivalent responses from public authorities, but note that none were surveyed in the SIPs of the first tranche and only in three of six SIPs in tranche 2. While trends are less obvious in this figure, collaboration with other public authorities became a more important motive for each tranche also for public authorities.

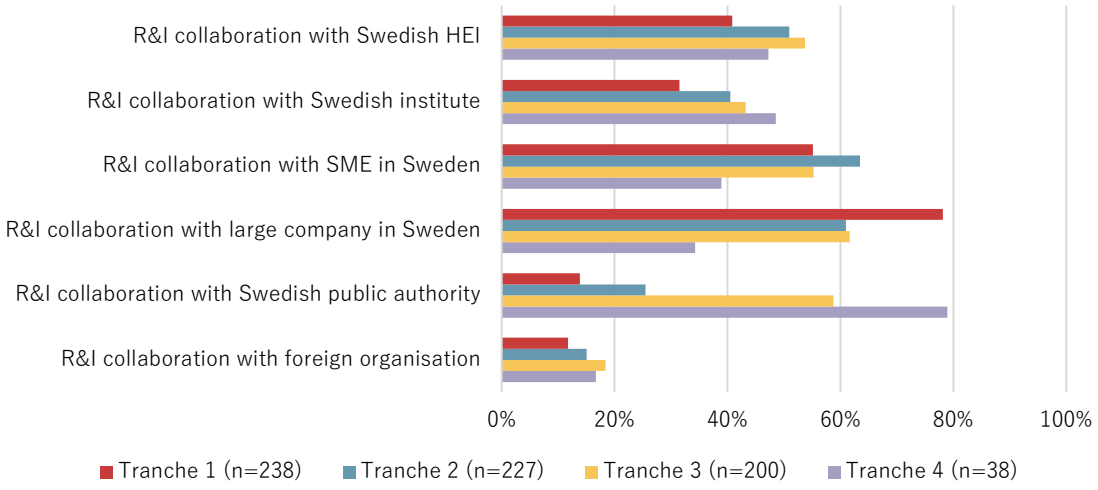
Figure 22 Public authorities' collaboration-related motives for engaging in R&I projects by tranche.



Source: Web surveys.

Figure 23, finally, shows R&D performers' responses, revealing that collaboration with public authorities became a much more important motive for each tranche, while collaboration with large companies became less important.

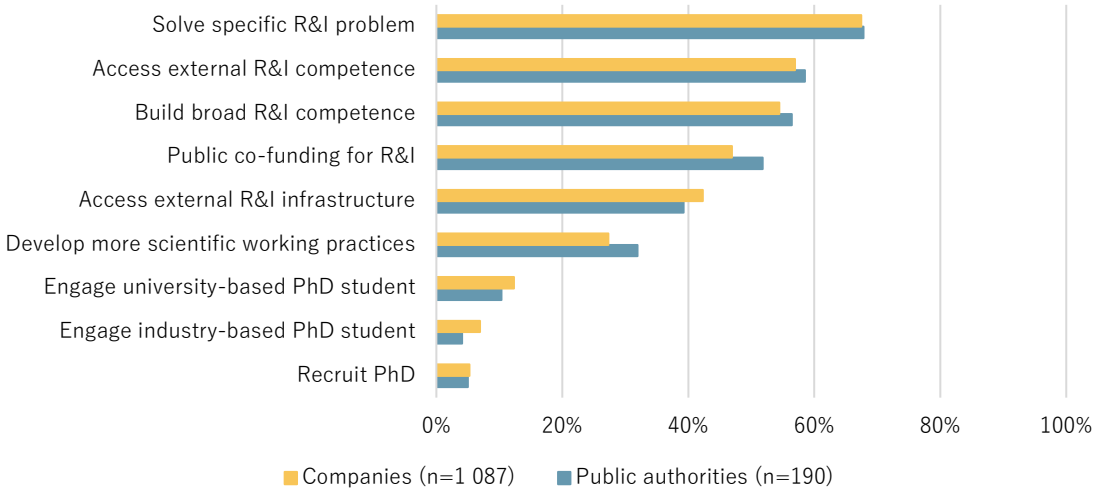
Figure 23 R&D performers' collaboration-related motives for engaging in R&I projects by tranche.



Source: Web surveys.

There are of course other motives to engage in R&I projects than to collaborate with others, and Figure 24 illustrates that the top-rated motives in this figure tend to be stronger than the collaboration-related motives reported in previous figures.

Figure 24 Companies' and public authorities' additional motives for engaging in R&I projects.



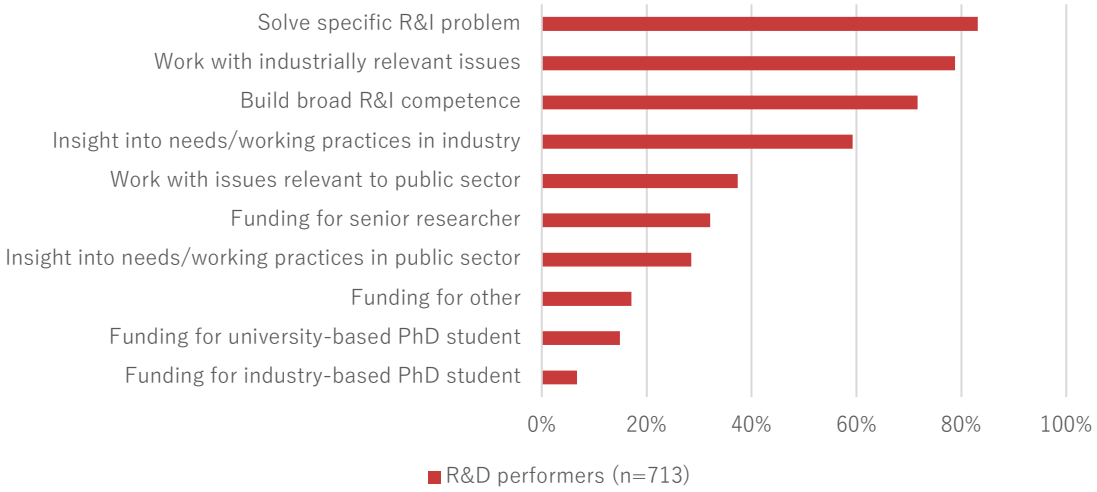
Source: Web surveys.

Companies and public authorities largely agree that they mainly were motivated by the opportunity to solve a specific R&I problem – with the assistance of others' competence and infrastructure – but they also sought to build in-house R&I competence. Receiving public co-funding was another significant motive, while development of more scientific working

practices was rated lower. In contrast, they were not particularly motivated by the opportunities to engage PhD students or to recruit PhDs.

R&D performers' additional motives are separately reported in Figure 25 since many of them differ from those of companies and public authorities, but R&D performers also ranked solving a specific R&I problem the highest. The figure reveals that industry needs were high on their agendas, whereas the needs of the public sector were less important. Public co-funding was of course also a strong motive, but note that R&D performers had four potential funding motives to rate where funding for senior researchers (presumably often the respondent him-/herself) was the most important. It is noteworthy that R&D performers agreed that SIPs are not suitable to engage PhD students.

Figure 25 R&D performers' additional motives for engaging in R&I projects.

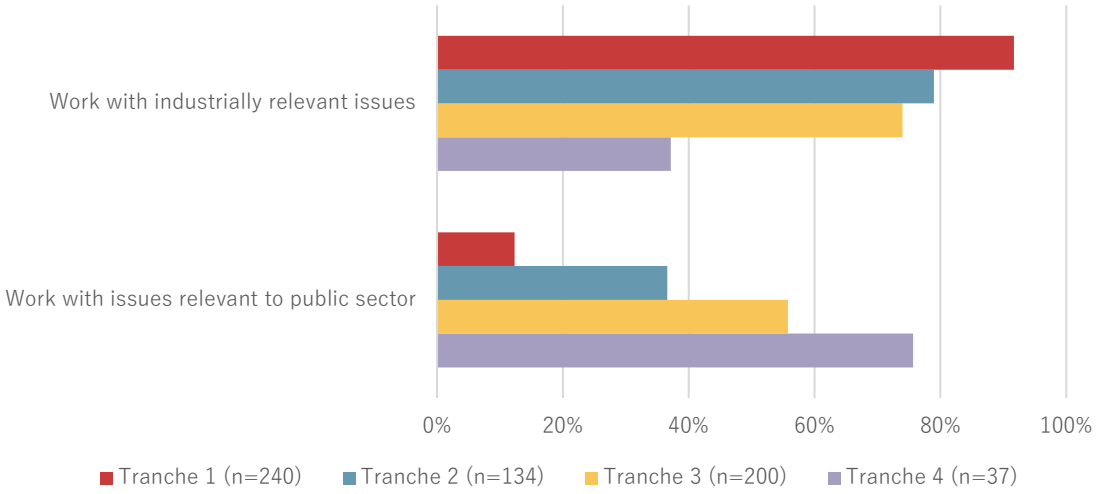


Source: Web surveys.

Whereas Figure 25 suggests that industry's needs were considerably higher on R&D performers' agendas than the public sector's, Figure 26 reveals that this was something that changed a lot from the SIPs of the earlier tranches.[21] This gradual evolution is in agreement with the responses reported in Figure 23.

[21] The figure only shows two possible motives from a considerably longer list.

Figure 26 Selection of R&D performers' additional motives for engaging in R&I projects by tranche.



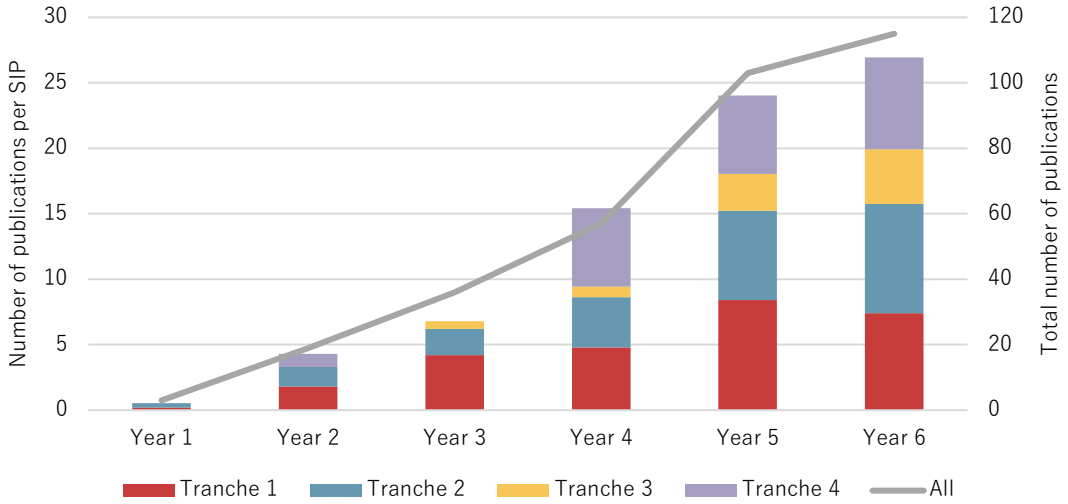
Source: Web surveys.

6.2 Publications

One indicator of programme productivity is academic output in terms of scientific papers. However, since SIPs are innovation and not research programmes, a large number of papers is not necessarily the most relevant indicator of success, and the three funding agencies harbour no specific expectations in this respect on individual SIPs. Having said that, bibliometric analyses allow some enlightening observations.

Figure 27 shows the average number of journal papers published per SIP per year of operation and by tranche identified in Scopus (bars, left axis). The figure illustrates the obvious circumstance that it takes a few years for a new R&I programme to start generating publishable results (and for journals to peer review papers). The figure also shows that the SIPs of the third tranche were considerably less prone to publish in scientific journals than the ones of the other tranches. Although this analysis obscures significant differences between SIPs within each tranche, it is still possible to conclude that the SIPs of the first two tranches were considerably more productive in this respect than the ones of the third tranche, probably since most of them built on decades of R&I collaboration (cf. Section 4.4). The second tranche nevertheless includes two SIPs without antecedent programmes, but their relatively low output is compensated for by outstandingly high outputs of three other SIPs in the tranche (Innovair, Swelife and BioInno, all with long histories of R&I collaboration). Viable of the fourth tranche has also been quite productive, despite lacking antecedent programme. In total, at least 333 journal papers (identified in Scopus) were published by the 17 SIPs during their first six years (line, right axis).

Figure 27 Average number of journal papers published per SIP per year of operation and by tranche (bars, left axis) and total number of journal papers per year of operation (line, right axis).

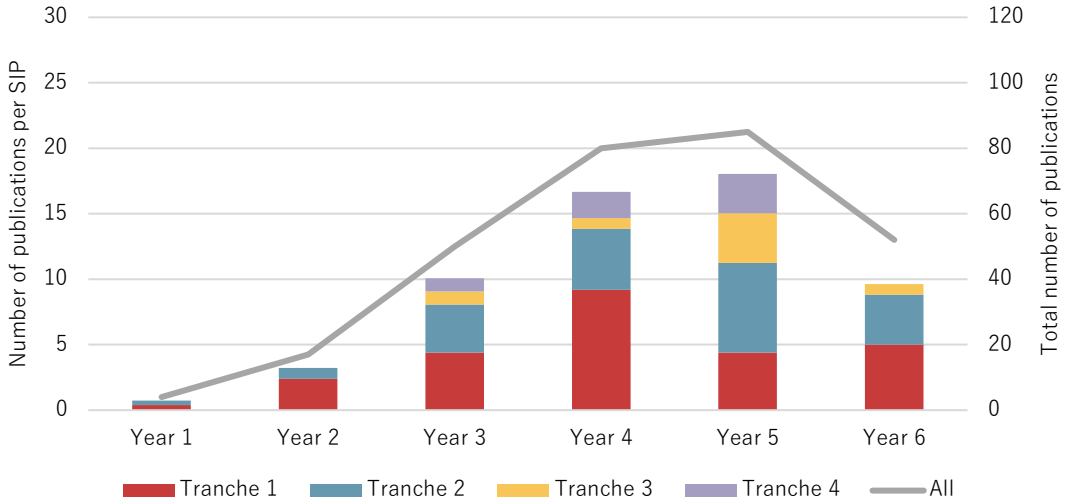


Source: Bibliometric analyses.[22]

Figure 28 shows the equivalent data for conference papers. Again, there was a ramp-up phase and the SIPs of the first two tranches were by far the most productive. The extraordinarily high numbers for the first tranche in year 4 and for the ones in the second tranche in year 5 are due to one SIP in each tranche (P2030 and Innovair, respectively) reaching publication peaks these years, possibly due to broad attendance at specific conferences. The drop in conference papers for the third tranche in year 6 is no doubt a Covid-19 effect (which possibly may have led to an increase in journal papers, cf. Figure 27, but that is speculation). In total, at least 288 conference papers (identified in Scopus) were published by the 17 SIPs during their first six years (line, right axis).

[22] The base data for the bibliometric analyses were the agencies' surveys of project managers in completed projects. However, not all project managers respond to these surveys, and they are only sent after project completion, so programme offices were given the opportunity to supplement the survey data. For these reasons, and due to the time lag inherent to the review and publishing processes, the papers identified do not include all papers resulting from the 17 programmes, but coverage should be comparable between SIPs.

Figure 28 Average number of conference papers published per SIP per year of operation and by tranche (bars, left axis) and total number of conference papers per year of operation (line, right axis).



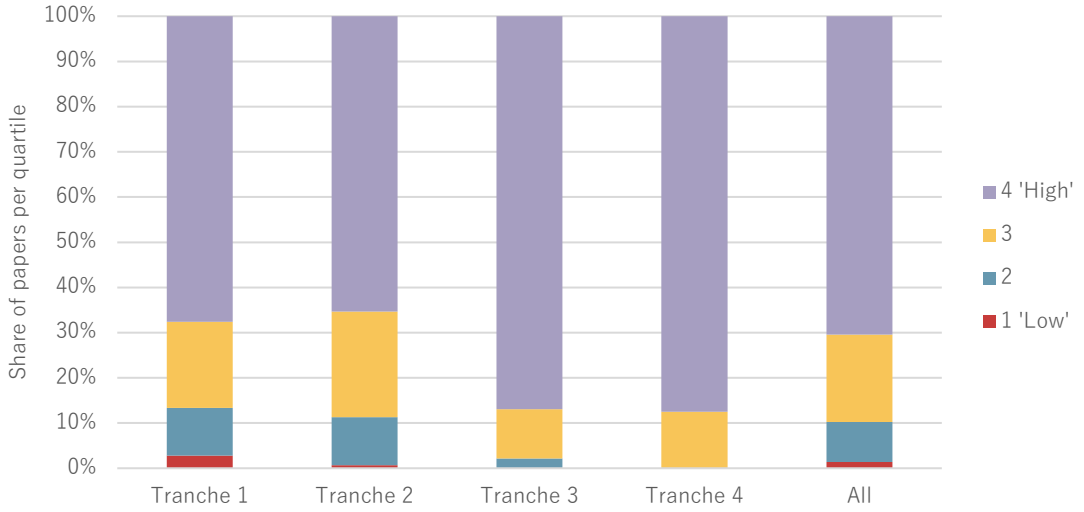
Source: Bibliometric analyses.

Overall, the variation in publication propensity between SIPs is huge. Considering both journal and conference papers, the average number of publications per SIP during their first six years was 37, but the two most productive SIPs published more than 100 papers each (Innovair and P2030) and the least productive published only three (Drive). One group of seven SIPs published 10–30 papers each and another group of seven SIPs 30–50 papers each.

The Source Normalized Impact per Paper (SNIP) indicator may be used to estimate the relative competitiveness of a journal (Waltman et al., 2013), which in turn may be used as proxy for the 'quality' of papers published in that journal. Grouping journals into four quartiles by their SNIP ranking places 25 percent of all journals into each quartile. Papers published in a specific journal may consequently be grouped using the journal's SNIP ranking and approximately 25 percent of all papers therefore should be expected in each quartile.

The journal papers published by the 17 SIPs were thus classified into four quartiles where quartile 1 indicates 'low quality' and quartile 4 'high quality'. Figure 29 illustrates that journal papers from SIPs in the first two tranches were similarly classified, as were those from SIPs in the latter two tranches. The journal papers of the SIPs of latter two tranches appear to be of higher quality, but this difference should not be exaggerated considering that these SIPs produced fewer papers (cf. Figure 27). Most journal papers produced by all 17 SIPs are nevertheless of high quality with seven out of ten (70%) papers classified into quartile 4 and nine out of ten (90%) into quartile 3 or higher.

Figure 29 Share of journal papers by SIP tranche and SNIP value quartile.



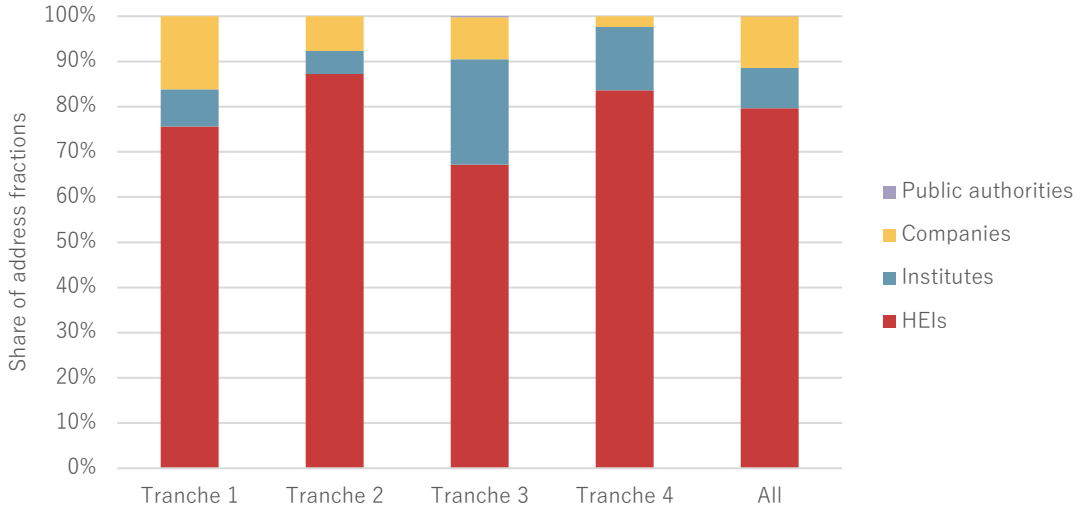
Source: Bibliometric analyses.

