# Impacts and indicators of Innovation Ecosystems

A Framework for Analysis

Valtteri Laasonen, Juho Nyman, Paolo Fornaro, Kaisa Lähteenmäki-Smith,
Jari Kolehmainen, Heli Koski and Tommi Ranta

PUBLICATIONS OF THE GOVERNMENT'S ANALYSIS,
ASSESSMENT AND RESEARCH ACTIVITIES 2022:23

tietokayttoon.fi/en

Government's analysis,
assessment and research activities

FINNISH
GOVERNMENT

Publications of the Government´s analysis, assessment and research activities 2022:23

# Impacts and indicators of Innovation Ecosystems

## A Framework for Analysis

Valtteri Laasonen, Juho Nyman, Paolo Fornaro,
Kaisa Lähteenmäki-Smith, Jari Kolehmainen,
Heli Koski, Tommi Ranta

Prime Minister’s Office Helsinki 2022

**Julkaisujen jakelu**
Distribution av publikationer

**Valtioneuvoston julkaisuarkisto Valto**

Publikations-arkivet Valto

julkaisut.valtioneuvosto.fi

**Julkaisumyynti**
Beställningar av publikationer

**Valtioneuvoston verkkokirjakauppa**

Statsrådets nätbokhandel

vnjulkaisumyynti.fi

**Publication distribution**

**Institutional Repository for the Government of Finland Valto**

julkaisut.valtioneuvosto.fi

**Publication sale**

**Online bookstore of the Finnish Government**

vnjulkaisumyynti.fi

Prime Minister's Office



ISBN pdf: 978-952-383-480-4
ISSN pdf: 2342-6799

Layout: Government Administration Department, Publications

Helsinki 2021 Finland

**Description sheet**
24 March 2022

# Impacts and indicators of Innovation Ecosystems
# A Framework for Analysis

**Publications of the Government's analysis, assessment and research activities 2021:23**

| | | | |
|---|---|---|---|
| **Publisher** | Prime Minister's Office | | |
| **Author(s)** | Valtteri Laasonen, Juho Nyman, Paolo Fornaro, Kaisa Lähteenmäki-Smith, Jari Kolehmainen, Heli Koski and Tommi Ranta | | |
| **Language** | English | **Pages** | 139 |

**Abstract**

The INNOVA project has produced information and tools to support the assessment of the impact of innovation ecosystems. Ecosystems are recognised to play an increasingly important role in the implementation of EU and Finnish innovation and industrial policies. However, assessing and measuring the impacts of different kind of ecosystems is challenging and requires a wide range of data and ecosystem-specific reviews. The empirical review carried out in this study will help to identify innovation ecosystems and their impacts. The built framework and case studies provide a basis for impact assessment of innovation ecosystems.

The results of the statistical analysis show a strong link between companies' participation in innovation ecosystems and better firm-level innovation performance. However, it is not possible to identify the causal links between the effects of innovation ecosystems on the basis of the reviews.

When examining the impacts of innovation ecosystems, special attention should be paid to the extent to which innovation ecosystems increase RDI cooperation between organisations and generate innovations that benefit society more broadly. The recommendations of the study emphasise the long-term nature of innovation policy and its monitoring, and the importance of cooperation between RDI funders, as well as impact-oriented policy formulation and implementation.

| | | | |
|---|---|---|---|
| **Provision** | This publication is part of the implementation of the Government Plan for Analysis, Assessment and Research. (tietokayttoon.fi) The content is the responsibility of the producers of the information and does not necessarily represent the view of the Government. | | |
| **Keywords** | research, research activities, research and development operations R&D, innovation activity, innovation policy | | |
| **ISBN PDF** | 978-952-383-480-4 | **ISSN PDF** | 2342-6799 |
| **URN-address** | https://urn.fi/URN:ISBN:978-952-383-480-4 | | |

**Kuvailulehti**
24.3.2022

# Innovaatioekosysteemien vaikuttavuus ja indikaattorit
## Viitekehys vaikutusten arvioinnille ja mittaamiselle

**Valtioneuvoston selvitys- ja tutkimustoiminnan julkaisusarja 2021:23**

| | | | |
|---|---|---|---|
| **Kustantaja** | Valtioneuvoston kanslia | | |
| **Tekijä/t** | Valtteri Laasonen, Juho Nyman, Paolo Fornaro, Kaisa Lähteenmäki-Smith, Jari Kolehmainen, Heli Koski ja Tommi Ranta | | |
| **Kieli** | englanti | **Sivumäärä** | 139 |

**Tiivistelmä**

INNOVA-hankkeessa on tuotettu tietoa ja työkaluja innovaatioekosysteemien vaikutusten arvioinnin tueksi. Ekosysteemeillä tunnistetaan olevan yhä tärkeämpi merkitys EU:n ja Suomen innovaatio- ja elinkeinopolitiikan toimeenpanossa. Erityyppisten ekosysteemien vaikutusten arviointi ja mittaaminen on kuitenkin haastavaa ja vaatii monipuolista aineistoa sekä ekosysteemikohtaista tarkastelua. Hankkeessa toteutettu empiirinen tarkastelu auttaa innovaatioekosysteemien ja niiden vaikutusten tunnistamisessa. Rakennettu viitekehys ja tapausesimerkit tarjoavat perustan innovaatioekosysteemien vaikutusten tarkasteluun ja arviointiin.

Tilastollisen tarkastelun tulokset kertovat vahvasta yhteydestä yritysten innovaatioekosysteemeihin osallistumisen ja tuloksekkaan innovaatiotoiminnan välillä. Tarkastelujen perusteella ei kuitenkaan ole mahdollista tunnistaa innovaatioekosysteemien vaikutusten syy-yhteyksiä.