The equivalent analysis was done for conference papers, but so few of the SIPs' conference papers had been published in conference series with SNIP value that we refrain from reporting these results in any detail.[23] Having said that, the conference papers do not appear to be of equally high quality as the journal papers, but a majority (53%) of the ones with SNIP value are nevertheless classified into quartile 4 and almost seven out of ten (69%) papers into quartile 3 or higher.

As expected, Figure 30 and Figure 31 show that authors from HEIs heavily dominate among authors of both journal and conference papers (in terms of address fractions). The figures also illustrate that company representatives made some contributions, particularly in SIPs of the first tranche. Company contributions to both journal and conference papers were in fact greater than those of institutes. Representatives of public authorities made some contributions to conference papers in SIPs of the second and third tranches, see Figure 31; however, this is almost entirely explained by Swelife (second tranche) and MT4H (third tranche) These two SIPs are active in life sciences wherein collaboration between HEIs on the one hand and regions and university hospitals (which are classified as public authorities) on the other traditionally is close; other SIPs have seen marginal (or no) author contributions from the public sector.

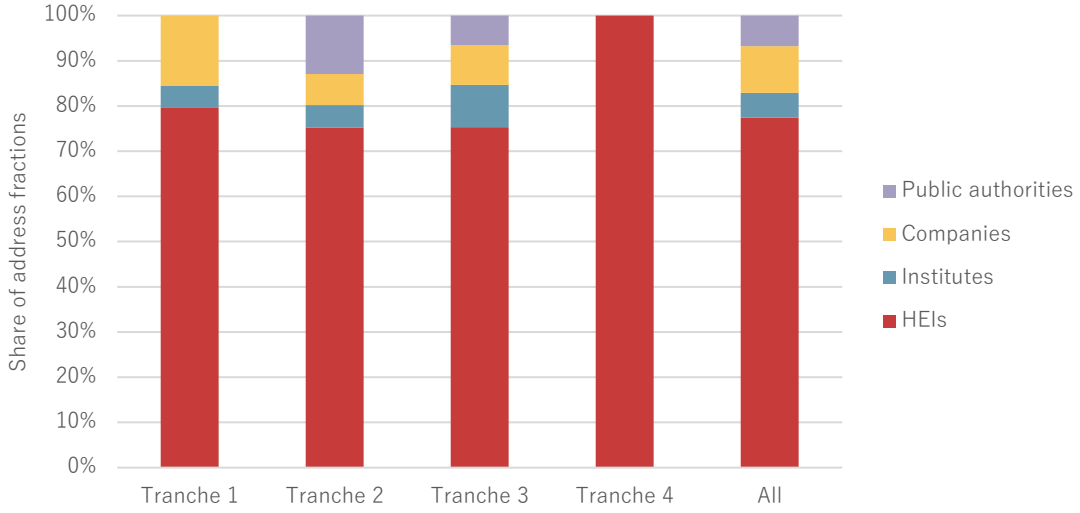
[23] Only 42% of conference papers had been published in conference series with SNIP value, and there were particularly few conference papers with SNIP value from the SIPs of the latter two tranches. In contrast, 96% of journal papers had been published in journals with SNIP value.

Figure 30 Relative author contributions to journal papers by SIP tranche and actor type.



Source: Bibliometric analyses.

Figure 31 Relative author contributions to conference papers by SIP tranche and actor type.



Source: Bibliometric analyses.

In total, HEI authors were responsible for 80 percent of address fractions of journal papers and slightly less (77%) of conference papers, while institute authors were responsible for 9 and 5 percent, respectively. Company author shares similarly were 11 and 10 percent, respectively, and public authority authors 0 and 7 percent, respectively.

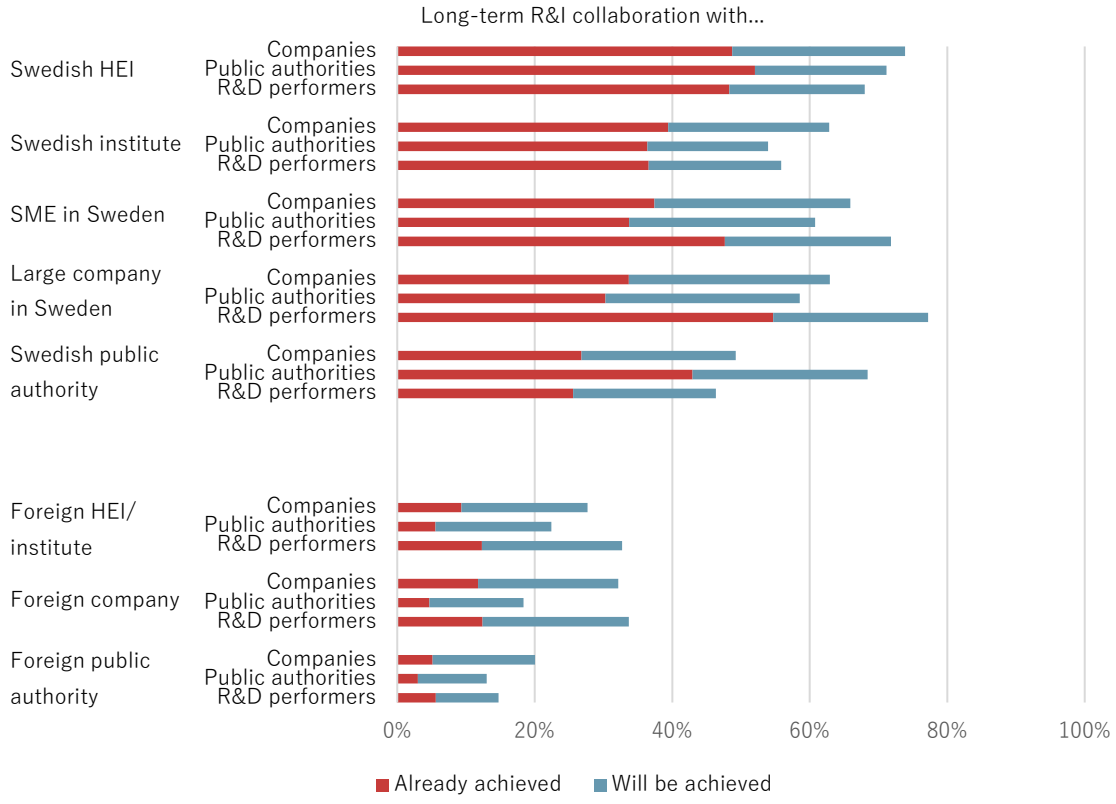
Since SIPs are innovation programmes focusing on user needs and they operate in quite varying contexts and with different objectives, academic output in terms of papers should not be interpreted as *the* measure of success of a SIP. However, judiciously and selectively interpreted it may be used as *one of several* indicators of success of the entire SIP initiative. On the same note, the rather modest contributions to papers by representatives of companies and public authorities reported above should not be interpreted as collaboration between R&D performers on the one hand and companies and public authorities on the other having been limited. As we will learn in the next section, collaboration between organisations of

different types in R&I projects generally has been intense, but it is, for well-known reasons, researchers in HEIs that have the most obvious incentives to publish, and it is not uncommon that they write papers on their own to report on results of collaborative projects.

6.3 Impacts

The long-term collaboration impacts shown in Figure 32 correlate rather well with participants' motives for engaging in R&I projects in the first place (cf. Figure 20). The same shares of respondents that reported that they were motivated by the opportunity to collaborate with Swedish HEIs and institutes assess that they had already established such long-term collaborations (red bars). In contrast, notably smaller shares assess that long-term collaboration with Swedish companies and public authorities had already been achieved, which may be reasonable considering that establishing long-term collaboration with users could take longer. However, if we also take expected future developments into account (blue bars) then impacts were expected to eventually exceed the original motives. An analysis of these data by tranche reveals that the trends are similar to those for motives (cf. Figure 21–Figure 23), i.e. of gradual shift in focus from collaboration with companies to public authorities.

Figure 32 Long-term R&I collaboration impacts of participation in R&I projects (Companies: n=857, Public authorities: n=156, R&D performers: n=616).

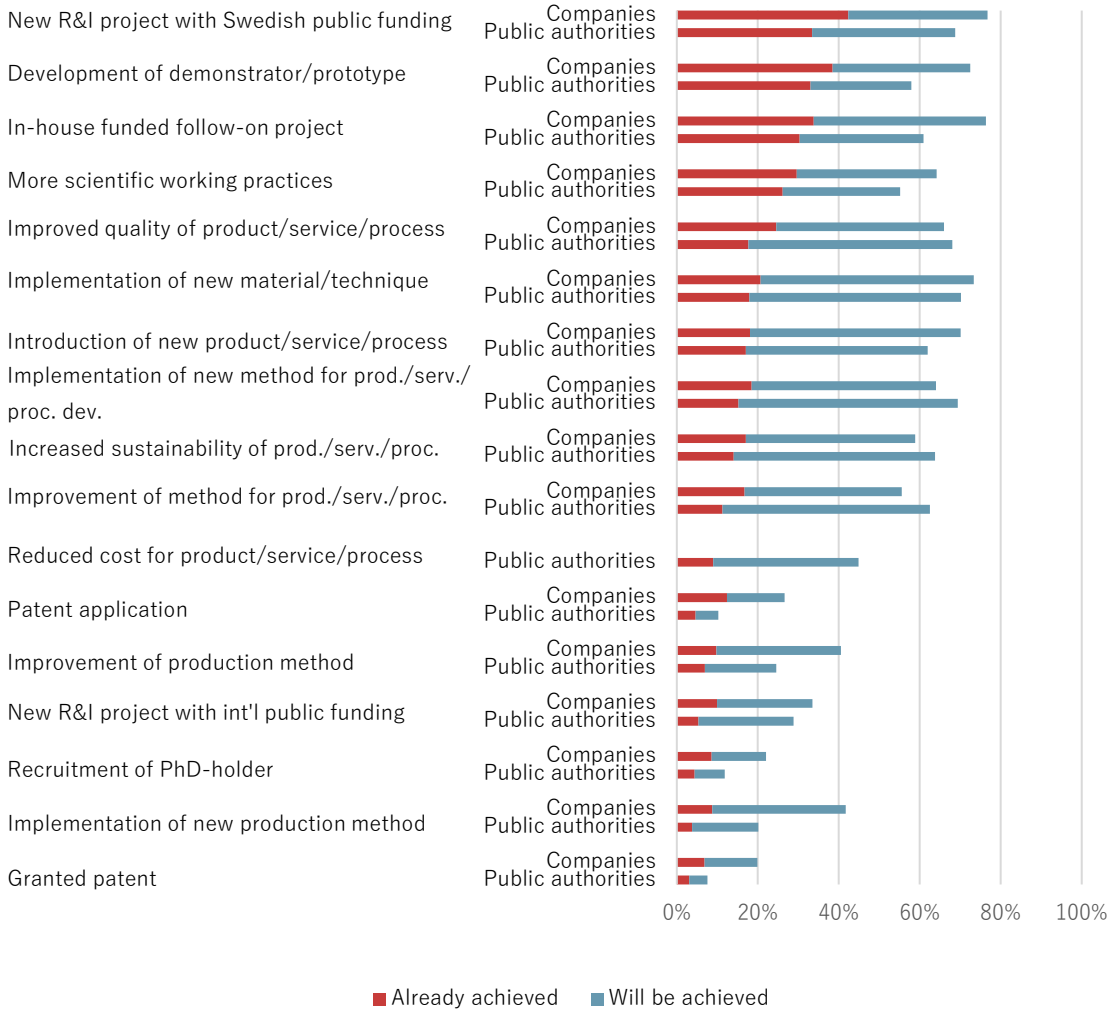


Source: Web surveys.

The impacts most often reported are indeed the collaboration-related ones. However, there are additional ones that are also quite common but that naturally take longer to be realised, see Figure 33. According to companies and public authorities the most frequently reported

additional impacts already achieved were new projects with Swedish public funding, development of prototypes, self-funded follow-on projects and more scientific working practices. Following on these were several aspects that refer to implementation of project results to improve the organisation's products, services or processes; together such 'intermediate' impacts may prove quite important in the longer term, particularly since expectations for future achievements are so large. On the other hand, patents, recruitment of researchers with doctorates, and new projects with international public funding were not very common impacts, and expectations were also quite modest.

Figure 33 Companies' and public authorities' additional impacts of participation in R&I projects (Companies: n=890, Public authorities: n=160).[24]



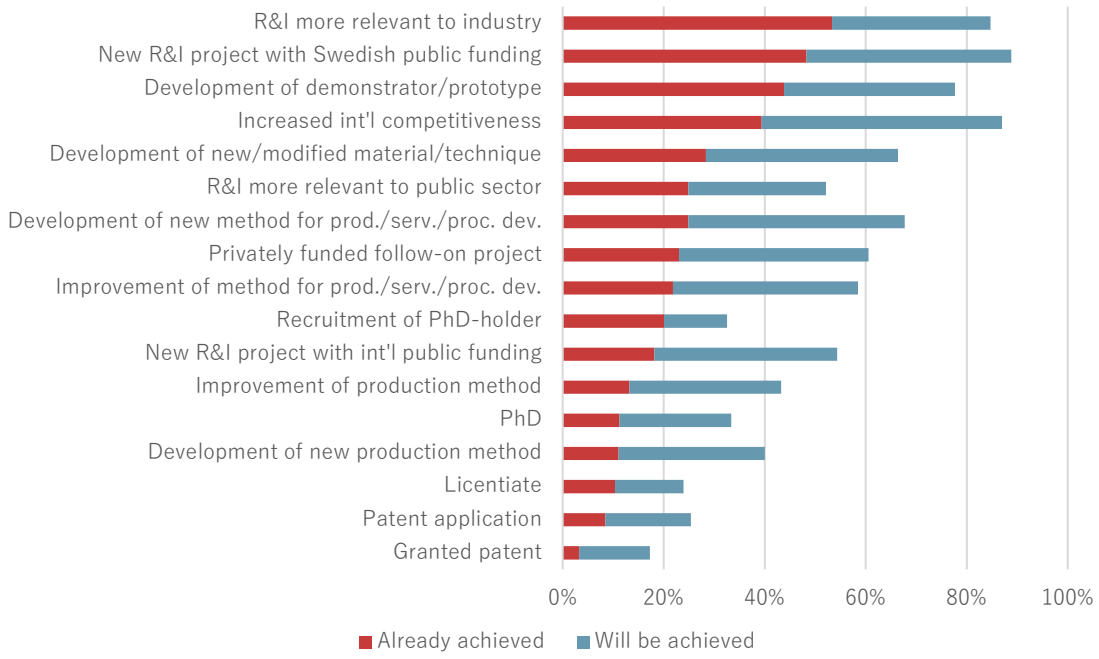
Source: Web surveys.

Figure 34 illustrates that the most common impacts already achieved by R&D performers were that their R&I had become more relevant to industry, new projects with Swedish public funding, development of prototypes and increased international competitiveness, followed by development or modification of materials or techniques and their R&I having become more

[24] The reduced cost alternative was posed to companies in a separate question and is reported separately.

relevant to the public sector. Around every fifth respondent reported that the project had resulted in new privately or internationally funded projects, but considerably fewer that patents and graduate degrees had been achieved.

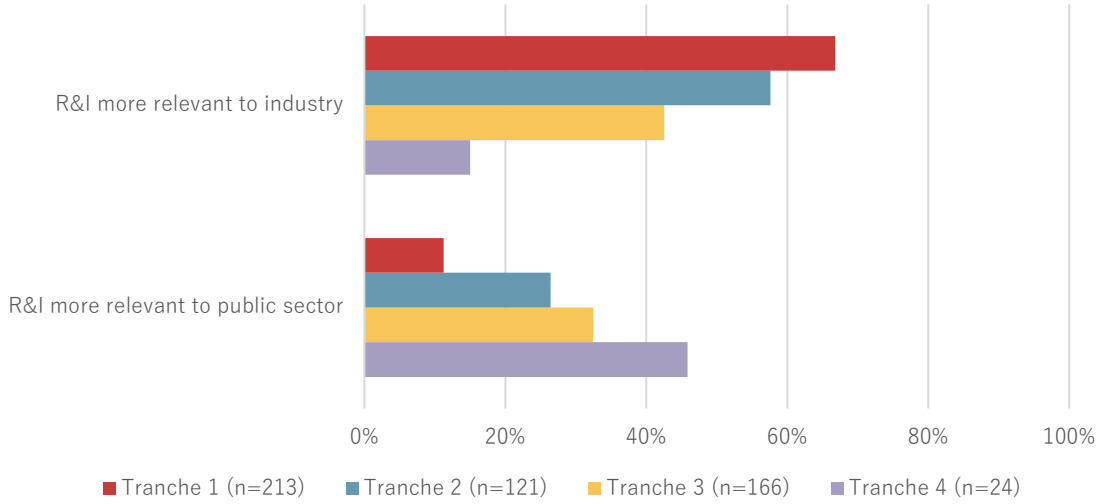
Figure 34 R&D performers' additional impacts of participation in R&I projects (n=619).



Source: Web surveys.

While a majority of R&D performer respondents assessed that their R&I activities had become more relevant to industry, less than half as many responded that it had become more relevant to the public sector – or society, if you wish. However, these averages for all 17 SIPs obscure the fact that there was a quite distinct change in focus from the needs of industry in the earlier tranches to the needs of the public sector in the latter, see Figure 35 which only shows impacts already achieved. (These impacts mirror the motives of Figure 26, so this should not come as a surprise.) Considering that the number of HEIs and institutes in Sweden is rather small, most of them probably cater to needs both in industry and in the public sector, but it seems reasonable to assume that it is different researchers that focus on public-sector needs from those who are motivated by working with industry.

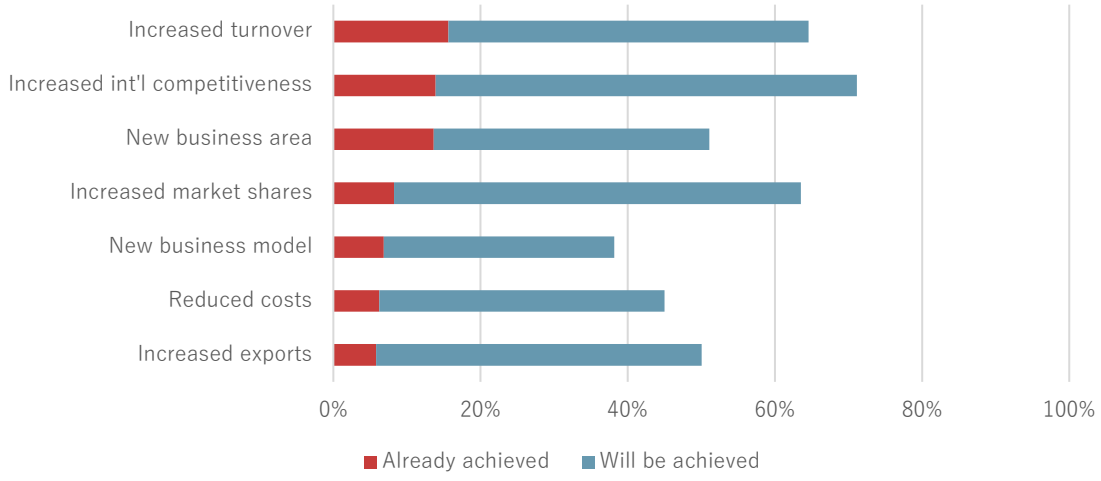
Figure 35 Selection of R&D performers' additional impacts already achieved following participation in R&I projects by tranche.



Source: Web surveys.

Rather few company respondents assessed that the company already had experienced commercial impacts, see Figure 36. This is reasonable since the time scales to realise such impacts tend to be longer, often considerably longer, than six years (the lifetime of the SIPs when they were evaluated, although no single R&I project had had that duration). With expectations included, a majority of company respondents nevertheless assessed that the company eventually would experience increased turnover, increased international competitiveness, new business areas, increased market shares and increased exports.

Figure 36 Commercial impacts for companies of participation in R&I projects (n=691).



Source: Web surveys.