Innovaatioekosysteemien vaikuttavuuden tarkastelussa tulisi kiinnittää huomiota erityisesti siihen, kuinka paljon innovaatioekosysteemit lisäävät organisaatioiden välistä TKI-yhteistyötä ja synnyttävät laajemmin yhteiskuntaa hyödyttäviä innovaatioita. Työn suosituksissa korostetaan innovaatiopolitiikan ja sen seurannan pitkäjänteisyyttä ja TKI-rahoittajien välisen yhteistyön merkitystä sekä vaikuttavuusohjautuvaa politiikan muotoilua ja toteutusta.

| | | | |
|---|---|---|---|
| **Klausuuli** | Tämä julkaisu on toteutettu osana valtioneuvoston selvitys- ja tutkimussuunnitelman toimeenpanoa.(tietokayttoon.fi) Julkaisun sisällöstä vastaavat tiedon tuottajat, eikä tekstisisältö välttämättä edusta valtioneuvoston näkemystä. | | |
| **Asiasanat** | tutkimus, tutkimustoiminta, innovaatiotoiminta, innovaatiopolitiikka, vaikuttavuus | | |
| **ISBN PDF** | 978-952-383-480-4 | **ISSN PDF** | 2342-6799 |
| **Julkaisun osoite** | https://urn.fi/URN:ISBN:978-952-383-480-4 | | |

**Presentationsblad**
24.3.2022

# Effekter och indikatorer på innovationsekosystem
# Ett analysramverk


| | | | |
|---|---|---|---|
| **Publikationsserie för statsrådets utrednings- och forskningsverksamhet 2021:23** | | | |
| **Utgivare** | Statsrådets kansli | | |
| **Författare** | Valtteri Laasonen, Juho Nyman, Paolo Fornaro, Kaisa Lähteenmäki-Smith, Jari Kolehmainen, Heli Koski och Tommi Ranta | | |
| **Språk** | Engelska | **Sidantal** | 139 |


**Referat**


INNOVA-projektet framställer information och verktyg för att stödja bedömningen av innovationsekosystemens effekter. Ekosystemen anses spela en allt viktigare roll i verkställandet av EU:s och Finlands innovations- och näringslivspolitik. Att bedöma och mäta effekterna av olika typer av ekosystem är dock en utmaning och kräver mångsidigt material samt ekosystemspecifika analyser. Den empiriska analysen som genomförts i detta projekt kommer att bidra till att identifiera innovationsekosystem och deras effekter. Referensramen för att undersöka innovationsekosystemens effekter och fallstudierna utgör en grund för konsekvensbedömningen.

Resultaten av den statistiska analysen visar att det finns en stark koppling mellan företagens deltagande i innovationsekosystem och framgångsrika innovationsresultat. Det är dock inte möjligt att identifiera orsakssamband mellan innovationsekosystemens effekter.

Särskild fokus på innovationsekosystemens roll i ökat externt FoUI-samarbete och i dess samhällspåverkan samt skapande av innovationer som gynnar samhället bör uppmärksammas, när man undersöker innovationsekosystemens effektivitet.
I rekommendationerna betonas vikten av långsiktig innovationspolitik och övervakning, vikten av samarbete samt att politiken utformas och genomförs på ett effektstyrt sätt.



| | | | |
|---|---|---|---|
| **Klausul** | Den här publikation är en del i genomförandet av statsrådets utrednings- och forskningsplan.(tietokayttoon.fi) De som producerar informationen ansvarar för innehållet i publikationen. Textinnehållet återspeglar inte nödvändigtvis statsrådets ståndpunkt. | | |
| **Nyckelord** | forskning, forkningsverksamhet, innovationsverksamhet, innovationspolitik, verkningsfullhet | | |
| **ISBN PDF** | 978-952-383-480-4 | **ISSN PDF** | 2342-6799 |
| **URN-adress** | https://urn.fi/URN:ISBN:978-952-383-480-4 | | |

# Contents

# Suomenkielinen tiivistelmä
## (Finnish summary)

Innovaatiot syntyvät enenevissä määrin useiden toimijoiden monitieteisen ja poikkisektoraalisen yhteistyön tuloksena. Näitä innovaatiotoiminnassa syntyviä eri toimijoiden muodostamia kokonaisuuksia kutsutaan innovaatioekosysteemeiksi. Yleensä innovaatioekosysteemeillä viitataan yritysten ja niiden alihankintaverkostojen, asiakkaiden tai loppukäyttäjien, tutkimustoimijoiden, julkisen sektorin ja esimerkiksi sijoittajien välisiin vuorovaikutussuhteisiin ja riippuvuuksiin. Innovaatioekosysteemeillä tunnistetaan olevan yhä tärkeämpi rooli innovaatio- ja teollisuuspolitiikan täytäntöönpanossa alueellisella, kansallisella ja EU:n tasolla.

Erityyppisten ekosysteemien merkityksen ja vaikutusten arviointi ja mittaaminen on vasta kehittymässä niin kansallisesti kuin kansainvälisestikin. Ekosysteemien vaikutusten arviointi on erittäin monimutkaista, eikä aiempi kirjallisuus ole toistaiseksi tarjonnut yleistettävää tapaa mitata innovaatioekosysteemien vaikutuksia. Ekosysteemien heterogeenisuus ja niille ominainen ainutlaatuisuus tekevät vaikutusten tarkastelusta ja tutkimusmenetelmien soveltamisesta haastavaa. Innovaatiopolitiikan vaikutusten arviointia tehdään edelleen hyvin perinteisistä lähtökohdista, eikä nykyinen tiedonkeruu riitä kuvaamaan etenkään laajempia yhteiskunnallisia muutoksia tai hyötyjä tavoittelevan, ja yhä hienojakoistuvan, innovaatiopolitiikan vaikutuksia.

Tämän selvityksen tausta kumpuaa innovaatiopolitiikan muutoksista ja käyttöön otettujen innovaatioekosysteemien vahvistamiseen liittyvien politiikkainstrumenttien nostattamasta tarpeesta ymmärtää ja saada tarkempaa tietoa innovaatioekosysteemien merkityksestä ja vaikutuksista. Selvityksessä on tehty kirjallisuuskatsaus, innovaatioekosysteemien lähtökohtiin liittyvä tilastollinen analyysi, innovaatiopolitiikan vertaileva analyysi Suomessa ja muutamissa verrokkimaissa sekä innovaatioekosysteemien tapaustutkimukset. Kirjallisuuskatsauksessa on syvennytty olemassa olevaan kirjallisuuteen innovaatioekosysteemien määrittelystä sekä vaikuttavuuden mittaamisesta ja sen haasteista. Tilastollista analyysiä koskevassa luvussa on käyty läpi käytettävissä olevia menetelmiä ja aineistoja sekä niihin perustuvia tuloksia. Analyysien avulla on

päästy kiinni ensinnäkin toimialaklusterien ja sitä kautta mahdollisten ekosysteemien tunnistamiseen yritystoimipaikkatason tietojen avulla. Ekosysteemeihin osallistumisen mahdollisia vaikutuksia on pyritty arvioimaan käyttäen Tilastokeskuksen yritystason aineistoja, jotka sisältävät tietoja yritysten yhteistyösuhteista innovaatiotoiminnassa. Tarkastelun avulla on pyritty tunnistamaan ulkoisen TKI-yhteistyön yhteyksiä erilaisiin yritystason mittareihin, kuten innovaatioiden todennäköisyyteen, työllisyyteen ja tuottavuuden kasvuun.

Olemme pyrkineet arvoimaan innovaatioekosysteemien vaikuttavuuden tarkastelua erityisesti innovaatiopolitiikan laajemmasta, yhteiskunnallisesta näkökulmasta. Raportissa on esitetty viitekehys innovaatioekosysteemien laajempien vaikutusten tarkastelulle. Innovaatioekosysteemien tyypittelyn ja niiden vaikuttavuuden arvioinnin viitekehyksen avulla on tehty tarkempi case-analyysi viidestä innovaatioekosysteemistä. Mallinnettu innovaatioekosysteemien vaikutusdynamiikka auttaa hahmottamaan millaisten polkujen kautta erilaiset tavoitellut ja mahdolliset vaikutukset syntyvät. Lisäksi laaditut vaikuttavuusmallit tuovat esille keskeisiä näkökulmia, mihin vaikuttavuuden tarkastelussa ja mittaamisessa olisi kiinnitettävä huomiota.

Käytettävissä olevien aineistojen ja menetelmien osalta työssä on jouduttu toteamaan useita rajoitteita. Innovaatioekosysteemien tunnistaminen, määrittely ja vaikuttavuuden mittaaminen ja todentaminen on haastavaa. Innovaatioekosysteemien kausaalivaikutuksia ei pystytä mittaamaan nykyisillä menetelmillä ja aineistoilla eikä niiden yhteyttä syntyviin laajempiin yhteiskunnallisiin vaikutuksiin ole mahdollista arvioida käyttäen kehittyneitä tilastollisia menetelmiä. Kausaalianalyysin näkökulmasta haasteita tuottavat muun muassa ekosysteemeille tyypillinen itseorganisoituminen ja orgaaninen dynamiikka. Jo pelkästään innovaatioekosysteemien ja tarkasteltavan toimijajoukon rajaamisen vaikeus haastavat vaikuttavuuden tarkastelua ja mittaamista. Lisäksi esimerkiksi alue- ja toimialarajoista irtautuminen tekee tilastollisista tarkasteluista entistä haasteellisempaa.

Innovaatioekosysteemit rakentuvat ja ponnistavat eri lähtökohdista ja ovat siis jo lähtökohdiltaan hyvin erilaisia. Tässä työssä käytettiin kolmijakoa tiede- ja tutkimuslähtöisiin, liiketoimintalähtöisiin ja alueellisesti juurtuneisiin innovaatioekosysteemeihin, mikä osoittautui varsin käyttökelpoiseksi analyysitarkoituksissa ja erilaisten vaikutuspolkujen hahmottamisessa. Vaikka ekosysteemeissä on yhteisiä piirteitä, niiden vaikuttavuuspolkujen mallintaminen ja tarkastelu edellyttää ekosysteemien erityispiirteiden ja erilaisten lähtökohtien huomioimista ja ekosysteemikohtaista tarkastelua. Vaikutusten ajalliset erot ovat myös huomattavia riippuen ekosysteemistä. Tämä nostaa esille tarpeen hyödyntää ja yhdistellä monipuolisia aineistoja laajempien vaikutusten tunnistamiseksi ja tarkastelemiseksi.

Aineistoanalyysiin perustuva tarkastelumme osoittaa, että tilastollisten menetelmien hyödyntäminen innovaatioekosysteemien tunnistamisessa voi olla hyödyllinen, joskaan ei yksinään riittävä askel innovaatioekosysteemien havaitsemiseksi. Tilastollisen tarkastelun tulokset kertovat vahvasta yhteydestä innovaatioekosysteemeihin osallistumisen ja tuloksekkaan innovaatiotoiminnan välillä. Tulokset kertovat myös ekosysteemeihin osallistumisen ja muiden yritystason tulosten, kuten työllisyyden ja palkkojen kasvun, välisistä positiivisista vaikutuksista, mutta tämä yhteys on paljon heikompi. Tehtyjen tilastollisten tarkastelujen perusteella emme kuitenkaan pysty tunnistamaan innovaatioekosysteemien vaikutusten syy-yhteyksiä.

Yhteiskunnan ja innovaatiopolitiikan näkökulmasta innovaatioekosysteemien vaikuttavuuden tarkastelussa ja mittaamisessa tulee kiinnittää huomiota erityisesti kahteen näkökulmaan: 1) innovaatioekosysteemien merkitykseen TKI-yhteistyön lisääntymisessä ja fasilitoinnissa sekä 2) yhteiskuntaa laajemmin hyödyttävien innovaatioiden syntymiseen ja yhteiskunnallisten muutosten vauhdittamiseen.

Ensinnäkin innovaatioekosysteemien vaikuttavuuden tarkastelu edellyttää huomion kohdistamista eri toimijoiden välisiin riippuvuussuhteisiin ja vuorovaikutukseen sekä siihen, mitä syntyy näiden eri toimijoiden vuorovaikutuksen tuloksena. Kyse on laajamittaisesta resurssien ja kyvykkyyksien mobilisoinnista ja yhdistämisestä TKI-toiminnassa. Toiminnallisesti kyse on yhteiskehittävästä ja avoimemmasta TKI-toiminnasta. Lisäarvo syntyy erityisesti tiedon siirtymien tehostumisesta ja kehityssyklin nopeutumisesta. Vaikuttavuutta tulee siis lähtökohdiltaan tarkastella syntyvän tiedon ja osaamisen ”läikkymisen” ja kumuloitumisen kautta.