7 Impacts for system and society

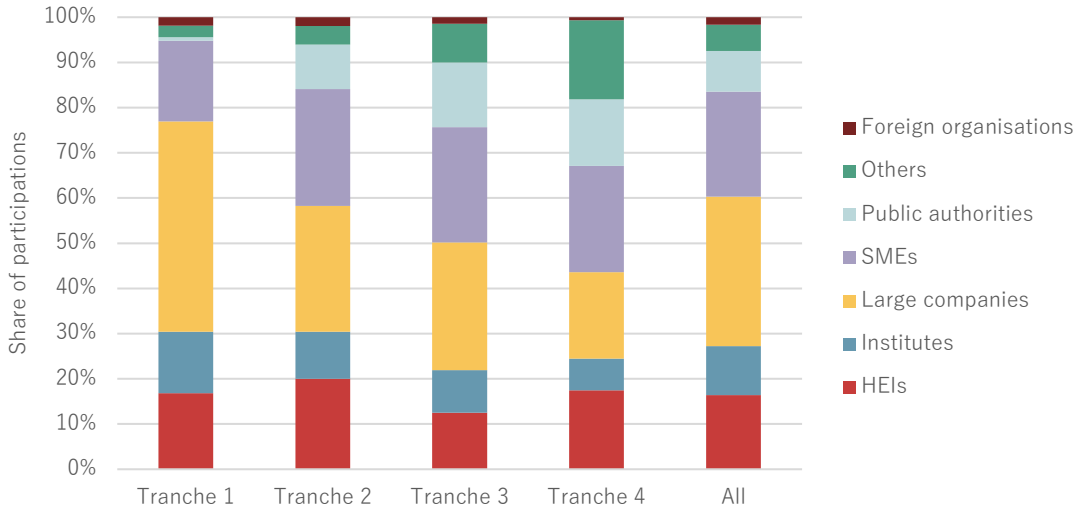
This chapter focuses on impacts beyond R&I project participants, both at systems level and on society as a whole. The chapter utilises all forms of empirical evidence, but mostly the funding agencies' project participation data, web surveys, documents and interviews.

7.1 Systemic impacts

In total, there were around 8 600 participations in the R&I projects of the 17 SIPs during their first six years. The average number of participations per SIP was 506. The largest number of participations was in RES (1 051), but MM, BioInno, P2030, SBE and Swelife had 600 or more participations, while SES had the least participations (257). There is, however, some evidence that, in SIPs with many participations, participation may have been superficial in some projects, including low survey response rates and low interest in being interviewed.

Figure 37, which shows the share of participations by actor type and tranche, underlines what we have seen in previous chapters, namely that companies have become less dominant with each tranche and that public authorities have become more active. The figure also illustrates that 'Others' – mostly industry confederations, technology parks, HEI holding companies, technology transfer offices, foundations and NGOs – have become more common. The figure resembles and shows similar trends as Figure 7 and Figure 8 (recipients of public funding and co-funders, respectively), but one may argue that this figure provides a more balanced picture of participation, since it reveals that companies, public authorities and others overall have had quite important roles in the 17 SIPs. (Note that Figure 37 refers to participations (not participants) in R&I projects, whereas Figure 7 and Figure 8 refer to funding to and co-funding by participants in all kinds of projects (not only R&I projects).)

Figure 37 Share of participations in R&I calls during the first six years by actor type and tranche.

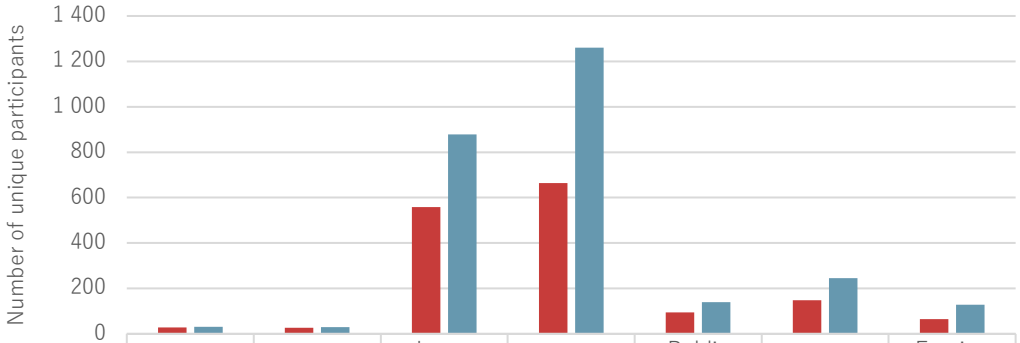


Source: Vinnova, Energy Agency and Formas.

A basic premise of the SIP initiative is that a SIP should be open to any legal entity registered in Sweden (cf. Section 4.2). We will now try to assess to what extent the 17 SIPs together have been successful in reaching actors of the main actor types.

If we consider project participations, we further may investigate the extent of the SIPs' mobilisation. While there have been 8 600 participations in R&I projects, most of these concern actors that have participated in more than one R&I project. Figure 38 reveals that there have been just over 2 700 unique participants during the first six years. The number of unique participants increased by 70 percent compared to the first three years (from almost 1 600). Participation of all actor types increased, but mostly among companies, others and foreign organisations. In contrast, there were much smaller increases for HEIs and institutes, mainly since most of them participated already in the first stage.

Figure 38 Number of unique participants in R&I calls during the first three and the first six years by actor type.



	HEIs	Institutes	Large companies	SMEs	Public authorities	Others	Foreign orgs.
3 years	28	27	559	664	95	148	65
6 years	31	29	879	1 260	139	245	129
Increase	11%	7%	57%	90%	46%	66%	98%

Source: Vinnova, Energy Agency and Formas.

Large companies. According to Statistics Sweden, there are 1 455 large companies (of the relevant legal forms) in Sweden, but only 700 in the top four NACE groups mentioned above. Since 879 large companies participated during the first six years, it seems reasonable to assume that a vast majority of these 700 companies indeed did participate – and many large companies from other NACE groups as well. In this sense, the SIPs seem successfully to have engaged most relevant large companies.

SMEs. The situation is less clear for SMEs, since there are more than 640 000 SMEs in total and almost 258 000 in the top four NACE groups. Only a small fraction of these SMEs are probably active in R&I or would benefit from becoming active in R&I, but the 1 260 participating SMEs nevertheless represent less than 0.5 percent of the ones in the top four NACE groups. Whether some SMEs that wanted to participate for one reason or another were denied the opportunity is impossible to say, but interviews in the individual programme evaluations nevertheless revealed that many participating SMEs had not previously engaged in R&I and/or had not collaborated on R&I matters.

Public authorities. Of 139 participating public authorities, 31 are at national level, 37 at regional and 71 at municipal. These include all 21 regional councils except Västernorrland, five of seven (regional) university hospitals and 67 of 290 municipalities. Among public authorities participating was obviously patchy.

HEIs. All Swedish universities and all university colleges but one (Swedish School of Sport and Health Sciences, GIH) have participated.[25] However, the 11 HEIs in the top 20 ranking of recipients of public funding (cf. Figure 10) accounted for 83 percent of all HEI participations and the five top beneficiaries – the ones in positions 2–6 – were responsible for almost two-thirds (65%) of HEI participations. At the other end of the list, one university and five university colleges had five or fewer participations. To a significant extent, this highly skewed participation pattern reflects where Sweden's top academic research base in the relevant areas is.

Institutes. Of the 29 institutes, 18 are now part of the RISE Group; together they were responsible for 75 percent of all institute participations. Other notable institute participants include one focusing on mining and metals (Swerim, which is 20% owned by RISE) and one focusing on environmental matters (IVL), which together with the RISE Group accounted for 98 percent of institute participations.

The 17 SIPs thus seem to have managed to engage most relevant Sweden-based actors. They have generally been open to all types of actors, and together they have been particularly successful in reaching out to significant proportions of available large companies, HEIs, institutes and regions. In terms of NACE codes, the SIPs seem to have been quite successful in engaging most companies that are large contributors to Sweden's BERD. The fact that participation of SMEs and other public authorities than regions have been far less comprehensive is likely due to lack of interest from actors of these types. However, these conclusions only consider organisations participating in at least one R&I project and therefore say nothing about the scope or intensity of their participation.

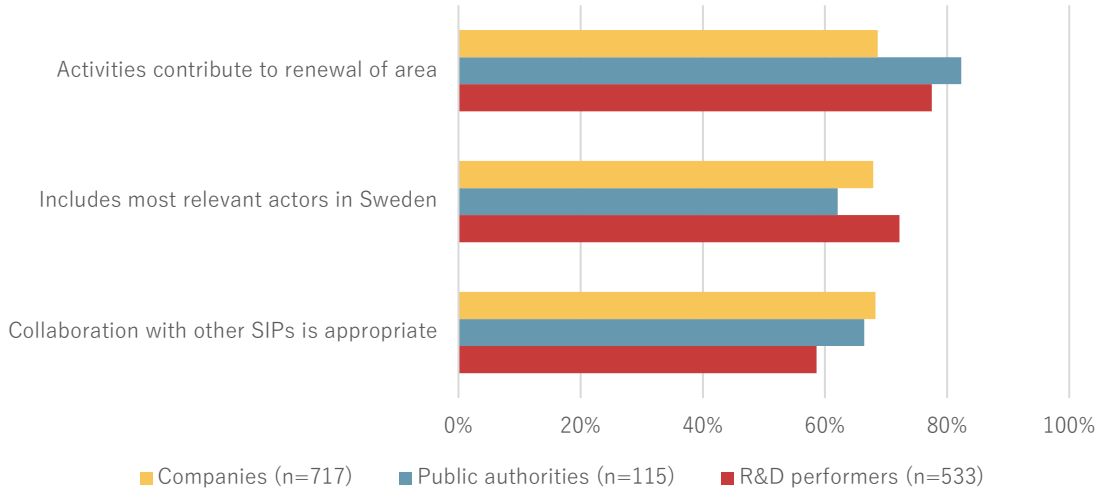
In terms of intensity of participation, Figure 13 illustrated that the regional distribution of public funding pretty much had been in line with where Sweden's main technical and medical HEIs and institutes are located. Figure 14 analogously illustrated that the regional distribution of co-funding had correlated quite well with where the value added of the top four NACE groups in Figure 12 (Manufacture & mining, Company services, R&D and ICT) is created. Companies from these NACE groups are responsible for 90 percent of Sweden's BERD.

The main participants among R&D providers have been strengthened and have thus become more attractive as partners, particularly to companies and public authorities. That said, SIP participation also has included novices to R&I, mainly among SMEs and public authorities, while the usual suspects probably have participated in (and co-funded) more R&I activities than they would otherwise have done. The obvious concentration to certain actors is a feature of the design of the SIP instrument due to its focus on user needs in areas of national strength in combination with the competition of open calls for R&I projects. From a national perspective, this concentration is not necessarily bad, but it has implications for systems innovation in that it is up to incumbents to drive change.

Figure 39 illustrates that most survey respondents agreed (to a large or very large extent) that their SIP had managed to engage most relevant Sweden-based actors and that it had renewed the SIP's self-defined area. Moreover, most respondents believed that collaboration with other SIPs had been appropriate. Interviewees in the programme evaluations echoed survey responses by emphasising the SIPs' accomplishments in engaging the relevant actors in formulating and realising a common agenda and thereby invigorating the area; this national mobilisation is repeatedly lauded by interviewees and topic experts alike.

[25] Sweden has 30 HEIs. The numbers in the figure are inflated by the inclusion of two participating HEI foundations.

Figure 39 Respondents' overall assessments of selected aspects of their SIP.



Source: Web surveys.

A few SIPs have developed collaboration networks more or less from scratch, while most have further developed and extended existing ones. Such network formation and extension has counteracted fragmentation of R&I activities, which arguably must have generated synergies. The synergies have been further accentuated by companies and public authorities having developed more scientific internal working practices, while R&D performers have adapted their operations better to serve industry and the public sector.

With varying ambitions, all SIPs have collaborated with other SIPs, but programme offices and programme boards have rarely seen this as a top priority. Significant collaboration has nevertheless been orchestrated, but mostly *ad hoc* since the agencies have not provided funding specifically to encourage inter-SIP collaboration. Larger potential synergies consequently remain unrealised.

Each evaluation team included two topic experts, who assessed 20 proposals and ten projects per SIP.[26] Their assessments of whether the relevant Sweden-based organisations participated in these projects and the extent to which the projects contributed to fulfilment of the SIP's objectives were on average both favourable. The topic experts gave the lowest ratings for the projects' scientific quality and scientific relevance, but higher marks for their contributions to new knowledge beyond scientific merits. These assessments seem to be in line with the SIPs being innovation and not research programmes, but the topic experts also gave low ratings to the projects' contributions to systemic changes.

The SIPs allocated significant shares of their resources to strategic projects to address challenges and needs common to the area or at least to many of its actors (cf. Figure 4). The purposes of such projects usually were to support future R&I projects and to facilitate implementation of innovations. Some projects included international outlooks and benchmarking exercises, while others developed platforms and infrastructure for subsequent use in R&I projects, as well as workshops, courses and graduate schools. There is

[26] Topic experts were nominated by the respective programme office and by the agencies, whereupon the agencies checked candidates for conflict of interest. The two experts per programme were enlisted as subcontractors to the evaluation teams. The ten projects and ten of the 20 proposals that the topic experts rated were chosen by the programme office resulting in an intentionally positive bias, while 10 proposals were randomly selected by the evaluators.

considerable evidence that strategic projects successfully addressed system-related deficiencies and contributed to changed working practices.

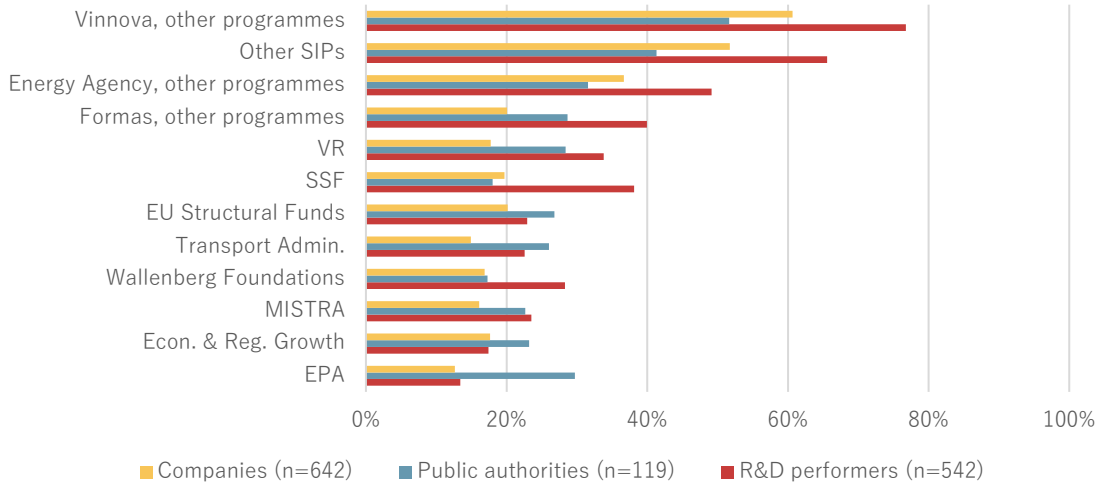
While most strategic projects were technically- or market-oriented, some were of administrative and legal nature. An important example of the latter arose due to the focus on public authorities as end users in some of the later SIPs, where the Law on Public Procurement (*Lag (2016:1145) om offentlig upphandling*, LOU) presents challenges for R&I collaboration, particularly of the long-lasting sort. The National Agency for Public Procurement participated in several projects in RES to contribute to development of knowledge and tools to promote circular procurement. Among other things, this resulted in the Agency together with other national authorities conducting workshops with several SIPs.

In conclusion, the SIP initiative has contributed to integration of R&I subsystems – and in some cases creation of new ones – that are characterised by wide participation, relevance, quality and efficiency.

7.2 Function in R&I funding system

An important issue from the three funding agencies' perspective is how other funding opportunities complement the SIP initiative, and vice versa. Figure 40 shows the 12 most important Swedish funders and programmes (ranked by the average assessments of the respondent categories), illustrating that the three agencies' other ('non-SIP') programmes, as well as other SIPs clearly were considered the most important sources of funding for the respondents themselves.

Figure 40 Respondents' assessments of which Swedish R&I funders and programmes that were important for their own organisations.[27]



Source: Web surveys.

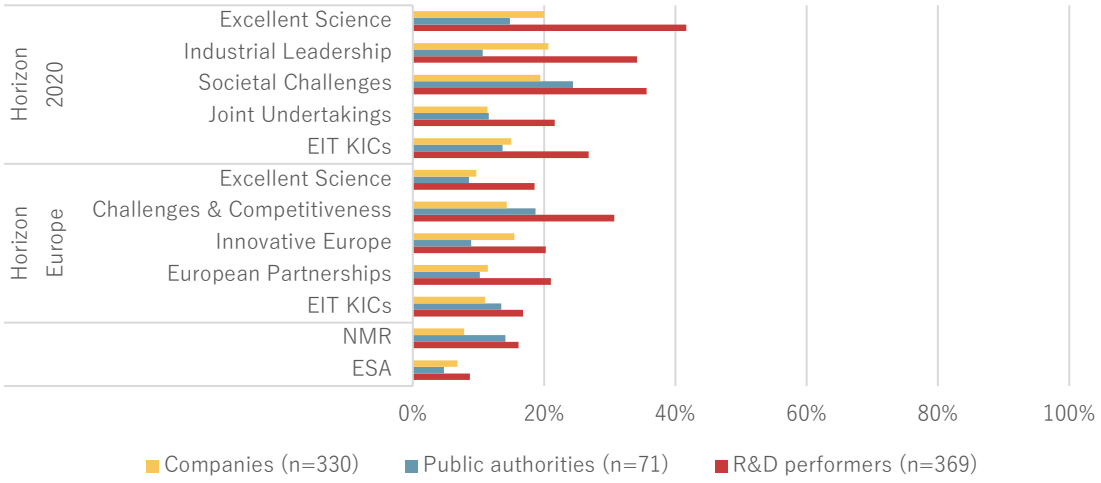
In the Swedish funding landscape, the SIP initiative, Vinnova and the Energy Agency essentially represent the most applied end of the spectrum of R&I funding opportunities. Formas and VR are also quite important, but they fulfil quite different needs since they

[27] VR = Swedish Research Council, SSF = Swedish Foundation for Strategic Research, Transport Admin. = Swedish Transport Administration, MISTRA = Swedish Foundation for Strategic Environmental Research, Econ. & Reg. Growth = Swedish Agency for Economic and Regional Growth, EPA = Swedish Environmental Protection Agency.

typically fund fundamental research, mostly at HEIs and generally without user participation.[28] While Vinnova and the Energy Agency, through their other programmes, thus largely fund similarly applied R&I as the SIPs do, there is nevertheless an element of complementarity between their funding offers (including the SIPs) and those of the funders of fundamental research. However, OECD (2016) has argued that the Swedish funding landscape has a weakness when it comes to strategic research, i.e. the middle of the TRL scale where SSF, MISTRA and the private Wallenberg Foundations are the most important funders, according to survey respondents.

Figure 41 shows the equivalent results for international funders and programmes, revealing that the SIP participants' appetite for venturing abroad was relatively low. This becomes even more obvious when considering that the number of respondents to this question was only between two thirds (for R&D performers) and half (for companies) of the number responding to the question on Swedish funding opportunities. Only R&D performers seemed to consider international opportunities in general and the EU Framework Programmes in specific somewhat important. Interviews in the programme evaluations reveal that the lukewarm interest at least in part is due to the rather generous funding opportunities and the high success rates that most SIPs offer.

Figure 41 Respondents' assessments of which international R&I funders and programmes that were important for their own organisations.[29]



Source: Web surveys.

There were nevertheless some notable differences between SIPs; a third or more of R&D performer respondents in SMI, P2030 and PiiA of the first tranche, in IoT, SES and Innovair of the second and in Viable of the fourth considered EU Framework Programmes important. In contrast, considerably lower shares of R&D performer respondents in the SIPs of the third tranche, most of which tackle themes of little concern to the Framework Programmes, agreed.

[28] Formas is in this respect a hybrid since most of its funding is oriented towards fundamental research. The one SIP for which it has main funding responsibility (SBE) is an exception.

[29] The Horizon Europe alternatives were only posed to the six SIPs of tranches 3 and 4. EIT KIC = European Institute of Innovation & Technology Knowledge and Innovation Communities, NMR = Nordic Council of Ministers, which in this context includes its funding agencies NordForsk, Nordic Innovation and Nordic Energy Research, ESA = European Space Agency.

Having said that, the programme evaluations reveal that some SIP actors have participated in international R&I programmes as a consequence of their SIP participation, and they have consequently learned what it takes to be successful in such programmes.