Toiseksi case-tarkastelut innovaatioekosysteemeistä osoittavat, että erilaiset ekosysteemit voivat parhaimmillaan vastata merkittäviin yhteiskunnallisiin muutoksiin ja haasteisiin. Yhteiskunnallisten haasteiden ratkominen edellyttää systeemisiä ratkaisuja, joita yksittäisten toimijoiden on mahdotonta yksinään saavuttaa. Ekosysteemeillä tavoitellaan laajempia ja kokonaisvaltaisempia sekä nopeammin syntyviä vaikutuksia. Tästä syystä ekosysteemin vaikutuksia arvioitaessa tulee kiinnittää huomiota TKI-toiminnan sisällölliseen suuntaamiseen sekä innovaatioiden laadulliseen ja määrälliseen näkökulmaan: miten ekosysteemi ja syntyvät innovaatiot hyödyttävät yhteiskuntaa ja miten innovaatiotoiminnan vaikutukset skaalautuvat yhteiskunnassa.

Innovaatioekosysteemien nousu innovaatiopolitiikan keskiöön muuttaa vaikuttavuusarvioinnin työkalupakkia. Vaikuttavuuspolkujen mallintaminen ja jaetun syvemmän ymmärryksen rakentaminen innovaatioekosysteemeillä tavoitelluista vaikutuksista on ainakin ensimmäinen askel päästä kiinni vaikuttavuuteen ja myös tarkempaan mittarointiin. Tämä edellyttää samalla sitä, että nämä vaikuttavuuspolut ovat ekosysteemien (keskeisten) toimijoiden tunnistamia ja johtamia.

Ekosysteemien vahvistamiseen liittyvät politiikkainstrumentit ja rahoitus ovat perusteltavissa erityisesti missiolähtöisen ja transformatiivisen innovaatiopolitiikan näkökulmasta. Muut rahoitus- ja politiikkainstrumentit eivät välttämättä aja yhtä tehokkaasti näitä tavoitteita eteenpäin. Uusi ekosysteemipolitiikka ei kuitenkaan poista tarvetta muille innovaatiopolitiikan välineille.

Lopuksi on syytä nostaa esille, että käytettävissä ei ole vielä riittävästi tietoa ekosysteemien kehittämiseen tähtäävien instrumenttien vaikuttavuudesta pitkällä aikavälillä ja siksi näitä instrumentteja ja niillä rahoitettuja ekosysteemejä on seurattava pitkäjänteisesti. Tässä työssä huomion arvioisina ekosysteemeihin ja erityisesti niiden julkiseen rahoitukseen liittyvinä riskeinä ovat mm. markkinahäiriöiden syntyminen. Julkisen tuen ohjautuminen yhä harvemmille toimijoille voi pahimmillaan antaa ekosysteemin tuetuille yrityksille epäreilua kilpailuetua ja vääristää kilpailua.

Työn keskeiset suositukset ovat:

1. Innovaatioekosysteemien vaikutukset syntyvät pitkällä aikavälillä, jolloin niiden kehitystä on tuettava pitkäjänteisen ja vaikuttavuusohjautuvan innovaatiopolitiikan ja instrumenttien avulla.
2. Jotta saavutetaan laajoja yhteiskunnallisia vaikutuksia, innovaatiopolitikan instrumenttien tulisi vahvistaa eri lähtökohdista rakentuvia ja eri vaikutuspolkuihin kiinnittyviä innovaatioekosysteemejä (tiede-, liiketoiminta- ja aluelähtöiset innovaatioekosysteemit). Tällöin instrumenteilla on myös parhaimmillaan toisiaan tukevia vaikutuksia.
3. Julkista rahoitusta saavien innovaatioekosysteemien tulisi mallintaa TKI-yhteistyön tuloksena odotetut vaikutukset ja vaikutuspolut. Tämä tarkoittaa vaikuttavuuden logiikan tarkempaa avaamista panosten ja toiminnan kautta syntyvistä odotetuista tuloksista ja edellisten yhteyksistä pitkän tähtäimen vaikutuksiin. Mallintaminen auttaa vaikutusten ja TKI-rahoituksen merkityksen tarkemmassa arvioinnissa sekä toimii työkaluna ekosysteemin toimijoille itselleen.
4. TKI-rahoittajien tulee tehdä nykyistä vahvempaa yhteistyötä innovaatioekosysteemeihin kiinnittyvän vaikuttavuustiedon keräämiseksi ja kansallisesti seurannan menetelmien kehittämiseksi. Rahoittajilta edellytetään jatkuvampaa ja rullaavaa seurantaa innovaatioekosysteemien ja niissä tapahtuvan TKI-yhteistyön kehityksestä sekä siitä, miten ekosysteemi ja syntyvät innovaatiot hyödyttävät yhteiskuntaa ja vaikutukset skaalautuvat yhteiskunnassa.
5. Suomen TKI-rahoittajien tulee tiivistää kansainvälistä yhteistyötä innovaatioekosysteemien vaikuttavuuden ja vertailtavuuden parantamiseksi. Suomella on ekosysteemien kehittämisessä vahva edelläkävijän rooli, mikä tarjoaa samalla suomalaisille innovaatioekosysteemeille ja organisaatioille mahdollisuuksia vahvistaa konkreettisesti kansainvälistä yhteistyötä. Lisäksi tämän tutkimuksen osana tehty tilastollinen analyysi ja käytetty yhteiseurooppalainen innovaatiotoiminta -tutkimuksen (CIS) aineisto tarjoaa vaikutusten arvioinnin ja datan näkökulmasta lähtökohtia laajemmalle kansainväliselle yhteistyölle ekosysteemien tunnistamisessa, vertailussa ja analysoinnissa.

# 1 Introduction

## 1.1 Assessing the impacts of innovation ecosystems

Innovations, new products and services increasingly emerge as a result of multidisciplinary and interdisciplinary cooperation between numerous actors. These entities, built on the interdependent relations between different actors in innovation activities, are called innovation ecosystems. Usually, innovation ecosystems are referred to in the context of the emerging interdependencies between companies and their subcontracting networks, customers or end-users, research actors, the public sector and, for example, investors.