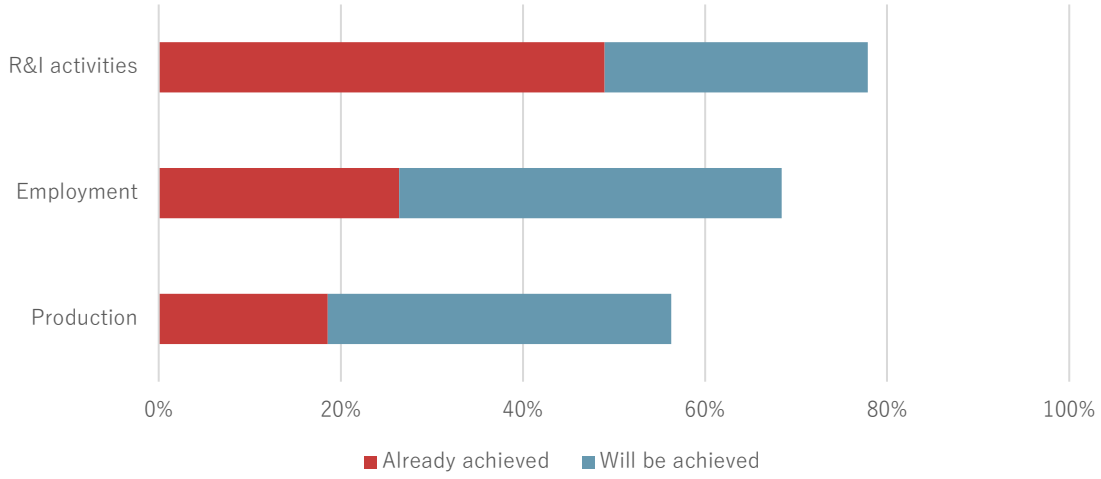
7.3 Industrial and societal impacts

The five high-level objectives of the SIP initiative focus on the competitiveness of industry and the nation on the one hand, and on addressing societal challenges on the other, in both cases with an eye on sustainability (cf. Section 4.2). The SIP instrument provided interested stakeholders with platforms for strategic dialogue that resulted in long-term visions based on needs, often stakeholders' own – basically correlating to the competitiveness objectives. With time, societal objectives became more pronounced, both for the SIPs of earlier tranches that later incorporated elements of societal objectives in their agendas, and the SIPs of later tranches that already from the onset had greater focus on societal needs.

The SIPs were required to be open to all, which resulted in network extension that in turn led to additional actors engaging in R&I, while incumbents likely invested more in R&I. The results of the R&I projects laid the foundation for positive impacts on the competitiveness of both industry and nation, by way of impacts for project participants. While company respondents and interviewees indicated that precious few commercial impacts had been realised after six years (cf. Figure 36), this is to be expected since lead times to commercial impacts in terms of for example turnover in most sectors are longer, often considerably longer, than that. However, many company respondents answered that they expect commercial impacts for the company in the future – eventually meaning job creation and revenue for the tax authorities.

Section 6.3 reported on commercial impacts for companies, but some impacts related to these may also be considered as societal impacts. Figure 42 shows that half of company respondents had noticed that their R&I project already had had positive impacts on the company's R&I activities. A quarter of respondents similarly had seen positive impacts on employment and almost one in five on production. Including expectations for the future, clear majorities sooner or later expected positive impacts in all three respects. Although these impacts primarily refer to the respondent's company (and, for multinational companies (MNCs), only their operations in Sweden), they may be interpreted as societal impacts in terms of contributing to a vital R&I and production base as well as a healthy labour market.

Figure 42 Company respondents' assessments of whether their project had contributed to or is expected to contribute to maintained or increased R&I activities, employment and production for the company in Sweden (n=736).

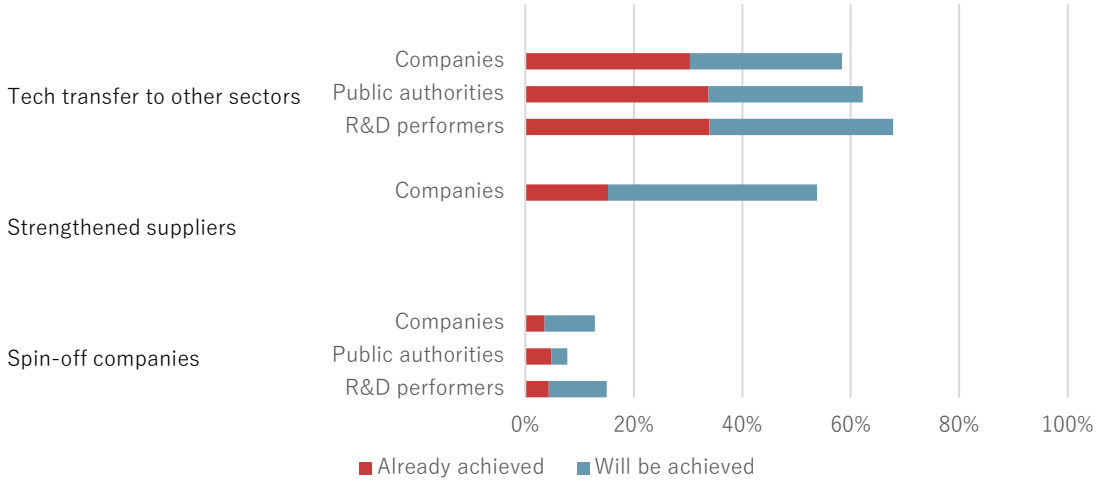


Source: Web surveys.

Approximately every third respondent believed that technology transfer to other sectors had taken place and almost as many that it would happen in the future, see Figure 43. Experience shows that technology transfer between actors mostly takes place through R&D performers who generally collaborate with several organisations, often in different sectors. Having said that, some company respondents believed that their suppliers had been strengthened – presumably directly through collaboration with their company – and many more that it would happen (this alternative was only posed to companies). Many SIP participants had participated in other Swedish and international R&I programmes and thus had produced additional results and gained access to others' results; in many cases, results from other programmes probably were part of the technology transfer. Very few spin-off companies had so far resulted and expectations for the future were obviously very low, but spin-off is not an (explicit) objective of the SIP initiative. Few respondents answered the spin-off question, perhaps indicating that it was considered irrelevant or difficult to assess, so these assessments should be taken with a grain of salt.

There is consequently compelling evidence to suggest that the SIPs have been beneficial to participating companies' competitiveness, but that the time scales in most cases are longer than the SIPs' existence at the time of the evaluations. There is also evidence that part of the technology transfer has involved actors, and in some cases sectors, that have not participated in SIPs. From a national perspective, the SIPs have mobilised actors, have successfully addressed system-related weaknesses, have increased the competitiveness of all types of actors, and have offered relatively generous and long-term public funding. This has contributed to making Sweden an attractive country in which to conduct R&I, making it more attractive for conducting business in general.

Figure 43 Respondents' assessments of whether their R&I project had contributed to technology transfer, strengthened suppliers and spin-off companies (Companies: n=247, Public authorities: n=33, R&D performers: n=163).



Source: Web surveys.

Impacts relating to national and global societal challenges are considerably more difficult to identify, in part since lead times likely are even longer than for competitiveness-related impacts. While the SIPs of earlier tranches gradually incorporated objectives relating to greater resource efficiency and recycling, it was not always done with great enthusiasm. Later tranches tended to pay more attention to systemic change from the outset. We return to this in Chapter 10.

8 Additionality and objective fulfilment

In this chapter, we first summarise the SIP initiative's additionality using the conclusions that the 17 evaluation teams drew based on all the empirical evidence they had at hand, which we support with the responses to a question in the web survey. In the second half of the chapter we summarise the 17 SIPs' collective contributions to fulfilment of the high-level objectives of the SIP initiative. While the assessments of the chapter are based on the conclusions of the 17 programme evaluations, we ultimately elect to draw our own conclusions.

8.1 Additionality

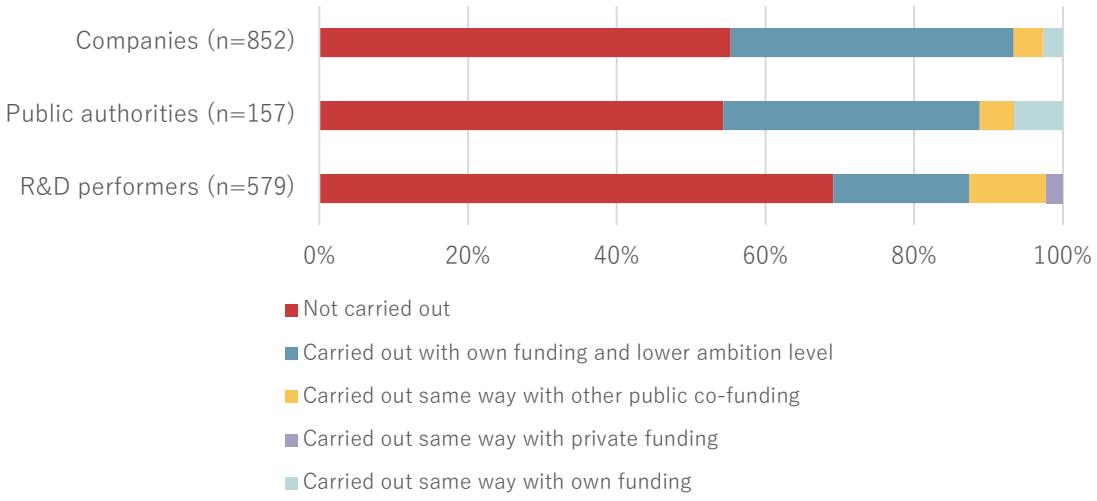
We address the additionality – added value – of the 17 SIPs, and thus of the SIP initiative as such, through four perspectives: input additionality, output additionality, behavioural additionality and additionality compared to BFPs.

8.1.1 Input additionality

Input additionality refers to whether actors have invested in activities that they would not otherwise have undertaken or have invested more in activities that anyway would have been undertaken.

Survey questions on what would have happened if an R&I project had not been funded tends to render a degree of tactical responses. The assessments reported in Figure 44 nevertheless clearly suggest that many, perhaps most, projects would not have been conducted had they not been funded by the SIP; seven in ten (69%) R&D performer respondents stated that this would have been the case. Although many respondents from companies (45%) and public authorities (46%) judged that they would have carried out the project anyway, most of them believed that it would have been done with lower ambition level, with fewer partners and/or over a longer time period.

Figure 44 Respondents' assessments of what would have happened if their R&I project had not been funded by the SIP.



Source: Web surveys.

Some projects thus certainly would have been carried out also without the SIPs (through other public programmes or self-funded), but SIP actors have likely participated in more

projects, meaning that their overall co-funding and corresponding activities were higher than they otherwise would have been. Possible reasons for this are that the programmes through their predictability (up to 12 years of funding) offer an attractive arena for collaboration that has lured additional actors, that they create a kind of 'contagion effect', and that public co-funding effectively amounts to risk sharing. For many actors, participation in SIP projects has led to follow-on projects through both Swedish 'non-SIP' and international R&I programmes, thus resulting in additional input in terms of both public funding and co-funding.

8.1.2 Output additionality

Output additionality pertains to the outputs (precursors to impacts) that would not have been realised without the SIPs.

Since there are projects that would not otherwise have been undertaken – both R&I projects and strategic projects – these projects are highly likely to have contributed to outputs that would not otherwise have emerged. The programmes have mobilised actors in their respective areas (and thereby counteracted fragmentation) that likely has generated synergies, while strategic projects have addressed system-related deficiencies through development of common platforms and infrastructures. The programmes' substantial budgets have strengthened key R&D performers and thus made them more competitive and therefore attractive as partners to companies and public authorities. Participants in other Swedish and international R&I programmes have produced R&I results themselves and gained access to others' results, while SIP actors of all types – though mainly R&D performers – have contributed to results dissemination to other organisations, including ones that have not participated in SIPs. Overall, this indicates that the programmes have increased productivity within their respective parts of the Swedish innovation system, which arguably means that the programmes have contributed to considerable output additionality.

8.1.3 Behavioural additionality

Behavioural additionality refers to lasting changes in beliefs, behaviour and working practices that would not have been realised without the SIPs.

The main stakeholders in the 17 areas have mobilised actors in implementing joint, actor-driven agendas and thus have worked towards common objectives. While there was evidence of this also in BFPs, these were generally closed clubs and the extent of mobilisation seen in the SIPs is unprecedented in Sweden. With time, the SIPs have reached out to ever more actors – including ones without previous experience of R&I and/or collaboration in R&I – to enlarge their collaboration networks. A few SIPs have developed networks from scratch or humble beginnings, while the majority – where actors, courtesy of previous public R&I programmes, already had well-established networks – have continued developing existing ones. All SIPs have collaborated with other SIPs (albeit to very different degrees), and some SIP actors have learned what it takes to be successful in international R&I programmes. Companies and public authorities have developed more scientific internal working practices, while R&D performers have adapted their operations better to serve industry and the public sector. Strategic projects that have addressed system-related weaknesses (mentioned for output additionality above) have undoubtedly contributed to changed working practices. The mobilisation and the synergies realised are indications of significant behavioural additionality at the levels of both subsystem and organisation, which likely contributes to more efficient use of resources in the Swedish innovation system. The sustainability of many of these changes is no doubt highly dependent on future availability of public funding, but even if funding were not available the widely spread positive experiences of collaboration would surely linger for quite some time.

8.1.4 Additionality compared to BFPs

We argued above that some projects funded through the SIPs certainly would have been conducted also without the programmes, so – given the overall premise of this report – it may be illustrative to compare the SIP instrument to the BFP instrument. Such a comparison, which of course overlaps with the discussions in the three previous subsections, may be summarised as SIPs additionally providing:

- A scope going beyond traditional sectors and including value chains.
- A bottom-up focus based on broader user needs, including – in some cases – societal ones.
- An openness to any legal entity in Sweden, leading to participation of many additional organisations, not least SMEs, where some of the additional ones did not have previous experience of R&I and/or collaboration in R&I.
- A genuine engagement of key actors due to the outsourcing of programme management and to the SIPs providing platforms for strategic dialogue.
- An opportunity to formulate long-term visions and to establish operations, including administration and complementary strategic projects (due to large budgets and 12-year funding perspective).
- An opportunity to use strategic projects to complement the R&I project offer, thus enabling a broader approach to address subsystem needs and deficiencies.

In conclusion, the SIP initiative has contributed to integration of R&I subsystems – and in some cases newly defined ones – characterised by wide participation, relevance, quality and efficiency (compared to, or more successfully than, BFPs).

8.2 Objective fulfilment

In this section, we summarise the extent to which the 17 SIPs after six years together seemed to be *en route* to fulfilling the SIP initiative's five high-level objectives (cf. Section 4.2), meaning that our assessments attempt to include expected future impacts. It should be noted that the agencies' expectation is not necessarily that all SIPs should contribute to all five high-level objectives (and certainly not to the same extent), but that they collectively should do so.

In the next chapter, we will discuss the fact that the evaluators found that almost all programmes had formulated objectives that were not amenable to monitoring and evaluation. As will become obvious from the remaining sections of this chapter, the same can be said of the objectives of the SIP initiative as a whole. This problem is by no means unique to the SIP initiative. R&I policy generally fails to make a clear distinction between specific or programme objectives, whose attainment should at least to some extent be empirically testable, and overall impacts or societal objectives, to which any programme can at best only contribute.

The five overall SIP objectives are inherently desirable but are neither time-bound nor specific in their ambition level. These are thus societal objectives to which the SIP initiative and individual SIPs can at best contribute.

8.2.1 Increased sustainable growth

The first objective presumably concerns both turnover growth in industry and growth more broadly, and this growth is to be sustainable.

All SIPs comprise R&I projects with potential to contribute to growth in participating companies' turnover, but survey responses and interviews indicate that precious little growth had been realised after six years (cf. Figure 36). This should not come as a surprise since lead times between research and commercialisation in most cases are longer, often considerably longer, than six years. However, a large majority of company respondents nevertheless judged that turnover eventually would increase. Although these assessments probably include a certain degree of undue optimism, it seems reasonable to conclude that there is substance to the expectations for future commercial company-level impacts. Whether growth will increase for entire industry sectors or whether growth prospects will improve to the extent that one could expect an increase in overall economic growth is impossible to say; both are in practice impossible to determine (even after the fact, given countless confounding factors).

The idea of 'sustainability' has many components, including reduced carbon and other emissions, respecting resource limits, maintaining biodiversity, and so on. The degree to which growth is sustainable depends on a combination of individual influences on these and the rate of growth of different parts of the economy that is unpredictable from the level of the individual project or SIP. However, at the SIP level we can in principle distinguish between activities that likely enable growth without reducing environmental and resource effects per unit of output, those routine industrial activities that tend to increase sustainability as a side-effect (for example by introducing processes that are less resource-intensive or that save weight, as in LIGHTer), and those aiming at a system.

Given the vague meaning of the word sustainable – the word is oftentimes rather carelessly used – the assessment of the fulfilment of this sub-objective is a matter of perspective. A benign interpretation is that all SIPs have R&I projects that may contribute to sustainable development. However, in most programmes projects aim to improve the competitiveness of individual companies through incremental development, for example, more efficiently to use energy or materials. A minority of the SIPs have sustainability as fundamental vision, but such ambitions are more prevalent in programmes in the latter tranches. The focus on sustainability has increased since the first SIPs were formed over a decade ago, reflecting developments in both R&I policy and societal expectations.

In conclusion, the SIPs will, with time, likely contribute to turnover growth (or maintenance in the face of rising competition) for many companies, but whether the growth rate will increase remains unclear. Moreover, the contributions specifically to sustainable growth probably will be rather modest, but a few SIPs in the latter tranches that have sustainability as fundamental premise are likely to make more significant contributions in this respect.

8.2.2 Improved competitiveness and increased exports for Swedish industry

This is two objectives unfortunately merged into one, a conflation that can also conceal the need for parts of industry to catch up with, or receive support to maintain parity with, international developments. Based on the argument that R&I is beneficial to company competitiveness and that collaboration on R&I may be even more so, most companies should eventually experience improved competitiveness. This is in line with survey results where seven in ten company respondents judged that the company's international competitiveness had increased or would increase in the future (cf. Figure 36). R&D provider respondents made even more positive assessments as regards their own international competitiveness (cf. Figure 34). However, the fact that most SIPs have rather weak international connections may be a concern, since there is a risk that project results are not internationally competitive. On the other hand, the large MNCs that participate in most programmes (some of which are

named in Figure 11) clearly already know what it takes to be internationally competitive, which likely benefits companies collaborating with them.

The logical sequence from improved competitiveness to increased exports is clearly long and fraught with uncertainty. Very few company respondents assessed that company exports had already increased, but including expectations half of them nevertheless judged that exports eventually would increase (cf. Figure 36).

8.2.3 To make Sweden an attractive country to invest and conduct business in

MNCs choose to locate, or retain, their R&I functions based on cost, tax and market-related factors, as well as on availability of qualified R&D performers, test and demonstration facilities, skilled labour, and public funding. However, most companies participating in SIPs are SMEs that generally do not have the same flexibility. Since the SIPs have succeeded in mobilising actors in their areas, successfully have addressed system-related deficiencies, have increased the competitiveness of all types of actors, and offer relatively generous and long-term public funding, it is indisputable that the programmes have made Sweden a more attractive country in which to invest and conduct business. The SIPs' contributions are consequently important, but the extent to which these effects will last depends on whether upcoming public R&I initiatives, including Impact Innovation, will further develop these accomplishments.

8.2.4 Sustainable societal development to secure employment, welfare, environmental and energy policy objectives

This objective is a composite of several vaguely formulated and partly contradictory objectives at such a high level that it is difficult to meaningfully conclude anything on fulfilment. Based in part on the discussions for the previous objectives, it is nevertheless possible to argue that the SIPs may make certain contributions to fulfilment also of this objective, but such arguments rely on benign assumptions and do not rest on firm empirical foundations. To very varying degrees, the programmes probably make certain contributions to this objective, but these contributions are likely quite modest overall.

8.2.5 Create conditions for sustainable solutions to global societal challenges

This objective is even more high-level than the previous one, and the background documents do not specify what 'global societal challenges' that the objective refers to, meaning that drawing conclusions on objective fulfilment is again quite difficult. Moreover, the SDGs of Agenda 2030 had not yet been adopted when the first 16 SIPs were established, so they were not expected to contribute to them from the onset. The programmes nevertheless surely contribute to creating some preconditions for developing sustainable solutions to certain global societal challenges, but these contributions are clearly marginal from a global perspective. However, the contributions to development of national solutions to parts of some challenges may possibly prove to be significant, but it is too early to conclude since the potential contributions largely are based on benign assumptions and expectations.