Innovation ecosystems are recognised as having an increasingly important role in the implementation of innovation and industrial policies at the national, regional and EU levels. The use of the innovation ecosystem concept has increased rapidly in recent years not only in policy action but also in academic research. Several studies have been conducted in Finland and internationally, examining innovation ecosystems, their development and significance from various perspectives.

Thus, the starting point for this study is based on both the needs arising from changes in innovation policy and its instruments and the question of how to obtain more detailed information on the impacts of innovation ecosystems and their innovation activities in general. Evaluation of innovation policy's impacts is, however, still carried out in a very traditional manner and, as such, the evaluation and measurement of these impacts has not been able to successfully monitor innovation policy change in real time.

Nevertheless, assessment and measurement of the significance and impacts of different types of ecosystems, both nationally and internationally, is still evolving while the assessment process itself remains a complex undertaking. The previous literature on innovation ecosystems has not yet provided a generalisable way to measure ecosystems and their impacts. The heterogeneity of the definitions of ecosystems and the uniqueness that characterises them makes it challenging to examine their impacts and to study and apply research methods. The analysis of impacts is further complicated by the self-organisation and organic dynamics of ecosystems. Thus, current ways of measuring innovation policy and data collection do not sufficiently capture the impacts of policies, particularly those pursuing wider societal changes and benefits.

This report consists of a literature review, a statistical analysis of the starting points for innovation ecosystems study, an analysis of innovation policy in Finland as well as a few comparison countries and a suite of case studies highlighting various innovation ecosystems. The literature review delves into the existing literature on the definition of innovation ecosystems and the measurement of effectiveness and its challenges. The statistical analysis chapter introduces the available data and methods for investigating innovation ecosystems and the results based on this analysis. First, the identification of industry clusters has led to the identification of potential ecosystems using raw firm- and plant-level data. Second, an empirical review of enterprise-level cooperation dynamics in innovation activity using Joint European Community Innovation Survey (CIS) data shows the potential impacts of ecosystem participation. The empirical investigation of firm-level collaboration patterns is then used to investigate the possible impacts of ecosystem participation and to identify the relationship (correlation) between external RDI cooperation and various firm-level performance measures, such as the propensity to innovate, as well as employment and productivity growth.

The comparative analysis of Finnish innovation policy and selected peer countries describes in more detail from which perspectives the examination of the impacts of innovation ecosystems is motivated. Based on the above, the report presents a framework for examining the wider impacts of innovation ecosystems. By utilising the presented framework for assessing the impacts of innovation ecosystems and the characterisation of innovation ecosystems, we carried out a more detailed case analysis of five innovation ecosystems. The modelled impact dynamics of different types of innovation ecosystems helps to outline the pathways through which different intended and potential impacts emerge. In addition, the developed impact models highlight key aspects that should be taken into account when reviewing and measuring impacts.

## 1.2 Changes and transitions in the narratives, realities and processes of innovation policy and innovation ecosystems

### Defining the ‘innovation ecosystem’ and related concepts

In this study, the notion of **impact** used **refers in particular to the wider societal impacts of innovation ecosystems**. The definition of impact is then derived from the perspective of innovation policy, i.e., how the innovation ecosystems and their activities, business and organisation-level impacts ultimately lead to the desired societal-wide benefits and impacts.

Innovation policy has traditionally sought to influence the development and uptake of innovation. Innovation has been seen as a key means of raising productivity, supporting economic and employment growth and increasing the well-being of citizens. In particular, innovation policy has expanded and deepened at the same time over the last decade. Widening here refers to addressing broader societal issues that cut across different policy sectors, such as climate change or sustainability challenges. At the same time, the actual policy actions and instruments have become more fragmented and increasingly targeted. This simultaneous development of a so-called mission-based and increasingly tailored innovation policy is well reflected in the rise of innovation ecosystems at the heart of innovation policy (e.g., Borrás 2009; Laasonen et al. 2020).

The concept of the innovation ecosystem has been used to describe various entities formed around business and innovation activities. It has garnered widespread attention especially in the literature on strategy, entrepreneurship, innovation and technology management (e.g., Adner & Kapoor, 2010; Gomes et al. 2018). The use and definition of the term has however remained unclear and somewhat volatile, at least in part due to its novelty. On the other hand, the use of the innovation ecosystem concept in versatile contexts leads, understandably perhaps, to quite different understandings and interpretations. Furthermore, the innovation ecosystem concept relates to many other ecosystem concepts, such as the industrial ecosystem, the business ecosystem, the start-up ecosystems and related concepts, such as platform management and multi-actor networks (see e.g., Tsujimoto et al. 2018; Sipola et al. 2016).

In this study, the innovation ecosystem concept is discussed and scrutinised from the perspective of innovation policy. In the past, innovation policy measures were designed and implemented by following the key ideas of value chains and networks, clusters and innovation systems, to name but a few examples. All those concepts basically describe sets of companies and other actors who collaborate in order to be competitive together, to deliver more value to end customers, create innovations and to achieve broad societal goals. All those concepts have their own characteristics and emphases (Table 1). Thus, all have contributed to the development of innovation policy measures. In this respect, the innovation system approach has been most influential, primarily by emphasising the importance of well-functioning institutions and versatile interaction relationships.

*Table 1. Examples of innovation policy concepts*[1]