9 Reactions to evaluators' recommendations

Each evaluation team was to provide an overall recommendation to the agencies as to whether the SIP they had evaluated should receive funding for another stage, as well as recommendations to the SIP itself in four categories:

- Scope
- Governance
- Implementation
- Openness and equal treatment

Despite genuine attempts to harmonise recommendations between evaluation teams in terms of both formulation and strictness of judgement, there is little doubt that there were some inconsistencies between the recommendations given. The annual meta-evaluations took the opportunity to attempt to improve consistency and, in some cases, ended up with more robust formulations. The meta-evaluations analysed recommendations across the programmes of each tranche, and formulated recommendations applicable to several SIPs as recommendations to the agencies to support the programmes in maintaining focus on certain particularly important and largely common issues. The meta-evaluations also took the opportunity to articulate recommendations on changed working practices for the agencies.

In this chapter, we first analyse – category by category – whether there were any notable trends in the recommendations, and then we consider the extent to which the recommendations appear to have been heeded by the agencies and by the SIPs, in the latter case based on our interpretation of the action plans the programmes submitted to the agencies together with their proposals for funding of a third stage. The analysis of the extent to which the recommendations have been heeded thus is possible only for the first 16 SIPs. The agencies' decision on whether to invite Viable in the fourth tranche to submit a proposal for funding of a third stage is not expected until late 2023 or beginning of 2024, meaning that the submission of Viable's (potential) proposal, including action plan, is not due until well after this report is finalised.

9.1 Overall recommendation

The agencies were recommended to award all 17 SIPs funding for a third stage. While probably not obvious from individual evaluation reports, there were in fact discussions within a few teams on the opposite recommendation, but in the end the scales narrowly tipped in favour of recommending funding for another stage also for these programmes. The agencies eventually invited the first 16 SIPs to submit proposals for a third stage and they subsequently granted all 16 proposals. Again, the agencies' decision for Viable is still pending when this is written.

Originally, the teams were asked to also recommend increased, unchanged or decreased funding compared to stage 2, should funding for a third stage be recommended. In the first tranche, the agencies were recommended to consider increasing the funding to LIGHTer, but this recommendation could not be implemented, owing to the tightening of the agencies' budgets. After the evaluation of the first tranche, the evaluators were instructed not to formulate such recommendations.

9.2 Scope

A majority of the SIPs were recommended to revisit their scope and objectives, but most recommendations were quite programme-specific since the SIPs generally addressed quite separate areas. Where adjustments were recommended, they relied heavily on the judgments of the two topic experts enlisted to support each evaluation team. Two programmes were not given a recommendation in this category.

Judging from their action plans, 12 (out of 16) programmes planned to heed the recommendations received, nine of them apparently happily so, but three clearly grudgingly. Two programmes appeared not to plan to make any significant change at all to their scope, apparently disagreeing with the recommendations received.

9.3 Governance

The individual programme evaluations concluded that two SIPs had excellent programme logics, while the remainder were recommended to refine their programme logics – and in some cases to develop new ones from scratch. Almost all SIPs were recommended to revisit their objectives to make them (more) amenable to monitoring and evaluation. Moreover, most SIPs were specifically recommended to formulate sustainability-related objectives, or to refine existing ones. Virtually all SIPs were also recommended to develop processes and routines to periodically monitor their projects' contributions to objective fulfilment. One programme did not receive any recommendation in this category.

The three annual meta-evaluations concluded – with five SIPs as exceptions – that the programme logics, including objectives and indicators, seemed not to have been developed to function as tools to manage and monitor programmes, and that they only to a limited extent were being used for such purposes. The meta-evaluations furthermore argued that while all SIPs had some form of system for monitoring operations, only three had implemented systems that allowed monitoring of the extent to which individual projects contribute to programme objectives. The meta-evaluations noted that the climate and environmental ambitions of the programmes of the first three tranches apparently successively had increased but noted that the corresponding objectives generally were not well integrated into programme logics. The agencies were therefore recommended to support most SIPs in developing adequate programme logics according to a proposed (and rather conventional) model, including objectives and indicators, and in developing appropriate systems to monitor and manage their programmes. The latter two meta-evaluations also concluded that programmes could improve their processes to identify stakeholder needs and ensure that these needs were better reflected in calls for R&I proposals; the agencies were therefore recommended to support programmes also in these respects.

Judging from their actions plans, 14 (out of 16) programmes planned to follow the recommendations received, 11 seemingly willingly and three obviously reluctantly. One programme apparently disagreed with the recommendations and appeared not to plan to heed them.

9.4 Implementation

Overall, the R&I project instruments, strategic projects and complementary activities (such as development of common infrastructures, market surveys, workshops, courses, conferences etc.), chosen by the SIPs were judged to be well adapted to their respective contexts and stakeholder needs, meaning that many recommendations were quite

programme specific. However, some recommendations applied to around half of the programmes:

- Whereas many SIPs already collaborated with other SIPs, nine were recommended to increase collaboration with topically related SIPs.
- Whereas a few SIPs already were intensely engaged internationally most were not, and eight programmes therefore were recommended to increase their international activities (such as monitoring of state-of-the-art, benchmarking, bilateral collaborations and participation in EU Framework Programmes).
- Whereas all SIPs had increased the number of unique participants in R&I projects from the first stage to the second, 12 programmes were recommended to reach out to additional actors.

The annual meta-evaluations of the first two tranches noted that participation in most programmes was concentrated to a few dominant incumbents (often an inheritance from past BFPs), and therefore argued that the SIPs had potential to engage additional actors to contribute to further impacts at systems level. The agencies thus were recommended to encourage most programmes in the first two tranches to continue to broaden participation with more relevant actors in additional industry sectors, particularly SMEs. (The absence of a similar recommendation in the third annual meta-evaluation was because of broader participation in those SIPs.)

The three meta-evaluations found that the activities of 14 (out of 16) SIPs were too nationally oriented, which in large part was assumed to be due to relatively ample funding opportunities and – in most SIPs – considerably higher success rates. The agencies were thus recommended to encourage all programmes but two to strengthen their international connections through more ambitious monitoring of the state-of-the-art, by requiring proposals to describe international developments, by stimulating increased participation of Swedish actors in international R&I programmes, and by increasing participation of foreign actors in SIP projects.

The SIPs' actions plans suggest that 14 (of 16) programmes planned to heed the recommendations, 11 apparently happily and three seemingly unwillingly. Two programmes disagreed with the recommendations and appeared to plan to ignore them.

9.5 Openness and gender equality

One of the characteristics of a SIP is that it should be open to any organisation in Sweden regardless of sector, and six SIPs were recommended to make renewed efforts to ensure that they were not (intentionally or unintentionally) excluding individual organisations or types of organisations. As many as 11 SIPs were advised to increase, and in several cases to maintain, focus on gender equality. Three programmes were not given a recommendation in this category.

As mentioned in the previous section, the first two annual meta-evaluations noted that most SIPs were characterised by participation being concentrated to incumbents, and therefore recommended the agencies to encourage these programmes to broaden participation to additional sectors and actors. Particularly the first annual meta-evaluation, but to a lesser degree also the second, saw a need for increased attention to gender equality in both programme management and among project leaders, although the meta-evaluations noted that gender equality certainly would be quite challenging to achieve given that most programmes addressed industry sectors traditionally dominated by men. The agencies were therefore recommended to support SIPs in focusing on gender equality in day-to-day

operations. (The absence of a recommendation on gender equality in the third meta-evaluation and the fact that the room for improvement in this respect was the most obvious in the first tranche is likely due to later programmes to a lesser extent building on BFPs and thus on traditionally strong industry sectors.)

Judging from the actions plans, 14 (of 16) programmes planned to heed the recommendations received, nine seemingly gladly and five obviously reluctantly. No programme seemed to completely disagree with the recommendations.

9.6 Recommendations to the agencies

As mentioned at the beginning of the chapter, the annual meta-evaluations formulated recommendations applicable to several SIPs as recommendations to the agencies to support the programmes in various respects. In addition, the meta-evaluations took the liberty of formulating recommendations to the agencies on how they could usefully change their own working practices and priorities. The agencies' reactions to eight recommendations that appeared – in one form or another – in at least two meta-evaluations are examined in the following subsections.

9.6.1 Provide support for development of programme logics

While evaluating the second tranche of SIPs, it became obvious that the inadequacy of most SIPs' programme logics and objectives was systematic. It was nonetheless recognised that it may be quite challenging to lead a process to develop a useful programme logic for someone (such as a programme manager) who is not familiar with the concept and rarely leads such processes. In the second and third annual meta-evaluations, the agencies were therefore recommended to provide SIPs with professional hands-on support to develop – or improve – programme logics and to formulate objectives amenable to monitoring and evaluation. The agencies were also recommended to raise their requirements for approving programme logics.

The agencies subsequently offered the SIPs process support and, so far, all programmes but one (one of the two that already had excellent programme logics) have accepted the offer. The support services, procured from a consultancy and amounting to a maximum of SEK100k for each SIP, are expected to result in programme logics that can be used for management by objectives, for monitoring and evaluation, as well as for planning and communication on programme activities and their contribution to results and impacts. As regards approval of programme logics, the agencies argue that doing so would be inappropriate and not in line with the fundamental principles of the SIP initiative.

9.6.2 Provide project portfolio transparency

Almost without exception, programme managers expressed frustration over not having sufficient insight into their own project portfolios. This resulted in all three meta-evaluations recommending that the agencies should endeavour to provide programme offices with more detailed project information, including finding a way to navigate around legitimate confidentiality concerns. While acknowledging that initially there were some reasons for these complaints, two out of three agencies argue that these issues were dealt with early on and that 16 out of 17 programme offices subsequently were provided with sufficiently detailed project information. Whether the fact that programme managers also in later tranches complained about the lack of transparency is due to the agencies not fully realising programme offices' legitimate needs, to programme offices not having digested the information received, to programme managers having an insatiable desire for information, or

whether programme offices have not requested all the information that they are entitled to remains unclear.

9.6.3 Provide common project monitoring system

All three meta-evaluations reasoned that it might be a good idea for the agencies to develop a common monitoring system that could be accessed by both agencies and programme offices to monitor project and programme progress towards objectives (cf. Section 9.6.1). The agencies argue that such an investment is not warranted, but explain that (upcoming) programme offices in Impact Innovation will be given access to project results reported to the agencies.

9.6.4 Harmonise working practices and requirements

The evaluations revealed that there were some inconsistencies among the agencies' treatment of programmes, particularly among SIPs managed by different agencies, and all three meta-evaluations therefore recommended the agencies to harmonise working practices and requirements. The agencies contend that differences between SIPs and between agencies complicate completely equal treatment, but they nevertheless continuously strive to reduce differences as far as possible. The ambition is to further harmonise working practices and requirements ahead of Impact Innovation. Moreover, the three agencies plan to provide programme offices with the same level of detail on project information (cf. Section 9.6.3).

9.6.5 Ensure systematic follow-up of evaluation recommendations

The six-year evaluations concluded that the recommendations provided in the three-year evaluations were not followed-up systematically for the first tranche of SIPs, but noted that the agencies subsequently had adopted structured and uniform processes. All three meta-evaluations argued for the importance of systematic processes to maximise benefits of evaluations, including documentation of progress on action plans and – in duly justified cases – why certain recommendations could be ignored. As may be inferred from the earlier sections of this chapter, the process employed following the six-year evaluations is exemplary and the SIPs' actions plans are followed up in the agencies' annual appraisals with programme offices. The on-going nine-year evaluations similarly assess the extent to which recommendations of the six-year evaluations have been heeded.

9.6.6 Provide funding for coordination and strategic projects commensurate with expectations

Programme offices are expected to fulfil a rather challenging list of functions and the latter two meta-evaluations argued that the coordination funds provided in many cases were not commensurate with expectations. Moreover, in several cases the recommendations given in the six-year evaluations in practice increased the need for resources. The agencies were therefore recommended to grant programmes increased funding for coordination to facilitate implementation of recommendations. Approximately a quarter of the SIPs have subsequently been granted increased funding for coordination.

The third meta-evaluation also recommended the agencies to adopt a more benign approach to strategic projects since these have proved important in addressing (programme-specific) system-related weaknesses. The requirements on strategic projects have not changed and the agencies argue that they are not opposed to such projects and explain that strategic projects are discussed during annual appraisals as a possibility to increase directionality.

9.6.7 Maintain attention to project quality

The first two meta-evaluations noted that success rates for R&I proposals were quite high in most calls by most SIPs and therefore pointed to the need to maintain a focus on quality in proposal assessment processes. The agencies argue that a partial explanation of low success rates is that programmes have formulated narrow calls that have attracted few proposers. While a narrow call logically may result in lower-quality proposals eventually being funded (than would a more widely formulated call that would have attracted more proposers resulting in greater competition), the agencies maintain that their strict assessment processes with independent external experts ensure that projects funded exceed an adequate quality threshold. Case in point, the individual programme evaluations found several examples of calls where budgets were not fully utilised for lack of sufficient good proposals.

9.6.8 Ensure sufficient attention to strategic research

With reference to OECD's finding that Sweden's R&I funding system has a weakness in terms of funding of strategic research at intermediate TRLs, all three meta-evaluations recommended the agencies to strive to remedy this systemic weakness through complementary instruments of their own, by actively stimulating increased participation in EU Framework Programmes and/or by encouraging other Swedish funders to increase their investments. The agencies say they are aware of this weakness but argue that it cannot be eliminated solely through the SIP instrument. International connections are nevertheless discussed in the annual appraisals and international ties are expected to further be emphasised in Impact Innovation.

10 Systems innovation

This chapter analyses the SIPs using the lens of transitions theory. We outline the need for policy learning in order to work with systems innovation and propose a theoretical framework for designing and evaluating them, based on functions from the transition management research literature. We classify the SIPs into two major types – reinforcers and transformers – and discuss the differences and their implications. We analyse the functions and point out that some of them lie outside the powers of today's innovation agencies, then describe the extent to which the existing SIPs perform each function. Finally, we discuss the gaps between the gross list of functions and what it has been possible for the SIPs to do. We conclude that certain gaps need to be closed via coordination with actors and agencies outside the traditional R&I sphere if a SIP-like funding instrument is to be used to support systems innovation.

10.1 The policy learning challenge

From a policymaking perspective, the SIP initiative is not only a significant R&I policy intervention but also an important experiment that helps us to do policy learning. The 17 individual six-year SIP evaluations on which this study is based reported on the progress and prospects of the SIPs, providing both judgements about their performance and recommendations for improvement. They provided the funding agencies with evidence, on which they could base their judgement for each SIP about whether to continue funding for another three-year stage. This meta-evaluation provides an opportunity to ask what we can learn about how to design and implement better programmes in a time when we need to make new kinds of policy to address the so-called societal challenges. These are 'wicked' problems in the sense of posing complex demands for change in societal systems that are themselves complex, such as climate heating, loss of biodiversity and a range of other problems that pose more or less existential threats to humanity and society.

We tend to think of R&I policy in terms of three 'generations' since the great explosion in spending on science that began during the Second World War. Starting after the War, the first generation involved delegating much authority for the funding and quality control of 'basic' research to the scientific community in the post-War period, building or growing research councils and national science foundations to fund it and ensure that the scientists could quality-control the work. The second involved a desire to impose some societal influence on research, and especially to connect it to industrial innovation, economic development and growth. Doing that required a new generation of organisations – innovation agencies, such as Vinnova and its predecessor STU, set up in 1968 – and learning how they should work. Currently we are trying to figure out what organisations we need and how they should work in order to do a third generation of policy to tackle societal challenges by triggering socio-technical transitions and doing 'systems innovation' in the sense not only of changing technology but also the societal rules and infrastructures within which they operate. These generations are layered upon each other – the first, for example, is still alive and well and living at the Swedish Research Council – but each new generation involves a revolution in funding practice and the theory upon which it is based.

It took about a decade, and investigations by the national audit office and a parliamentary committee, to figure out how to make STU work as an innovation agency (Weinberger, 1997), and we now face a similar learning problem in the third generation. At such times of change we cannot do traditional policy learning by benchmarking and copying other countries' practices – there is barely any new practice to observe, and little chance of working out which

parts of it are good. So we have looked at the SIPs through the lens of the socio-technical transitions theory that underlies third-generation R&I policy. It is important to emphasise that this analysis is not an evaluation of the SIPs but a kind of 'thought experiment' intended to help with future policy and programme design.

10.2 A theoretical framework

A lot of the transitions literature is conceptual or based on historical examples, rather than policy-induced transitions, so there is still a lot of work to do to build a good empirical base for theory and policy.

A central idea in transitions theory is that technologies have social as well as technical components. A fossil-fuelled car, for example, is only useful because there are rules about how to use it, standards for things like safety and emissions, training and skills about how to drive and maintain it, infrastructures like roads and petrol stations, markets for new and used vehicles, components and fuels, scientific knowledge about combustion, materials properties, and so on. Such a big and complex 'socio-technical regime' tends to be very stable, so transitioning to, say electric cars or greater use of public transport is very difficult. Yet such transitions are needed to tackle any of societal challenges.

Much of the discussion about transitions builds on a useful heuristic called the multi-level perspective (Rip & Kemp, 1998, and Geels, 2002, 2010, 2018). This sees the socio-technical regime as the middle of three layers, and as being acted upon by the layer above and the layer below it. The top layer is the 'socio-technical landscape' and comprises politics, policy and society as well as the wider context (the environment, resources, geopolitics, and so on). Pressure from the landscape can be one way to break down parts of the regime and enable a transition from one socio-technical system to another – changing from fossil-fuelled to electric cars – via changes in laws, infrastructure and taxation, for example. The bottom layer contains 'niche technologies' and works rather like the product cycle, with technical innovations emerging, often in very clumsy forms, and competing with each other, and successful innovations then scaling up to such an extent that they can influence or change aspects of the regime. Historical examples of socio-technical transitions, such as the gradual replacement of sail by steam power in international shipping, have generally happened as a result of technological and economic forces. Tackling societal challenges involves a strong role for government as well as niche innovation, so the transition towards electric cars is happening as a result of pressures on the fossil-fuel regime from both the landscape and the niche level.

There are three approaches to triggering and managing transitions in the literature – transition management, strategic niche management, and technological innovation systems (TIS) theory – which can be used as sources of ideas for driving transitions. These approaches overlap, and some writers appear in more than one of the three. There is so far no consensus on what list of transitional functions would be best, though there is growing interest in the TIS functions.

- Transition management (Rip & Kemp, 1998) is the oldest approach. According to Berkhout et al. (2004) "Transition management is the transformation of a socio-technical regime guided primarily by negotiation between social actors from beyond the regime." Key elements are long-term thinking across successive short-term policies; working with multiple domains, actors, and governance levels; learning-by-doing; systems innovation; considering multiple options (Kemp & Rotmans, 2001). 'Guiding visions' (Rotmans, et al., 2001, and Berkhout, et al., 2004) can play important roles by mapping a 'possibility space' and setting the 'directionality' of the intervention. Completing transitions may require

‘creative destruction’ to kill off the socio-technical system being replaced (Kivimaa & Kern, 2016).

- Niche management acts on external innovations with potential to upset the socio-technical regime. It may be necessary to protect them in their immature stages, until they are robust enough to compete with existing technologies (Kemp, et al., 1998), for example through subsidy. Experiments are necessary, as is a ‘selection environment’ (most often a market) in order to find effective and acceptable solutions (Loorbach & van Raak, 2006). Like transition management, strategic niche management involves articulation of supply/technology, demand, regulation etc and the formation of actor networks (Kemp, et al., 1998).
- There is a separate literature on the development of TIS, which has its roots in industrial dynamics research at CTH and focuses on the functions needed to build a new TIS or to have one TIS take over from an earlier one (Bergek, et al., 2007, Hekkert, et al., 2007, and Lindner, et al., 2016). Such functions include knowledge development and diffusion, entrepreneurial experimentation, influence on the direction of search, market formation, legitimation, resource mobilisation, and the development of positive externalities (Bergek, 2019).

The literature also points to a need for ‘transition intermediaries’ to manage interfaces, build platforms and networks and collect strategic intelligence as well as helping articulate demand, visions and strategy (Smits & Kuhlmann, 2002). While Rip and Kemp (1998) point out that government is the natural organiser of transitions, subsequent attention has focused largely on fragmented lists of mostly non-government actors (Kivimaa, et al., 2019, and Sovakool, et al., 2020) whose incentives are diverse and not always clear. While their original purpose was more traditional management of R&I project portfolios, through the lens of transition theory, the SIPs themselves can be seen as potential transitions intermediaries.