| | VALUE CHAIN AND VALUE NETWORK | CLUSTER | INNOVATION SYSTEM | INNOVATION ECOSYSTEM |
|---|---|---|---|---|
| ***Description*** | A chain or a network built by a leading company. The exact tasks, requirements and prices for the actors in the chain or network are defined on a contractual basis. The value network is a model of cooperation between connected parties that generate value for the end customer. | A set of companies from a certain industry and related industries (both vertical and horizontal) and public bodies. | All relevant economic, social, political, organisational and institutional factors influencing the development, diffusion and use of innovation | A set of different actors sharing a common goal. The actors are interdependent, interacting and learning from each other. The innovation ecosystem acts as an environment for the co-creation of innovation and there are at the same time parallel, crossing and even competing networks within the same ecosystem. |
| ***Members and actors*** | Companies have the mutually supportive skills required to deliver products, services or projects together. | Companies typically share the same knowledge base, business logic and value chains (typically a specific industry and regionally related companies and knowledge networks) | Interaction between companies, research actors, government and public (and semi-public) actors and users. The geographical scope varies from local to supranational, typically regional and national innovation systems | A heterogeneous group of actors with versatile backgrounds addressing common challenges related to technology, business and social problems (e.g., wicked problems). |
| ***Dynamics*** | Value chains are based mainly on bilateral collaboration relations, whereas value networks are more multidimensional. Roles and tasks in relation to competence sharing are well-defined. | The competitive environment between companies may limit collaboration, similar knowledge and skills challenge renewal of the cluster. | Focus on the functioning of the system and its institutions as a whole, as well as the interaction (e.g., knowledge sharing) between and among actors regionally and nationally | Competition and collaboration between and among actors are typical; the diversity of actors contributes to system durability |
| ***Theoretical background*** | Porter 1990, Stabell, Charles & Fjeldstad 1998 | Porter 1990 | Freeman 1987, Lundvall 1992, Edquist 1997 | Moore 1993 and 1996, Autio and Thomas (2014) |

In this study, an **innovation ecosystem refers to a set of different actors around the creation and exploitation of new knowledge**. In most cases, innovation ecosystems consist of interdependencies between companies and their subcontracting networks, customers or end-users, research actors, the public sector and investors, and flows of information, people, finance and services. It is however essential for the definition that attention is paid to those factors that are relevant to the performance of the innovation activity of an individual actor and a set of actors (Granstrand & Holgersson 2020).

[1] Modified from Valkokari, K., Hyytinen, K., Kutinlahti P. & M. Hjelt (2020)

Other concepts related to the notion of innovation ecosystem include research ecosystems, start-up ecosystems and the business ecosystem. The goal of the information and research ecosystem is to produce new information. Its key players are, for example, researchers, universities, research institutes, students, etc. At the heart of the start-up ecosystem, we can find entrepreneurs, start-ups, investors, business incubators and ecosystems built around the company or its product, each with the aim of exploiting and commercialising information. The different ecosystem concepts are not mutually exclusive but rather are partly overlapping and parallel, focusing on a specific ecosystem objective or environment. In comparison to previous policy concepts, in innovation ecosystems the focus is even more on the interdependence of different actors, the relationships and interactions between actors and evolutionary developments. It is also distinctive of this mode of operation that these interdependences can be quite versatile; there may exist at the same time parallel, intersecting or even competing networks within the same innovation ecosystem.

## Finnish and European policy perspectives

In Finland, the development of innovation ecosystems has become an increasingly visible part of national and regional innovation policy and its implementation. In the 21st century, particularly since the launch of the National Innovation Strategy in 2008, innovation policy in Finland has begun to place greater emphasis on global innovation ecosystems and “ecosystem development” alongside the more locally-tuned cluster concept and cluster development.

A major change in innovation policy compared to the past is that policies and instruments are increasingly targeting an identifiable ecosystem with policies increasingly focused on strengthening the effectiveness of the ecosystem as a whole as well as the conditions for its innovation. Where more attention is paid to companies in the same business segment in cluster policy, the development of innovation ecosystems is often motivated by a societal challenge or a change trend at the phenomenon level which also involves significant business opportunities. At the same time, responding to developments requires new, broader multidisciplinary cooperation in RDI activities rather than the more traditional sector-specific approach to cooperation, as well as the pooling of resources and expertise of different actors.

The National RDI Roadmap (2020) states that in order to strengthen, broaden and increase the effectiveness of knowledge networks, research and its networks need to be grouped into larger clusters and ecosystems. Innovation ecosystems are thus seen to play a significant role in making the government's goal of raising Finland's research and development spending to 4% of GDP by 2030 possible. The importance of innovation ecosystems in terms of long-term goals is strongly linked to the diversification of Finland's economic structure and improvements in productivity development. Addressing societal challenges requires risk-sharing between companies and the public sector, as well as an increasingly strong partnership between participating actors. In Finland, an ecosystem-based innovation policy has also been justified in response to the challenges of transformative innovation policy, such as the systemic challenges related to the coordination of demand and policy-learning.

European innovation policy has also begun to emphasise the importance of industrial ecosystems. Current EU policy emphasizes that there is a need to focus on specific technologies, but also to look carefully at the opportunities and challenges of industrial ecosystems. National ecosystem actions also play a key role in implementing the EU's recovery package and industrial strategy. In connection with the announcement of the recovery package, the Commission presented 13 industrial ecosystems that it considered to be of major importance to the EU[2]. The Commission will also use industrial ecosystems to assess economic recovery and develop ecosystem-specific policies.

## 1.3 Objectives and research questions of the study

The INNOVA project examined innovation ecosystems, particularly from the perspective of their expected impacts and indicators, by means of which they can be monitored. The project was implemented between March 2021 and February 2022. The aim is to provide information and create tools to help better understand the impact of innovation ecosystems and the different paths from inputs to the various wider impacts created. Thus, the project has developed impact assessment and ecosystem measurement tools promoting RDI activities. The ultimate aim here is to support the evaluation of the impacts of policies supporting innovation ecosystems. These are implementation of the measures in the national RDI roadmap, reflection on partnership models for private-public RDI cooperation, ecosystem agreements between the state and university cities and implementation of the EU recovery package and its industrial strategy.

The main research questions in this study were as follows:

- What is known about the impacts of innovation ecosystems based on previous research?
- What are the aims of the different kind of ecosystems and how should they be defined from the perspective of their impacts?

[2] https://euclidnetwork.eu/2020/07/social-and-proximity-economy-recognised-as-key-industrial-ecosystem-in-europe/

- What existing data can be used to assess the impacts of innovation ecosystems? And what kinds of data should be collected to better study the impacts of ecosystems?
- To what extent do Finnish companies participate in different ecosystems and what kinds of partnerships do ecosystems build on? What kinds of links to participation in innovation ecosystems can be identified for business success?
- How should the impacts of innovation ecosystems be assessed and by what indicators?