There are many variations on these ideas. In our meta-evaluation of the first tranche of SIPs (Åström & Arnold, 2020), we developed a checklist of functions that used the TIS functions defined by Bergek et al. (2007) and Hekkert et al. (2007), and supplemented these with a short list of functions from the wider transitions literature that appeared to fill gaps. We used them to structure our analysis of the SIPs also in the policy learning sections of the annual meta-evaluations of the second and third tranches (Åström et al., 2020, 2021), and we have largely retained them for this report. We made three small modifications to the list during that time. First, we realised that ‘market formation’ involves two rather different kinds of activities – demand articulation and opening up new markets – so we separated these. Second, we dropped ‘development of positive externalities’ as this is not a function directly done by a policy intervention, but rather a desirable outcome of that intervention. Third, because some of the functions would require the SIPs to do things (like creating new markets) that are outside their power, we added ‘coordination’ as a transition management function, on the argument that if those things are nonetheless necessary, it would be sensible for the SIPs in their roles as transition intermediaries to try to persuade others to do them. Table 1 shows the resulting list and explains what we mean by each of the functions. Broadly, we would expect the SIP boards and programme offices to be doing the transition management functions, while the TIS functions are more likely to be realised through combinations of projects.

Table 1 Transition-related functions from the literature.

Function	Explanation
Transition management functions	
Creating arenas for priority setting	This involves creating opportunities for actors to define the kind of transition they desire and decide how they want to address it. In a narrow definition, all the SIPs have such 'arenas' in the shape of their boards. In general, the literature would expect such arenas to be inclusive if they are to be effective.
'Creative destruction' and handling incumbents	Activities that tend to push out old, undesirable (e.g. highly polluting) technologies. This may require the displacement of incumbents committed to the old regime, or co-opting them so that their business strategy becomes committed to fostering the new regime.
Use of 'guiding visions'	A 'guiding vision' is a clear statement about directionality, defining the societal problem to be addressed and proposing how to do so. By defining 'what success looks like', it implies that the SIP's activities should converge on a solution, rather than leaving that open-ended. It is likely to involve some analysis of the socio-technical system to be changed and involve elements of foresight or road mapping.
Building actor networks or coalitions	All the SIPs build 'project networks' through project funding. This function involves organisations more actively building and driving networks and setting their agendas to contribute to systems innovation, for example by lobbying or acting as a transition intermediary.
Action at the political and policy levels	This involves activities such as trying to change government policy, or get laws or regulations changed in order to remove barriers to systems innovation.
Coordination	This function is in fact not derived from the literature, which tends to conceive of systems innovation as being implemented either through multi-level governance or by a single organisation or actor network (whose identity is rarely discussed). Some of the functions discussed in the table are beyond the powers of the funding agencies or the SIPs, So, by 'coordination' we mean actively engaging with external actors to coordinate the development of policy or an innovation agenda, or to access external resources and powers not available inside the SIP.
TIS functions	
Entrepreneurial experimentation with new technologies, markets and business opportunities	Trial-and-error experimentation with new technologies, products and markets to see what innovations can be successful and generate new business opportunities. This can include setting up common technology or market testing facilities such as test beds.
Knowledge development, via R&D and learning-by-doing	R&D and knowledge development in the form of 'learning by searching' and 'learning by doing'. This can be done based on existing as well as new knowledge.
Knowledge diffusion through networks	Dissemination or exchange of information in networks. Includes education, training, 'learning by interacting' and 'learning by using' (if user-producer networks are concerned).
Directionality, via activities that encourage new innovators to enter and focus the directions of technical change they pursue	Activities that influence or determine the direction of technical change. These can include clarifying needs, choosing among alternative technological options, choosing among alternative markets that have different needs, and developing new business models. This can involve a 'guiding vision' for the SIP or road maps that guide what all or some of the SIP does.

Function	Explanation
Market formation by opening up market space or articulating demand	This could involve something as simple as analysing potential demand and telling potential suppliers that a new market could be created. It could involve helping set up a new market, for example by bringing potential suppliers and users together.
Market formation by creating protected space for niche innovations	Creating a protected space in which new technologies or 'niche innovations' can be developed and improved before they are exposed to full market competition.
Legitimation	Creating legitimacy for a technological trajectory by involving interested stakeholder groups, putting the new technology on the agenda, and lobbying for resources or favourable tax regimes, demonstrations to persuade suppliers, users and the public that an innovative technology is viable.
Resource mobilisation	Mobilisation of competence/human capital, financial capital and complementary assets (e.g. infrastructure).
Reflexivity	This involves the SIP in deliberately and systematically learning from its experience and potentially changing its objectives or behaviour in response to that learning. This could be from the process of reviewing their agendas, evaluation, their own studies, consultation and so on.

10.3 The SIPs

For the purpose of this analysis, we have aimed to update our understanding of the individual SIPs, compared with what was known at the time if their six-year evaluations, in order to capture what we can of their subsequent learning, largely from public sources. That means that we can see longer histories for the early SIPs than for the more recent ones. We do not see that as a problem, because we are not here trying to compare their performance or outcomes.

Based on their scope and goals, we classified the SIPs (Table 2 , Column 3) as:

- **Reinforcers,** centrally concerned with traditional innovation and competitiveness goals. They generally said little about sustainability or systems innovation at the outset, but have in most cases increased the attention paid to sustainability goals. The reinforcers cluster in the two first tranches, and most of them stay close to the former BFP model.
- **Transformers**, which to varying degrees aim at systems innovation or changes in existing socio-technical systems and regimes. They dominate the third (and fourth) tranches.
- **TIS-builder**, aiming to create a new technological innovation system (and by implication a new socio-technical regime). Grafen is the only pure case, though the printed electronics strand of SES also aims to support the development of a new technological innovation system, while the rest of SES is reinforcing more established electronics industry segments.

IoT can be considered a **mixed** case, originally acting as a reinforcer but in the second stage changing its strategy away from broad technology support and towards using IoT in state-sector services. MT4H made a similar but less radical change in direction following the three-year evaluation, creating national development projects (*Nationella utvecklingsprojekt*, NUP) and using additional funding from the Collaboration Programme for Research and Innovation initiative to work on AI in healthcare and try to increase the absorptive capacity of the health regions for innovation. MT4H's third (2021) agenda further emphasised the demand side.

Both IoT and to a lesser degree MT4H therefore increased their efforts on the demand side, but without orientating their work towards more specific problems.

Given their supply-side focus, the reinforcers tend to have low directionality (Table 2, Column 4), doing a broad range of projects that support their branch rather than focusing on specific demand-side needs. The transformers have medium or high directionality, with a greater problem focus. With the exception of Viable Cities, they are also among the smaller SIPs in terms of public funding, ranked 10th and above (Column 5).

Table 2 SIP characteristics.[30]

Tr.	SIP	Type	Directionality	Funding rank	Industry structure	Main funding beneficiaries	Main co-funders	Significant public co-funding	Member-ship org.?	Host
4	Viable	Transformer	H	6	N/A	HEIs	Cities	Y	Y	KTH
3	MT4H	Reinforcer	L	9	SMEs	HEIs	SMEs	Y		KTH -> I
3	Drive	Transformer	H	12	Oligopoly	Big cos	Big cos		Y	Lindholmen Science Park
3	Infra	Transformer	H	16	Mixed	HEIs	Big cos	Y	Y	KTH
3	RES	Transformer	H	10	Mixed	RIs	Big cos		Y	RISE
3	SBE	Transformer	M	11	Mixed	HEIs	Big cos		Y	I
2	IoT	Mixed	L –> M	14	Mixed	HEIs/RIs	Big cos	Y	Till 2019	UU -> UU Innovation
2	BioInno	Reinforcer	M	4	Oligopoly	HEIs	Big cos		Y	I
2	Innovair	Reinforcer	L	1	Oligopoly	HEIs	Big cos			I
2	Swelife	Reinforcer	L	3	SMEs	HEIs/SMEs	SMEs	Y		LU
2	SES	Reinforcer	L	8	Oligopoly	HEIs/RIs	Big cos/SMEs			RISE Acreo-> I
2	Grafen	TIS-Builder	H	17	Nascent	HEIs	Big cos/SMEs		Y	Chalmers Industriteknik
1	MM	Reinforcer	L	2	Oligopoly	HEIs/RIs	Big cos			I
1	PiiA	Reinforcer	L	7	Oligopoly	RIs	Big cos			RISE
1	SMI	Reinforcer	L	13	Oligopoly	HEIs	Big cos			LTU
1	LIGHTer	Reinforcer	M	15	Oligopoly	HEIs/RIs	Big cos		Y	RISE IVF
1	P2030	Reinforcer	L	5	Oligopoly	HEIs	Big cos			I

[30] RI = research institute, I = industry or branch association. Arrows indicate change of host location. Y = yes, L = low, M = medium, H = high. The funding ranking is based on the total public funding to the SIPs in the first six years (cf. Figure 2 above).

Most of the industries where the SIPs operate are international oligopolies (Column 6), with power concentrated in the hands of a small number of dominant companies. Some of these SIPs span multiple oligopolies. Either way, here the power of incumbents will be high. The reinforcers tend to work in oligopolies. The transformers tend to work in more fluid industrial structures, with a more mixed range of company sizes and therefore lower concentrations of market power. This appears to make it more feasible to attempt systems innovation than in the international oligopoly sectors. Swelife and MT4H form a special, health-orientated sub-group in the reinforcer category, continuing traditional but rather fragmented R&I efforts predominantly among the SMEs that dominate these segments.

In almost all the SIPs, HEIs and institutes were the main beneficiaries of state funding (Column 7), with co-funding largely coming from big companies (Column 8). SMEs were important co-funders in four cases, unsurprisingly in branches with a large SME sector.

Five of the SIPs – Viable, Drive, Infra, RES and SBE – are more orientated to Swedish problem-owners than the others, addressing the needs of the Swedish state or sectors of the economy that focus on infrastructure. They are all transformers, suggesting that it may be more tractable to do systems innovation at the national than the international level. In three of these cases (IoT, Infra, Viable), public authorities are major co-funders[31] of projects; another two cases (Swelife, MT4H) are in SME-dominated businesses with public authority customers, so public authorities are important co-funders (Column 9).

Nine of the SIPs (Column 10) have employed membership programmes to organise users.[32] Most of these are transformers, and the TIS-builder Grafen is also in this category, suggesting that deliberate and open network-building is seen as especially important for systems innovation, in line with theory.

It appears that industry associations and innovation-related organisations tend to make comfortable homes for SIP programme offices (Column 11). Some do well at universities, but others have moved out. MT4H started as a consortium based at KTH, but was sufficiently unhappy with the restrictions that placed on it that it set itself up as a limited company and left the campus. IoT was similarly unhappy at UU and moved from the university itself into its innovation division. SES left RISE in dissatisfaction after the first funding period. Drive and Grafen have been in university-related innovation facilities from the outset – respectively Lindholmen Science Park and Chalmers Industriteknik. RES, PiiA and LIGHTer are based within the RISE group. Other SIPs are based at industry or branch associations.

We looked at some other variables in relation to the SIPs but did not find patterns that seemed meaningful.

- On average, the Top-5 and Top-10 R&I project co-funders provide greater percentages of the co-funding among reinforcers (40% and 51% respectively) than the others (29% and 41%). The ratio of the size of the SIP networks in Year 6 to that in Year 3 is also higher among reinforcers (2.1 compared with 1.6). However, in both cases, the variations among individual SIPs is high, and seem likely to be more a function of SIP behaviour and context than of the type of SIP.
- We checked whether the proportion of the project funding spent on strategic projects correlates with the types of SIP, but this appears again to be a function of behaviour rather than structure (cf. Figure 4).

[31] Accounting for 18-45% of the co-funding. In the other SIPs, the proportion is in the low single figures or zero.

[32] IoT abandoned this organisational form after it changed its strategy to focus on the public sector.

- Finally, we looked for a systematic relationship between the type of SIP and the average TRL of the project work or the TRL progress made. There is little difference between the means of the reinforcers' versus others' project work (cf. Figure 19).

10.4 Performing transition-related functions

In this section we consider, first, the extent to which it is legitimate for state innovation funding agencies to fund the individual functions, then go on to report on the extent to which the functions were performed in the SIP initiative.

10.4.1 Legitimacy

Many of the transition functions map easily onto activities routinely performed in technology programmes. Programmes built on public-private partnerships (such as Vinnväxt or CCs) have for some time created arenas for priority setting, since they to a fair extent decide their own agendas. They also build their own networks. The other transition management functions can be more problematic. 'Creative destruction' is not generally something an innovation agency can do. However, it is perfectly possible to require the use of guiding visions, action at the political level and coordination with others when designing a new programme.

Among the TIS functions, entrepreneurial experimentation is problematic. Technology programmes frequently include technical testing and demonstration but do not normally fund experiments with business models that require market-based activities. Knowledge development and diffusion are business-as-usual for innovation agencies. While imposing strong directionality is unusual, it is legitimate to design programmes that require it, and this has already been done to some extent in challenge-based programmes. It does, however, require a very different style of programming, starting with problems rather than technological opportunities, and aiming to provide specific solutions. While exploring and explaining needs are legitimate activities in traditional technology programmes, creating or otherwise interfering in markets is not generally seen as an appropriate role for innovation agencies.

R&I funding agencies often try to reduce technical risks and thus to legitimate new technologies through test, demonstration and prototype projects. Legitimating systems innovation is a newer activity. Agencies have the ability to require that their beneficiaries leverage the funding they receive to obtain additional funds from other sources, though there are limits to this possibility. The resource mobilisation function covers activities like scaling up that get close to the market and require large amounts of money. Finally, innovation agencies are already requiring beneficiaries to be reflexive in larger programmes, reflecting on and modifying their plans and agendas based on experience.

Table 3 summarises these dimensions of legitimacy.

Table 3 The extent to which it is legitimate for state agencies to fund transition functions.

Function	Legitimacy
Transition management functions	
Creating arenas for priority setting	XX
'Creative destruction' and handling incumbents	X
Use of 'guiding visions'	?
Building actor networks or coalitions	XX
Action at the political and policy levels	?
Coordination	?
TIS functions	
Entrepreneurial experimentation with new technologies, markets and business opportunities	X
Knowledge development, via R&D and learning-by-doing	XXX
Knowledge diffusion through networks	XXX
Directionality, via activities that encourage new innovators to enter and focus the directions of technical change they pursue	?
Market formation by opening up market space or articulating demand: • Opening up market space • Articulating demand	 X XXX
Market formation by creating protected space for niche innovations	X
Legitimation	XX
Resource mobilisation	XX
Reflexivity	XX

Key: X = little or no legitimacy. XX = some legitimacy. XXX = strong legitimacy. ? = 'could impose this on projects.

The extent to which the SIPs use the functions listed is quite variable, reinforcing our impression that the funding instrument is quite flexible, and that it has potential for being used in a more transformative way than has been the case so far.

10.4.2 Transition management functions

Creating arenas for priority setting. In practice, the SIA exercise and the SIPs themselves create (or re-use) priority-setting arenas, focused on the agendas, providing an important opportunity to structure and coordinate activities within the SIP. In many cases, however, this simply allowed existing actors to extend existing priorities, rather than provoking change. Perhaps a more demanding and transitional set of requirements for applicants to SIP initiative successors could trigger more ambitious agendas.

'Creative destruction' and handling incumbents. It would be surprising to see any 'creative destruction' activities in technology programmes – the relevant actors are more likely to be regulators, lawmakers and investors. However, the involvement of incumbents was often very

encouraging. The transitions literature tends to assume that incumbent economic actors will try to prevent change, especially if they are big and powerful. But where incumbents start to believe that change is coming in markets and demand, they tend to realign themselves to the new opportunities, rather than to block them, since in general it is more profitable to be among the leaders than the laggards when products and markets change. If SIP ambitions align with policy ambitions at the national level the argument for change becomes even more compelling.

'Guiding visions' in the sense of the transitions literature are largely absent from the SIP programme. Their purpose is both to clarify the central mission of the intervention and to provide a place in which to test and improve it. A guiding vision would differ from the SIP agendas in being problem and solution-focused, exploring **systems** changes needed and providing a road map for implementing them, which would be subject to revision as the SIP learns.

Building actor networks or coalitions has the potential to go beyond forming passive networks (such as those made up of project participants) to create self-organising coalitions with active agendas. BFP-based SIPs often have roots in branch or industry associations, which are in effect advocacy coalitions that campaign in support of the interests and competitiveness of existing the branch. In the context of systems innovation, actor networks or coalitions need to be focused on changing the system. Some of the membership organisations created for the SIPs (Table 2) have potential to remain active after the SIP funding ends and continue to pursue a transitional vision, perhaps even acting as transition intermediaries.

Action by the SIPs **at the political and policy levels** has so far been rather minimal. In some cases this is because the SIP is an outgrowth of an active network like the Association of Swedish Engineering Industries (*Teknikföretagen*), which maintains its own contacts with the political level. Innovair is an important exception, which is deeply embedded in politics and policy for the aircraft industry, which has both civil and military dimensions. Some SIPs, such as Grafen, Drive, SBE and SES, have limited activities in standardisation, but most do not engage in activities like standardisation or regulation. The more systems innovation-orientated the SIP, the greater the need to engage in such areas in future. For example, increased circular economy would lead to a need for greater labelling of materials, traceability, new standards and regulations, training, and so on.

Coordination is needed so that it becomes possible to reach outside the traditional roles of innovation agencies and technology programmes to reach agreements with other actors whose support is needed for the SIP to reach its goals. This may well be at the policy level – for example engaging ministries responsible for environment or health – or at the level of cooperating with agencies and funders outside the R&I sphere. Swelife has made use of the national life sciences office as a source of intelligence about needs and technical opportunities, replacing an internal advisory committee in 2019, resulting in changes to the organisational division of labour in relation to life sciences. There appear to be other opportunities to coordinate between SIPs and national policy bodies that could be taken, and which would tend to align SIP activities and policy.

10.4.3 TIS Functions

Entrepreneurial experimentation in the SIPs has largely been limited to technical aspects, with most of the SIPs doing test and demonstration activities. The transformers tend to engage more with actual and potential users, but the SIPs' expectations about doing

entrepreneurial experimentation are limited, and in some cases there is anxiety that doing so would break state aid rules.

Knowledge development on the other hand is core business for the SIPs. While some work is done at low TRLs, for example in Grafen and Innovair, most is at higher TRLs (cf. Figure 19), reflecting the focus on innovation in the programmes and the strong role of industry in the governance of the individual SIPs. The transformers place more emphasis on non-technical knowledge and are more likely to involve users than the reinforcers.

Currently, most SIPs find it hard to get enough control over which R&I projects are funded to make it possible to manage a series of project sub-portfolios, in which projects are interdependent or together fill very specific knowledge gaps. While it is important for the agencies to maintain control of project selection to avoid rent-seeking behaviour by the SIPs themselves, there is a need to adjust the decision-making process if SIPs are to become more transformative.

Knowledge diffusion through networks is one of the SIPs strong points. Almost uniformly, they are very outwards-facing in disseminating project results, holding presentations and workshops and by running annual meetings of their communities. Their web sites mostly emphasise dissemination and they seem strongly incentivised to make their presence known, so they are very visible. Some, such as SES and P2030, provide handbooks and training. The work of some transformers will, if successful, imply a need to build absorptive capacity in business and the public sector, for example in circular economy or smarter buildings, so it may be useful to extend dissemination activities further into professional education and training.

Directionality. We would tend to describe the reinforcers' work as mostly thematic rather than directional, in the sense that they support specific areas of technology and focus their attention on the supply side, so they have a large amount of freedom. This is less true in Innovair, where the SIP works within a bigger European framework that has rather specific technical goals, than the other branch-orientated SIPs, which to some degree are continuing in the more open BFP tradition. The intensity of the directionality varies among the transformers. Drive and Viable are very strongly focused on specific problems and their solutions, the other transformers tackle broader problems and systems. There is scope in almost all cases to use the SIP instrument with stronger directionality, but this would entail more analysis of the problems, and demand and systems analysis in defining solutions. Two SIPs were constructed based on large numbers of SIAs – respectively seven and ten. The resulting fragmentation and the involvement of many different interest groups tends to get in the way of having any powerful kind of additionality.

Market formation by opening up market space or articulating demand. Creating markets is clearly beyond what a SIP can do, so this can only be tackled by coordination with other actors. The supply-side focus of many of the SIPs means that they do not study the demand side or end-users of innovations much, with most of the effort devoted to understanding their context being directed towards current technological trends and exploring the state of the art in technology. Even in the remaining cases, our impression was that there is scope for more systemic analysis and explicit exploration of users and their potential demand.

The nature of demand in the SIP initiative is itself problematic because it is generally fragmented. There is a clear need for change within the public sector, notably in healthcare and welfare which are notoriously fragmented (and not just in Sweden). There may also be scope for demand aggregation in the private sector, so that demand for more transformative solutions can be made effective in markets.

Market formation by creating protected space for niche innovations is similarly beyond the power of technology programmes because it involves acting on markets, though there is scope for doing this by coordinating with others, for example linking with development banks, foundations, or regulators.

Legitimation. Technical legitimation is done through test and demonstration. Reinforcers do not have a systems innovation agenda, so they do not need to legitimate it. Transformers disseminate and lobby in support of their directionality. In some cases (such as RES, BioInno, Swelife) the SIP's legitimacy is increased by national policy initiatives.

Resource mobilisation for scaling up and otherwise moving technologies closer to practice is also beyond the direct power of a technology programme. Some SIPs are paying more attention than previously to the potential for this when considering project proposals. There may also be opportunities to coordinate with other kinds of funders, so as to generate more resources 'downstream' of technological development.

Reflexivity is in principle built into the three-year funding cycle of the SIPs, with both an evaluation and the need to write a new funding proposal providing a justification for reflection on their achievements and planning the next steps. The stability of many of the agendas despite this cycle was a little surprising, notably among the reinforcers. This may have been exacerbated by the fact that most of them are consortia rather than membership organisations, so that signals about needs come primarily from inside the SIP organisation. There is a clear trend for the SIAs and other planning documents to make more reference to sustainability over time, though it is less clear that this makes a great deal of difference to the work being done. Four SIPs made major changes to their strategies, however:

- MT4H decided in the second funding period to refocus its work from technological development towards implementation.
- RES followed the wider pattern of thinking in circular economy by abandoning its initial focus on waste, which it inherited from its predecessor programme funded by the Energy Agency and turning its attention to design and circularity rather than only focusing on waste streams.
- IoT learnt that it would not be able to keep up with the pace of change in IoT technology and the maturation of the industry structure towards larger entities, and refocused itself on using Internet of Things technology to increase efficiency and effectiveness in state-provided services.
- Swelife refocused from doing many individual projects to using strategic projects to define priorities and cluster projects within these areas, reducing fragmentation.

10.5 Reorientating the SIP instrument towards systems innovation

This section summarises the implications of our analysis for developing a SIP-like funding instrument to support systems innovation. Some of the transition management and TIS functions identified are already well done today. These are largely 'classical' functions performed in technology programmes for many years. Second, there are functions that could be strengthened to provide better support for systems innovation, without going beyond the areas of operation that are seen as legitimate for innovation agencies. Third, there are functions that can only be done by coordinating with others or that need to be coordinated in order to be effective.

The functions already done well today by the SIPs are:

- **Knowledge development, via R&D and learning-by-doing.** This is the central purpose of traditional technology programmes, the SIPs as originally conceived, and the main focus of subsidy. Normally innovation agencies fund little learning-by-doing, but this is more important if programmes address implementation as well as R&D.
- **Knowledge diffusion through networks.** The SIPs are particularly good at this, building large networks, and emphasising dissemination to the extent that many employ professional communicators in the programme offices. Dissemination tends to focus on how to put knowledge into practice, to the extent that it can include handbooks, while there is less emphasis on academic research outputs.
- **'Creative destruction' and handling incumbents.** Creative destruction is rarely an issue in traditional R&I programmes, and would need to be done via coordination with other actors (see below). The transitions literature tends to assume that strong incumbents will want to defend their existing positions and therefore resist systems innovation. In the SIPs (and in other R&I programmes we have evaluated over the years) oppositional incumbents do not appear to be a problem, presumably because they see no point in joining the programme. Large incumbents appear to participate in SIPs either to continue doing incremental innovation or where they see market opportunities arising from more radical change.

Functions already done by the SIPs but which could usefully be strengthened in an instrument more strongly focused on systems innovation are:

- **Creating arenas for priority setting.** The standard SIP governance structure with a board and a programme office creates an 'arena' that maintains responsibility for innovation agendas and their revisions. Reinforcer SIPs' governance tends to be strongly dominated by the industrial and research communities. Transformers' governance tends to be more open to public organisations and the demand side. Greater involvement of such non-R&I actors would Increase SIPs' freedom to focus further on problems and implementation by involving more of the wider system in which innovation is sought.
- **Use of 'guiding visions'.** Most of the SIP agendas that set visions do so in broad terms and in one or two lines, as opposed to the more specific description of problems, solutions and directionality foreseen in the transitions literature. Drive Sweden is unusual in presenting such a vision, allowing it to focus more specifically than most of the SIPs on systems innovation. The SIP instrument thus permits the use of guiding visions. While these are not usually used in technology programmes, requiring their use (and the system analysis and road mapping effort required to generate such visions) would be helpful to tackle systems innovation.
- **Building actor networks or coalitions.** The coalitions associated with the reinforcer SIPs generally have their roots in seeking industrial competitiveness. Transformers tend to involve coalitions with a more direct interest in systems innovation, but there is scope for these to be made more active in support of the SIPs' change goals and involving more actors from outside the R&I communities.
- **Action at the political and policy levels.** Similarly, the funding instrument does not constrain SIPs from being more active in lobbying and cooperating at these levels in pursuit of their change goals, but this opportunity is under-exploited. Since systems innovation involves rule changes and mobilising resources, a more systemic instrument would need to embrace more interaction with the political and policy levels.
- **Directionality**. The directionality exerted by the current SIPs is in most cases rather weak. This is partly because most of the SIPs have little or at best moderate ambition to do

systems innovation. It is partly also because the link between strategic projects and SIP strategy on the one hand and the calls and appraisal procedures for R&I project proposals on the other is itself not as strong as the SIPs would want. Making very specific calls for proposals can result in few adequate proposals being made. It would nonetheless be desirable to strengthen this link to make the SIPs more effective in moving towards their goals, for example through more interactive procurement processes and broader involvement in setting SIP strategies.

- **Reflexivity.** The current SIPs are to various degrees reflexive in the way they learn from experience and changes in the context how to adjust their agendas, though it is notable how stable many of them are in practice. Increasing the focus on systems innovation would require more reflexivity and the SIP instrument does not prevent this.

Functions that would need coordination with actors and authorities outside the R&I space are:

- **Entrepreneurial experimentation.** The SIPs are constrained by their R&I mandate and state-aid rules from doing many activities 'downstream' of R&D. Hence, they can experiment with technology but not to any significant extent with markets, for which they would need to coordinate with other actors.
- **Market formation by opening up market space or articulating demand.** As with entrepreneurial experimentation, the SIPs' position in the R&I 'space' means they can largely only help open up new markets by coordinating with others. Articulating demand, however, is fully possible within the SIP instrument, though more such activity is needed in order to handle systems innovation well.
- **Market formation by creating protected space for niche innovations.** This requires activities such as intervention in markets, changes to regulation, resources to subsidise niche activities or to subsidise demand for a period to allow scaling up. All of these are beyond the power of R&I funders.
- **Resource mobilisation.** This involves finding resources to fund activities downstream of R&I, such as scaling up or capital investment, which are similarly beyond the powers of innovation agencies.

This analysis confirms our observation that the failure in the transitions literature to take account of the organisational structure and roles of different parts of government and the state is an important weakness. Once we take account of these, it becomes clear that it is hard to find a single place in the government system that can address all the transition management and TIS functions described. If there is such a place, it will be very high up in the system and will in turn need to activate many parts of government and the state as well as non-government actors. It seems there is no escape from the need for **coordination**, and that the things that need to be coordinated will depend (a) on where in the government system an intervention is positioned, and (b) the requirements of the system innovation that any specific intervention addresses.

SIP-like interventions may well need the four types of coordination just discussed. However, we should also recall that the list of functions we have used is not a well-founded theory but a heuristic. Quite likely, individual interventions may need some of the functions but not others – particularly if they tackle a **part** of a systems innovation. Finally, each systems innovation intervention needs its own robust theory of change, by all means in part inspired by the suggested functions, but specific to the problems and the systems addressed.

11 Recommendations

Our analysis in previous chapters suggests that the SIP funding instrument is rather flexible, making it useful for addressing a wide range of R&I policy needs. Chapter 9 summarises, at an overall level, the extent to which the recommendations of the 17 programme evaluations have been implemented and follows up the extent to which with the main recommendations to the agencies formulated in the three annual meta-evaluations have been heeded. The recommendations to the agencies are still valid, so we refrain from reiterating them in this chapter. However, as we argued in Chapter 10, tackling systems innovation implies acting outside as well as inside the R&I policy sphere. In this chapter, we therefore deal separately with the external and internal dimensions, so our first set of recommendations is addressed to the policy system as a whole, while the second set is addressed to the SIP funding agencies and similar organisations.

11.1 Interventions in the policy system

The need to deal with systems innovation means that policy interventions must become increasingly systemic, extending the second-generation concern with well-functioning innovation systems. While in the past it has been possible to run R&I policy in ministry 'silos', the level of coordination and consistency across the growing number of ministries and other actors now needs to increase. Policy needs to balance interventions across fundamental research, technological innovation and tackling societal challenges and socio-technical transitions, between national and international focus, as well as between traditional supply-side and demand-side policies.

11.1.1 Holistic R&I policy should cover all three policy generations

The policy generations described in the previous chapter are an example of policy 'layering'. Rather than later generations of policy replacing earlier ones they co-exist, in this case because each generation has a different purpose. Government policy needs not only to use all three for their respective purposes but also aim for complementarity so that, for example, the production of basic research and PhDs is consistent with the thematic needs of innovation and systems innovation policies.

A case in point is the effective replacement, in budgetary terms, of the BFPs with SIPs. The BFPs and other second-generation technology programmes play important roles in the Swedish R&I system. For example, they support the competitiveness of Swedish industry by:

- Raising the research content of industrial R&D and therefore the rate of significant innovation in industry compared to what companies would be doing without subsidy or cooperation with the research sector.
- Increasing firms' risk appetite in innovation through risk-sharing with the state.
- Building research, cooperation and innovation capabilities among companies and sustain innovation networks.

These are not necessarily central concerns in systems innovation-orientated initiatives, so there is a continuing need to maintain second-generation policies that support industrial innovation and competitiveness.

11.1.2 Maintain a strong international dimension in R&I policy and programmes

It is cliché but nonetheless true to say that science is global and that excellence can only be attained by participating globally. Equally, notwithstanding current alarming geopolitical

tensions, there is a global innovation system in which it is hard to avoid participation and where the current discussion of 'technological sovereignty' once more throws the need to balance national or European capability against the advantages of global trade. For both reasons, R&I policies need a strong international dimension, which we feel has been somewhat under-emphasised in the SIPs.

Although there are examples of significant interaction in EU Framework Programmes among some SIP actors, most show little interest. This reflects the generally lukewarm interest within the Swedish R&I community that to a significant extent is caused by lavish national funding offered by, among others, the SIPs, and by limited enthusiasm for the Framework Programmes from the government down (Åström et al., 2023). Experience shows that very clear incentives are needed to induce additional actors to participate in EU Framework Programmes; national programmes are necessary to create conditions for actors to be able to participate, but they are by no means sufficient to persuade actors to do so.

Other factors militating against international collaboration have been the big role of industry in governance that has caused the SIPs to focus on high-TRL, close-to-market and often incremental innovation with fairly short-term aims, and the programme rules that participating organisations must be resident in Sweden. A more balanced governance and careful consideration of when tactically to relax the residency requirement could improve the degree to which SIPs participate internationally, reducing the chances of reinventing the wheel or missing out on key developments elsewhere.

11.1.3 Find the right level to intervene

As Viable illustrates there is a wide range of system sizes that can be tackled, from the city level addressed by the SIP to the Swedish level, which is governed by national policy, the European level where the EU is active, and up to the global level which is governed by the Paris Agreement and the Conference of the Parties (CoP) process. Systems innovation needs are often also technically nested – for example, decarbonising the electricity system involves changes in power generation, distribution, consumption, and so on. If we focus on distribution, for example, that constitutes a socio-technical (sub)system in its own right that could be the subject of intervention.

Especially in relation to very large systems innovations, the national R&I system can be too small and too narrow to be an effective place to drive an intervention. A new place may be needed. For example, Sweden, Germany and the Netherlands have all decided to put extended versions of their existing industry ministries in charge of climate change policy, while Austria recently set up a national hub in the finance ministry to tackle it. Whichever level is chosen to intervene must be able to perform or access the full range of functions needed to do so. Correspondingly, while innovation agencies may have many of the necessary tools at their disposal, our analysis shows that they cannot cover the complete range of functions and that they must coordinate their actions with others who can provide the complementary power and capabilities needed. The transitions literature points out that interventions often have a three-level structure, namely intervention strategy and design, management and coordination, and the operational or project level. These are not necessarily housed in the same organisation.

11.1.4 Actions separate from systems innovation interventions are needed to organise and reduce fragmentation on the demand side

Systems innovation interventions rely on connecting problems and their solutions to the knowledge and other means to address them. The SIP experience shows that fragmentation

and lack of organisation on the demand side makes it hard to achieve this connection. This is most obvious in the public healthcare sector, which is notoriously fragmented and lacking in common standards and processes that support a consistent pattern of demand and enables scale-up. A better-organised public demand side would not only benefit systems innovation interventions but also produce significant efficiency improvements.

EU Directive 2014/24 (implemented as the Law on Public Procurement (*Lag om offentlig upphandling*, LOU) is understood to forbid interventions creating discriminatory agreements between supply and demand sides, so reforming the public demand side cannot be done in conjunction with a SIP or a similar instrument. However, that still appears to leave scope for procurers to make collective arrangements, set standards, develop model contracts and so forth on their own account, provided these apply equally to all potential suppliers. Such reforms are badly needed and should in any case be pursued separately from systems innovation interventions.

Organising private-sector demand is difficult, but experience – for example in Sweden with the Environmental Technology Delegation (*Miljöteknikdelegationen)* – shows that it can be done, and that there can be enthusiasm for it where (as with environmental improvements) there is a common good that can be pursued.

11.2 Interventions at the level of innovation agencies

Effective systems innovation intervention by innovation agencies requires a change in focus from technology generation to solving societal problems and the use of transition functions identified in the transitions literature. This will involve capacity-building, cooperation with actors outside the traditional R&I community and shifting the balance of power in intervention governance towards the demand side. Monitoring and evaluation need to follow the changing needs of interventions through their life cycles.

11.2.1 Systems innovation interventions should pursue societal objectives

Systems innovation projects start by identifying a problem in the delivery of societal services such as health, environment or energy supply, and create a programme of work to identify a solution and work towards implementing it. This contrasts with traditional R&I projects, which focus on increasing the supply of new knowledge and disseminating it in such a way that it hopefully generates innovations and other outcomes that bring social benefits. It follows that the organising principle in systems innovation is that the scope of the intervention is determined by the nature of the problem to be solved and the implementation mechanisms needed, whereas the scope of traditional R&I programmes is essentially determined by the constituencies they represent, whether they be members of the physics research community or of a branch of industry. This implies that theories of change should be much more explicit and realistic than most are today about their programme objectives and the mechanisms through which they will be reached. They should have strong directionality and be informed by explicit 'guiding visions' that generate a focus on implementation, and may well be supported by foresight exercises or road maps. Unlike traditional 'fund-and-forget' projects, they also need a process (reflexivity) through which they periodically revisit and potentially revise aspects of their objectives and plans. Their timescales should be long but – correspondingly – they need multi-stage funding with demanding evaluation requirements at each stage-gate.

This implies a need for the authorities to understand that theories of change are hypothesis-based and can evolve, based on experience and changes in the context. Since systems innovation projects tackle complex socio-technical systems, there will be surprises. (Part of

the definition of complex systems is that they have 'emergent' properties.) Funding agencies thus need greater licence than today to take risks, and (in the absence of negligence or mismanagement) it should be possible to terminate failing activities without either the funding agency or the project incurring dishonour.

11.2.2 Interventions should be generated in competition and involve not only the R&I community but also the other actors needed to implement system innovations

A great strength of the long and large innovation programmes implemented in Sweden during recent years – such as the SIPs, CCs, and Vinnväxt – has been that competition has been used to decide what the specific projects should be. Those competitions serve to identify 'coalitions of the willing' – strong actor groups with a common purpose and the power to effect change if they are successful. Systems innovation programmes need to generate coalitions with these qualities that extend well beyond the R&I system and industrial competitiveness to solve problem identified in the provision of societal services. This is likely to involve problem-owners as well as other actors who are needed to ensure implementation but who are not part of the R&I community. To a greater extent than in traditional technology programmes, interventions should therefore be supported not only by a theory of change but also by a stakeholder analysis that demonstrates how all the needed actor categories are involved.

11.2.3 Systems innovation interventions should use functions from transitions research to strengthen their ability to affect implementation

The list of functions we discussed in the previous chapter is not authoritative (in part because the evidence base underlying it needs strengthening, and there is no 'general theory' of transitions on which to rely), but to a first approximation it appears to be useful and should serve at the minimum as a way to prompt theory-of-change design so that these functions are included when appropriate.

11.2.4 Build capacity for systems innovation, both in the agencies and in the beneficiary communities

The SIP experience clearly shows the value of experience among the well-practised and -organised communities that are used to benefitting from state technology programmes. It has been correspondingly harder for the SIPs with less such experience to design their interventions and 'hit the ground running'. Correspondingly, like their equivalents in other countries, the agencies are still learning about transitions intervention design and management. Agencies should therefore organise learning and training exercises for the benefit of both communities and potentially support external organisations such as branch associations to do so.

11.2.5 Systems innovation projects funded by innovation agencies should coordinate with other actors, to access transition functions not available within the R&I sphere

As indicated in the previous chapter, functions such as 'creative destruction', entrepreneurial experimentation, 'market formation' and 'mobilising resources' for scaling-up and implementation can be beyond the reach of innovation agencies and the projects they fund. Innovation agencies are not completely powerless in relation to such functions – for example, they can tackle the technological part of 'entrepreneurial experimentation' but not really the business part, or they can require project proposals to identify expected sources of 'mobilising resources'. However, coordination or joint action with other actors such as business support

agencies, investors, regulators and standardisation bodies may be necessary in order to access the full functions.

11.2.6 Adjust the balance of power in governance

The SIPs offer a recent example of a growing trend towards using public-private partnerships (PPPs) in intervention governance. This is a strong way to recruit context-specific expertise and activate the participating organisations. As in other PPPs, the SIPs' activities have been influenced by the composition of the partnerships, which in this case tend to be industry dominated, resulting in rather incremental innovations in the projects funded, and neglect of many implementation issues. The balance of power in the PPPs and their boards needs to be adjusted to give a role to downstream and demand-side actors in order to compensate for this deficit.

The balance of power between the SIPs and the funding agencies has also been problematic. While the agencies have maintained control over proposal assessment and selection for most projects, this has made it difficult for the SIPs to build sub-portfolios of the projects needed to deliver their agendas. The agencies should look for a way to increase the PPPs' influence over project selection while at the same time protecting themselves from adverse selection by the SIP communities, for example by allowing SIP representatives to explain sub-portfolio thinking to the agency's peer reviewers or to allow for revisions of the ranked list, but only of proposals above threshold. The agencies should also provide larger coordination budgets and encourage more extensive use of strategic projects to improve chances of achieving directionality.

11.2.7 Monitoring and evaluation should reflect the life cycle and intended long duration of systems innovation interventions

Vinnova has developed evaluation practices for long programmes that reflect their life cycle, supporting the start-up phase with formative evaluation then adding greater summative elements during the life of the programme. This has worked well, and there is evidence from the SIPs, the earlier CCs and Vinnväxt that the use of some external support, such as real-time evaluation, help with elaborating theories of change or using a moderator to support reflexivity exercises, can improve performance. Such support helps participants learn and understand some of the new routines needed to work with systems innovation, rather than in more traditional R&I programmes.

A second dimension is the need to devise monitoring systems based on robust theories of change that collect information about short-term activities and outcomes relevant to achieving long-term impacts and which can be used in reflecting upon and adjusting the innovation agenda. This requires clear, specific and realistic intermediate objectives. Monitoring and evaluation cannot capture long-term impacts that are only expected to be realised in the future.

12 Conclusions

In this final chapter we summarise the main findings of the previous chapters and draw our overall conclusions.