The structure of the report is as follows. In the next section the project's data, methods and the empirical context are introduced. The third section discusses the theoretical foundations in respect of measuring innovation (and related) ecosystems and their impacts. The rest of the third section deals with empirical and statistical analysis of innovation ecosystems. In the fourth section we analyse innovation policy in Finland and a few peer countries from the perspective of innovation ecosystems. On that basis, in the fifth section we propose a framework to analyse the impacts of innovation ecosystems. In the sixth section, the case studies on innovation ecosystems are analysed. The final section presents the main conclusions and discusses their implications for policy and research.

# 2 Methods and data

The main methods used in this work were desk study, background interviews, statistical analysis and case studies. These approaches are outlined in greater detail in the following sub-sections. In addition, two workshops were held in the context of the fourth working package to discuss the results and conclusions of the project. The first workshop was held on November 30, 2021. In addition to the organisations involved in the project and its data collection, representatives of various ministries and government agencies, as well as representatives of the business community and researchers were invited to participate in the event. The purpose of the workshop was to present the preliminary results of the study and to discuss the impacts of innovation ecosystems. In addition, based on the results, options and pathways for further developing innovation ecosystems and their impact assessment were also considered together with the participants. A second workshop was held on 3 February 2022 for representatives of various ministries and the parties responsible for RDI funding and for collating statistics on RDI activities. The purpose of the workshop was to discuss and verify the main conclusions of the study.

## 2.1 Desk study and background interviews

The desk study consists of a synthesis of the recent scientific literature and studies related to innovation ecosystems and their impacts. The literature review brings together the current state of play in terms of innovation ecosystems and the challenges of measuring their impact, as well as the materials and methods used. In addition to the literature review, background interviews were conducted as individual or focus group interviews. In these interviews, representatives from the ministries and government agencies, as well as researchers in innovation policy and innovation ecosystems fields in Finland and abroad were interviewed (see appendix 1). With the help of the desk study and expert interview results, the framework of this study was refined such that the perspectives of examining different ecosystems and impacts were more fully taken into account.

We have also examined the current state of innovation policy in four European reference countries, in particular, through documentary data and additional interviews, on how innovation ecosystems and their roles are reflected in the innovation policies and instruments of the reference countries. The country cases covered were the United Kingdom (in particular the Catapult programme), Belgium (in particular the Flanders Make strategic research centre), Sweden (in particular the strategic innovation programmes) and Denmark (in particular the innovation networks).

## 2.2 Statistical analysis

Our empirical analysis consists of two main parts. First, we look at the presence of clusters by using indicators of co-agglomerations and of industry concentration, in tandem with plant-level data obtained from Statistics Finland databases. In the second part, we adopt simple regression techniques to gauge the correlation between ecosystem participation (proxied by collaboration with external partners) and various firm-level outcomes. The data used to carry this analysis is based on a number of firm-level and worker-level sources, all of which are again obtained from Statistics Finland.

For the co-agglomeration analysis we rely on the co-agglomeration index formulated in Ellison, Glaeser and Kerr (2010) and we apply it to two different geographical scales (municipalities and regions). Formally, with industry *i* employment share for area *r* denoted as $s_{ir}$, and relative size of the area (e.g., share of aggregate employment) denoted as $x_r$, the co-agglomeration index for pairs of industries 1 and 2 is given by:

$$\gamma_{12} = \sum_r (s_{r1} - x_r)(s_{r2} - x_r)/(1 - \sum_r x_r^2). \qquad (1)$$

A higher index for two industries implies that establishments operating in those industries tend to be located in the same area. Following the example of Ellison, Glaeser and Kerr (2010) we use a threshold value of 0.1 to indicate a significant co-agglomeration. To analyse the degree of clustering of individual industries we rely on location quotients which are the ratio of the share of employment in a given industry and area, divided by the share of employment for the industry of interest at the national level. Denoting $x_{ir}$ as the employment of industry *i* in region *r*, and $x_i$ as the total employment of industry *i* at the national level, the location quotient for industry *i* in area *r* is given by:

$$LQ_{ir} = \frac{x_{ir}/x_r}{x_i/x}. \qquad (2)$$

A location quotient above one means that a given industry is overrepresented in an area. Following Malmber and Maskell (2002) we use 3 as the threshold value to indicate a meaningful geographical concentration. For both these two analyses, we rely on establishments-level, and we use the Standard Industrial Classification TOL 2008 at 2 and 3-digit levels, depending on the specific exercise.

As mentioned above, for the analysis on collaborations between firms and different external partners, we rely on simple cross-sectional and panel regression techniques, to identify the relation (correlational) between ecosystem participation on various firm-level outcomes, such as the propensity to innovate, employment and productivity growth. For this exercise, the main data source is the Community Innovation Survey (CIS), for the years 2008, 2010, 2012, 2014, 2016 and 2018. For each survey wave, firms are asked numerous questions regarding their innovation activities and whether they have collaborated with various entities during the three most recent years (for example, for the 2010 wave, the survey refers to innovation activity between 2008 and 2010). Importantly for us, we have the possibility to link the firms participating in the survey to register-based information, both regarding the firms themselves and their employees. This wide variety of data allows us to study firm-level outcomes, such as productivity and employment growth, as well as employee-level indicators, such us the share of workers with university degrees or the share of workers starting their own firms.

## 2.3 Case studies on innovation ecosystems

The idea behind the case studies was to analyse various perspectives on the impacts of innovation ecosystems. This work ended up classifying innovation ecosystems into three: 1) science / research-based, 2) business-oriented, and 3) regionally- rooted innovation ecosystems. Altogether five different cases were selected for this study according to separately agreed criteria.

To create understanding of the functioning and impacts of innovation ecosystems, it was important to gather information from as wide a range of sources as possible. Each case study required a customised review and targeted data collection. The implementation process was all as follows. The **Desk study** is based on the materials obtained from the ecosystems and ecosystem actors which provided a general overview of the innovation ecosystem. The RDI project data from Business Finland for the period 2015 to 2021 was also used to form a general picture of the inputs and ecosystem actions. With the help of Business Finland, a search was made in the Business Finland project database and the RDI projects implemented by the ecosystem organisations. Analysis of the project data was carried out by means of a qualitative and descriptive review. In addition, data from Invest in Finland concerning foreign investments in Finland between 2016 – 2021 were used as secondary material.