12.1 A diverse group

The 17 SIPs encompass a wide variety of areas, objectives and implementation strategies. Actors in areas that previously had benefited from publicly co-funded R&I programmes clearly had an advantage in quickly getting their houses in order, creating a path dependency that benefited incumbents and continued the pattern of incremental innovation that typified the BFPs (Åström et al., 2012). The areas most obviously benefiting were those – a majority – that had been the subject of BFPs where SIPs could continue building on many years, in some cases decades, of R&I collaboration. In contrast, actors in areas that lacked a solid history of public R&I programmes struggled to get organised and to agree on scope and focus, in part due to a lack of influential actors who could facilitate and drive developments. Hence, in most cases the SIP instrument provided networks of established R&I actors with an opportunity to continue with business as usual to maintain their competitiveness in traditional areas of Swedish industrial strengths. In other cases it provided seed funding to new and promising areas, increasing the chances of more radical innovation and possibly laying the foundations for future areas of strength. The four SIP tranches exhibit an evolution from focusing on industry needs in the earlier tranches to tackling broader societal needs in the later ones – with corresponding changes in the actor types that dominate participation. In part, this evolution became possible as significant branches of industry (and their corresponding lobbies) had their main needs satisfied by at least one SIP, creating space for new areas with less established actor constellations. While the SIP instrument has proved flexible enough to accommodate this very diverse group of areas and actor constellations, the diversity has stretched the uniform evaluation methodology required by the agencies.

12.2 Participants

Taking Sweden's industrial structure as point of departure, we note that a very large proportion of the companies that contribute most to the nation's BERD in the main NACE groups seem to have participated. The geographical origin of the SIPs' co-funding from industry also correlates quite well with that of Sweden's value added. This substantiates the statement in the previous section that the R&I needs of Sweden's major industry sectors eventually were satisfied. Company co-funding is nevertheless highly skewed by a small number of MNC incumbents, but this is inevitable given their size and dominant positions.

Far fewer SIPs focused on societal needs. Those that did tended to be disadvantaged by not previously having benefited from publicly co-funded R&I programmes and their comparative inexperience at producing competitive proposals to such schemes. Further, many public authorities apparently find it hard to articulate broad societal needs, or do not see it as their role to do so. This may partly explain why public authority participation is patchy; while all regional councils but one have participated, few national authorities have and not even one municipality in four.

All Sweden's main R&D performers have participated, but most of the public funding has gone to the main technical and medical HEIs and institutes. This has resulted in a highly skewed regional distribution of public funding, which nevertheless makes sense given the areas addressed by the 17 SIPs and the location of the nation's main R&D performers.

During their first six years the 17 SIPs engaged 2 700 unique actors, an increase of 70 percent compared to the first three years. While participation obviously has been dominated by industry incumbents and the main R&D performers, the 17 SIPs have been open to all types of actors and they have managed to engage most relevant actors, including ones without previous experience of R&I or of collaborating with others on R&I matters. The dominance of established actors is a feature of the SIP instrument's focus on areas of national strength in combination with open, competitive calls. From a national perspective, this concentration is not necessarily bad, but it has implications for systems innovation because it relies on incumbents to drive change.

12.3 Impacts

Observing impacts of R&I projects that are on-going or that have recently been completed is for several reasons tricky. Impacts take a long time to emerge and will ultimately be expressed only after further developments in innovation and business models, attribution to a single project is almost never possible, and there are many confounding factors (that have little or nothing to do with R&I) that influence whether commercialisation succeeds. What we can see at this stage is signs that the SIPs are broadly making progress towards their overall objectives (even if these in many cases should be expressed in more temperate and specific terms).

The most common impact for project participants of all types was to establish long-term R&I collaboration with others, which arguably provides foundation for additional impacts. Among the most common additional impacts for companies and public authorities alike were new projects with Swedish public funding and self-funded follow-on projects, thus indicating that participants have 'real projects' that require a sequence of projects to gradually approach their long-terms goals. Many projects produced prototypes but resulted in few patents and few PhD recruitments, which is in line with incremental development at intermediate TRLs dominating the programmes. Expectations for future impacts were high overall. Several frequently reported impacts refer to using project results to improve products, services or processes. Together such intermediate impacts may prove important in the longer term, particularly since expectations for future achievements in these respects were high. While some companies reported that commercial impacts had already been achieved, most referred to expected future ones. Few implementation-related impacts were reported by public authorities, possibly in part since they are difficult to identify.

The additional impacts reported by R&D performers largely correlated with those of companies and public authorities. Among the most common ones were new publicly funded projects and development of prototypes, but there were few patents or postgraduate degrees, confirming the presence of real projects also among R&D performers, and that projects entailed more development than research. Many R&D performers reported increased international competitiveness with high expectations for further increases in the future.

Companies and public authorities agreed that they had developed more scientific working practices, while most R&D performers believed that they had adapted theirs better to serve industry and some of them better to serve public authorities. This bodes well for future R&I collaboration being mutually beneficial.

The 17 SIPs' achievements in engaging the relevant actors in formulating and realising common agendas and thereby invigorating their areas have brought substantial systemic impacts. While most impacts hitherto summarised refer to R&I projects, strategic projects have achieved system-level impacts by addressing common challenges and needs through international outlooks and benchmarking exercises, development of common platforms and

infrastructure, as well as courses and graduate schools. Strategic projects have successfully addressed system-related weaknesses and have contributed to changed working practices, which has resulted in integration of R&I subsystems that are characterised by wide participation, relevance, quality and efficiency.

The SIP initiative's additionality is considerable, while its objective fulfilment is only partial. The latter is mainly due to the objectives being high-level societal objectives to which the SIP initiative and individual SIPs can at best contribute.

12.4 Systems innovation

The SIP instrument was originally designed as a more open successor to the BFPs, supporting industrial innovation and competitiveness. The government then decided that it should be used to help address societal challenges, creating an interesting kind of natural experiment that has allowed us to ask what changes would be needed in order to make it fully effective in the context of societal challenges, and systems innovation more generally. The wider policy context has also changed during the lifetime of the SIPs towards increased focus on sustainability, and this appears to have influenced the behaviour of the SIPs. Now, issues such as circular economy, sustainability more generally, but also the life sciences are being tackled at the national level in addition to the level of instruments like the SIPs. This has potential to develop into a system where certain prioritised themes are handled nationally through multi-level governance while others are delegated to agency programmes.

Systems innovation requires instruments with more functionality than the SIP funding agencies can provide. However, they can help co-produce them together with other actors that have the competence and ability to tackle needs outside the R&I sphere, such as scaling up, creating new markets, regulating and the 'creative destruction' of old regimes and infrastructures (like fossil-fuel based production) that need to be superseded. The specific requirements for coordination will vary from case to case, but agencies will clearly need new coordination skills and processes.

A strength of the SIP instrument is that it can be used to involve implementers and the demand side to a greater extent than it has done so far. Probably, other demand-side instruments will be needed in addition, for example in demand aggregation. Reforms are clearly needed in some government organisations (notably, but not only, in healthcare) to increase their ability to understand and articulate their needs and to standardise and efficiently procure the innovations they need.

The SIP initiative has used PPPs to run the individual SIPs and re-learnt the old lesson that the interests of those who control governance are reflected in what organisations do. Industry is the strong interest group in most of the SIPs. This has encouraged innovation to be incremental and technology-focused. To respond more fully to the need for socio-technical change, the demand side, including public authorities, needs to be more involved. Adjustments need to be made, also, to find out how to govern individual PPPs in ways that prevent rent-seeking behaviour while allowing them effectively to implement strategy. For the cases where multi-level governance is needed, new models will be needed to integrate the work at government and funding instrument levels.

We have in this study relied heavily on the new and fast-developing research literature about socio-technical transitions for ideas. There is very little policy experience to date from which we can learn, but nonetheless a great need to develop policy further. This is therefore a period in which policy experimentation – and sometimes failure – is very much needed. This means

more research (specifically focused on policy implementation of socio-technical transitions) is needed, as is building capacity to design and use new policies and instrument.

12.5 Endnote

Our overall conclusion is that the SIP instrument has proved effective as a second-generation instrument to build national capacity and competitiveness. With some adjustments to the instrument itself and to aspects of governance, it is likely to be effective also in stimulating systems innovation and addressing third-generation policy needs. It does, however, need to be used within a wider policy and instrument mix that meets the needs of all three policy generations – fundamental research, technological development and innovation, and transitions or systems innovation.

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Appendix A Evaluation reports

All reports have summaries in English.

A.1 Programme evaluations

A.1.1 First tranche

- M. Uhrwing, J. Ryd, A. Tutal, A. Swenning, T. Åström, T. Fängström, M. Lindström, S. Eriksson Berggren och E. Arnold, ”Sexårsutvärdering av det strategiska innovationsprogrammet för Metalliska material”, VR 2019:16, Vinnova, 2019.
- J. Hugosson, S. Pardon, I. Bodén, S. Christner, T. Åström, T. Fängström, M. Lindström, S. Eriksson Berggren och E. Arnold, ”Sexårsutvärdering av det strategiska innovationsprogrammet för processindustriell IT och automation – PiiA”, VR 2019:17 Vinnova, 2019.
- M. Uhrwing, A. Bengtsson Jallow, S. Kuritzén, H. Andréasson, T. Åström, T. Fängström, M. Lindström, S. Eriksson Berggren och E. Arnold, ”Sexårsutvärdering av det strategiska innovationsprogrammet för svensk gruv- och metallutvinnande industri – STRIM”, VR 2019:18, Vinnova, 2019.
- J. Nylander, A. Tutal, T. Åström, T. Fängström, M. Lindström, S. Eriksson Berggren och E. Arnold, ”Sexårsutvärdering av det strategiska innovationsprogrammet för Lättvikt”, VR 2019:19, Vinnova, 2019.
- T. Fridholm, B. Bengtsson, A. Mattsson, T. Åström, T. Fängström, M. Lindström, S. Eriksson Berggren och E. Arnold, ”Sexårsutvärdering av det strategiska innovationsprogrammet Produktion2030”, VR 2019:20, Vinnova, 2019.

A.1.2 Second tranche

- J. van Rooijen, M. Viberg, S. Eriksson Berggren, T. Åström, S. Kuritzén, J. Olsson och E. Arnold, ”Sexårsutvärdering av det strategiska innovationsprogrammet BioInnovation”, VR 2020:13, Vinnova, 2020.
- T. Åström, A. Bengtsson Jallow, M. Viberg, S. Eriksson Berggren, S. Kuritzén, J. Olsson och E. Arnold, ”Sexårsutvärdering av det strategiska innovationsprogrammet för flyg, Innovair”, VR 2020:14, Vinnova, 2020.
- M. Almerud, J. Olsson, J. Ryd, T. Åström, S. Eriksson Berggren, S. Kuritzén och E. Arnold, ”Sexårsutvärdering av det strategiska innovationsprogrammet Swelife”, VR 2020:15, Vinnova, 2020.
- J. Niki Hugosson, E. Cederberg och A. Mattsson, T. Åström, S. Eriksson Berggren, S. Kuritzén, J. Olsson och E. Arnold, ”Sexårsutvärdering av det strategiska innovationsprogrammet Smartare elektroniksystem”, VR 2020:16, Vinnova, 2020.
- M. Lindström, A. Bengtsson Jallow, J. Ryd, T. Åström, S. Eriksson Berggren, S. Kuritzén, J. Olsson och E. Arnold, ”Sexårsutvärdering av det strategiska innovationsprogrammet SIO Grafen”, VR 2020:17, Vinnova, 2020.
- T. Fridholm, B. Bengtsson, S. Christner, T. Åström, S. Eriksson Berggren, S. Kuritzén, J. Olsson och E. Arnold, ”Sexårsutvärdering av det strategiska innovationsprogrammet för Sakernas Internet (IoT Sverige)”, VR 2020:18, Vinnova, 2020.

A.1.3 Third tranche

- B. Sandberg, A. Bengtsson Jallow, V. Stafström, C. Palm, T. Åström, J. Olsson, S. Eriksson Berggren, J. Ryd och E. Arnold, ”Sexårsutvärdering av det strategiska innovationsprogrammet Drive Sweden”, VR 2021:11, Vinnova, 2021.
- A. Bengtsson Jallow, M. Ricksten, J. Ryd, L. Edander Arvefjord, M. Lindström, T. Åström, J. Olsson, S. Eriksson Berggren, V. Stafström och E. Arnold, ”Sexårsutvärdering av det strategiska innovationsprogrammet InfraSweden2030”, VR 2021:12, Vinnova, 2021.
- M. Almerud, J. Olsson, L. Edander Arvefjord, T. Åström, S. Eriksson Berggren, J. Ryd, V. Stafström och E. Arnold, ”Sexårsutvärdering av det strategiska innovationsprogrammet Medtech4Health”, VR 2021:13, Vinnova, 2021.
- T. Fridholm, J. Niki Hugosson, K. Ekeroot, T. Åström, J. Olsson, S. Eriksson Berggren, J. Ryd, V. Stafström och E. Arnold, ”Sexårsutvärdering av det strategiska innovationsprogrammet RE:Source”, VR 2021:14, Vinnova, 2021.
- D. Holmberg, M. Ricksten, V. Stafström, C. Palm, T. Åström, J. Olsson, S. Eriksson Berggren, J. Ryd och E. Arnold, ”Sexårsutvärdering av det strategiska innovationsprogrammet Smart Built Environment”, VR 2021:15, Vinnova, 2021.

A.1.4 Fourth tranche

- M. Almerud, T. Åström, S. Eriksson Berggren, A. Bengtsson Jallow, V. Stafström, C. Palm och E. Arnold, ”Sexårsutvärdering av det strategiska innovationsprogrammet Viable Cities”, VR 2023:15, Vinnova, 2023.

A.2 Annual meta-evaluations

- T. Åström och E. Arnold, ”Metautvärdering av första omgången strategiska innovationsprogram efter sex år”, VR 2019:15, Vinnova, 2019.
- T. Åström och E. Arnold, ”Metautvärdering av första omgången strategiska innovationsprogram efter sex år”, VR 2020:10, Vinnova, 2020. (Updated version including Appendix A)
- T. Åström, E. Arnold och J. Olsson, ”Metautvärdering av andra omgången strategiska innovationsprogram efter sex år”, VR 2020:19, Vinnova, 2020.
- T. Åström, E. Arnold och J. Olsson, ”Metautvärdering av tredje omgången strategiska innovationsprogram efter sex år”, VR 2021:10, Vinnova, 2021.

Appendix B Web survey responses

Table 4 Number of web survey respondents and response rates.

		Number of respondents			Response rates		
Tranche	**SIP**	**Companies**	**Public authorities**	**R&D performers**	**Companies**	**Public authorities**	**R&D performers**
1	MM	78	N/A	63	31%	N/A	43%
	P2030	90	N/A	72	34%	N/A	58%
	PiiA	66	N/A	42	40%	N/A	68%
	SMI	46	N/A	34	37%	N/A	45%
	LIGHTer	68	N/A	36	40%	N/A	50%
2	Innovair	74	N/A	57	52%	N/A	54%
	BioInno	106	9	75	37%	53%	60%
	Swelife	67	39	62	51%	40%	47%
	SES	52	N/A	33	45%	N/A	56%
	IoT	56	16	25	44%	55%	50%
	Grafen	48	N/A	29	48%	N/A	55%
3	SBE	95	24	39	45%	40%	58%
	RES	127	10	73	37%	32%	56%
	MT4H	55	35	28	45%	60%	53%
	Drive	52	27	34	44%	50%	62%
	Infra	56	20	34	46%	63%	43%
4	Viable	37	29	39	29%	62%	48%
	Total/average	**1 173**	**209**	**775**	**41%**	**51%**	**53%**

Source: Web surveys.

Appendix C Interviewees

Charlotte Andersson	SMI
Malin Andersson	Drive
Kristin Blom	IoT
Camilla Byström	Infra
Per Edström	BioInno
Kristina Gabrielii	SBE
Fredrik Lekarp	Infra
Gert Nilsson	MM
Peter Nordström	Swelife
Cecilia Ramberg	LIGHTer
Yvonne Rosmark	Innovair
Elisabeth Sagström-Bäck	Grafen
Lena Strömberg	MT4H
Cecilia Tall	RES
Peter Wallin	PiiA
Cecilia Warrol	P2030
Anna Wibom	SES

Appendix D Abbreviations

BERD	Business Expenditure on Research and Development
BFP	*Branschforskningsprogram* (Branch Research Programme)
BioInno	BioInnovation
CoP	Conference of the Parties
CC	*Kompetenscentrum* (Competence Centre)
CTH	*Chalmers tekniska högskola* (Chalmers University of Technology)
Drive	Drive Sweden
Econ. & Reg. Growth	*Tillväxtverket* (Swedish Agency for Economic and Regional Growth)
ECS	Electronic Components and Systems
EIT KIC	European Institute of Innovation & Technology Knowledge and Innovation Communities
ENDREA	Engineering Design Research and Education Agenda (SSF programme)
Energy Agency	*Statens energimyndighet* (Swedish Energy Agency)
EPA	*Naturvårdsverket* (Swedish Environmental Protection Agency)
ESA	Europeiska rymdorganisationen (European Space Agency)
FFI	*Fordonsstrategiska forskning och innovation* (Strategic Vehicle Research and Innovation programme) (Vinnova, Swedish Transport Admin. and Energy Agency programme)
ffp	*fordonsforskningsprogrammet* (Vehicle Research Programme)
Formas	*Forskningsrådet för miljö, areella näringar och samhällsbyggande* (Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning)
GIH	*Gymnastik- och idrottshögskolan* (Swedish School of Sport and Health Sciences)
GKN	GKN Aerospace Sweden
Grafen	SIO Grafen
HEI	Higher Education Institution (university or university college)
HH	*Högskolan i Halmstad* (Halmstad University)
HV	*Högskolan Väst* (University West)
I	Industry or branch association
ICT	Information and Communications Technology
Infra	InfraSweden2030
IoT	IoT Sverige
IT	Information Technology

IVL	*Institutet för vatten- och luftvårdsforskning* (Swedish Environmental Research Institute)
IVSS	Intelligent Vehicle Safety Systems (Vinnova programme)
KI	Karolinska institutet
KTH	*Kungl Tekniska högskolan* (KTH Royal Institute of Technology)
LIU	*Linköpings universitet* (Linköping University)
LOU	Lag om offentlig upphandling (Law on public procurement)
LTU	*Luleå tekniska universitet* (Luleå University of Technology)
LU	*Lunds universitet* (Lunds University)
MDU	*Mälardalens universitet* (Mälardalen University)
MISTRA	*Stiftelsen för miljöstrategisk forskning* (Swedish Foundation for Strategic Environmental Research)
MM	Metallic Materials
MNC	Multinational company
MT4H	Medtech4Health
NACE	Nomenclature statistique des activités économiques dans la Communauté européenne (Statistical classification of economic activities in the European Community)
NFFP	*Nationella flygtekniska forskningsprogrammet* (National Aeronautics Research Programme)
NFR	*Naturvetenskapliga forskningsrådet* (Natural Sciences Research Council)
NGO	Non-Governmental Organisation
NMR	*Nordiska ministerrådet* (Nordic Council of Ministers, including NordForsk, Nordic Innovation and Nordic Energy Research)
NUTEK	*Närings- och teknikutvecklingsverket* (Swedish National Board for Industrial and Technical Development)
OECD	Organisation for Economic Co-operation and Development
P2030	Sustainable Production in Sweden
PiiA	Process Industrial IT and Automation
PPP	Public-Private Partnership
PROPER	Production Engineering Education and Research (SSF programme)
R&D	Research and development
R&D performer	HEI and/or institute
R&I	Research and innovation
RES	RE:Source
RI	Research institute

RISE	Research Institutes of Sweden
SBE	Smart Built Environment
SDG	Sustainable Development Goal
SES	Smarter Electronic Systems
SFO	*Strategiskt forskningsområde* (Strategic Research Area)
SIA	*Strategisk innovationsagenda* (Strategic Innovation Agenda)
SIO	*Strategiskt innovationsområde* (Strategic Innovation Area)
SIP	*Strategiskt innovationsprogram* (Strategic Innovation Programme)
SME	Small and Medium-sized Enterprise
SMI	Swedish Mining Innovation
SNIP	Source Normalized Impact per Paper
SSF	*Stiftelsen för strategisk forskning* (Swedish Foundation for Strategic Research)
STRIM	Mining and Metal Producing Industry, name change to Swedish Mining Innovation (SMI)
STU	*Styrelsen för teknisk utveckling* (Swedish National Board for Technological Development)
TIS	Technological Innovation Systems
Transport Admin.	*Trafikverket* (Swedish Transport Administration)
TRL	Technology Readiness Level
UMU	*Umeå universitet* (Umeå University)
UU	*Uppsala universitet* (Uppsala University)
VGR	Regional council of Västra Götaland
Viable	Viable Cities
V-ICT	Vehicle-Information and Communication Technology (Vinnova programme)
Vinnova	*Verket för innovationssystem* (Swedish Governmental Agency for Innovation Systems)
VR	*Vetenskapsrådet* (Swedish Research Council)
WMS	Wood Material Science and Engineering Research Programme (Swedish-Finnish programme)

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