After the desk study an **in-depth interview** was carried out with the key actor(s) of the ecosystem under consideration. The interview was carried out to deepen the picture of the features of the innovation ecosystem and the impacts that the ecosystem is expected to have on different actors and more broadly. After this first interview **a web-based survey or more interviews** were carried out with the ecosystem actors. The idea here was to gather together the views of different ecosystem organisations on

RDI cooperation and features, functioning in ecosystems both more generally and more specifically in relation to the case ecosystem. In addition, the significance and impacts of innovation ecosystems on one's own organisation / society at large was also mapped out.

After the collection of this data the attributes of each innovation ecosystem case was analysed: 1) structure, 2) goal(s), 3) interdependencies and 4) temporal dimension. The aim here was to develop and analyse impact pathways for each case ecosystem: 1) Inputs and actions, 2) outputs and outcomes and 3) wider impacts. The results of each case study were presented in a **focus group interview** and discussed and validated with the key actor(s) of each ecosystem.

# 3 Setting the scene for the statistical analysis of innovation ecosystems

This chapter examines, in greater detail, the starting points for the statistical analysis of innovation ecosystems. The key messages of the chapter are:

- Innovation ecosystems and their impacts are hard to tackle empirically, especially causally.
- We rely on approximations such as the formation of local clusters and collaboration patterns among firms to identify ecosystems and their effects.
- Cluster analysis offers a first step towards identifying innovation ecosystems
- Participation in innovation ecosystems is strongly related to better firm-level innovation performance, but less so with employment and productivity growth
- We need new data sources to improve the identification of ecosystems, including surveys and text-based analyses. The costliness of data gathering should be assessed in the light of the difficulty to establish causal links
- While the clear relation with innovation is promising, their impact assessment should take into account possible side effects such as crowding-out and diminished competition

## 3.1 Summary of the literature review

In this section, we summarise the main findings we can draw from the previous literature on measuring innovation (and related) ecosystems and their impacts, while we report a more detailed survey (with references to specific works) in Appendix 4. It is helpful to separate the review of the previous literature into two main branches: economics and management science.

**The two literatures examined here provide a trade-off:** while the economic literature is characterised by a lack of focus on the “ideal” (in the sense of corresponding to the theoretical definition) ecosystem concept, it compensates by providing generalisable quantitative results, even uncovering causal relations which can be useful in policymaking. On the other hand, the management literature has extensively addressed the ecosystem concept, but lacks a generalised quantitative analysis, especially a causal one. Instead, management science works have usually relied on specific cases to collect empirical evidence and to gauge the impacts of ecosystems (usually restricting their focus to the members of the ecosystems).

## Economics

**The economics literature has not touched the innovation ecosystem phenomenon explicitly, while it has extensively covered similar concepts such as innovation clusters and knowledge spillovers.** These concepts have however been considered distinct from innovation ecosystems in multiple previous works. Nevertheless, ecosystems, clusters and networks do share a number of features, such as the importance of cooperation between different entities, making them relevant for this study.

In terms of identifying and measuring the presence of clusters, the economics literature has relied on input-output linkages between industries, as well as the tendency to rely on similar types of occupations and knowledge (proxied by patents). Moreover, many previous studies have looked at location-based correlation measures which indicate how much establishments of different industries tend to locate in the same area. Another strand of research has abstracted from inter-industry relations, focusing instead on the geographical concentration of individual industries. A good example of this is offered by the location quotient which is the ratio between the employment (other measures can be used) share of a given industry in a given location and the share of employment for the same industry at the national level.

In terms of the impacts generated by the presence of clusters and industrial co-agglomerations on the firms belonging to the clusters, as well as on the areas where they are located, **previous works have found that participation in clusters positively affects the capacity of firms to innovate**, also through indirect spillovers. Moreover, other studies have reported a positive association between the presence of clusters and start-up creations, as well as with productivity growth. A related interesting strand of literature which is particularly relevant for innovation ecosystems, is concerned with knowledge spillovers. Multiple works have identified the positive impact of knowledge spillovers across areas and individuals, in terms of innovation activities and research.

## Management Science

**The management science literature has dealt with the concepts of innovation, entrepreneurial and business ecosystems much more extensively than the economics one, even though quantitative and generalisable studies are few**.

Instead of proposing standard methods to measure ecosystems, previous studies have concentrated on mapping networks starting from specific focal firms or industries, known *a-priori*. **Visualisation techniques have been used to map networks**

**of firms and entities which can be deemed to form an innovation (or business) ecosystem**, while proxies such as the prominence of firm-university collaboration and the presence of clusters have been used in more aggregate analyses. A more extensive literature has dealt with measuring the presence of entrepreneurial ecosystems at different geographical scales, providing a large set of indices, partly because of the strong emphasis on localisation.

Regarding the impacts of ecosystems, previous works have largely been interested in estimating the effect of (or rather the correlation between) ecosystem participation on firm performance, finding, usually, a **positive impact on measures such as sales growth and innovation activity**. It is, however, important to bear in mind that this literature is sparse**, it does not offer causal analyses** and it does not deal with aggregate effects. Similarly, in terms of the measurement of ecosystems, the literature on entrepreneurial ecosystems is, relatively speaking, more developed in terms of gauging impacts at different levels of analysis, typically finding positive effects on innovation and a generalised importance of healthy entrepreneurial ecosystems in order to stimulate economic growth.

### Conclusions

While the vastness of the literature does not allow us to draw some clear-cut conclusions, we can nevertheless attempt to relay some broad messages. First of all**, ecosystems are not easy to measure**, especially if we consider the global scale. On the other hand, if the focus is at a finer geographical level, multiple techniques can be used to measure the presence of clusters and networks. While multiple works emanating from both economics and management point to a **positive effect (or at least correlation) of ecosystems on their participants, the evidence regarding aggregate impacts remains however somewhat weaker** though there are multiple findings pointing to the beneficial impact of clusters and knowledge networks on the overall economic performance of the area in which they are located.

## 3.2 Introduction to the empirical analysis

In this part of the report, we conduct a statistical analysis of Finnish (innovation) ecosystems through the use of different empirical techniques. In particular, we adopt two main strategies in relation to two main objectives. **We want to measure the possible existence of ecosystems in different Finnish areas, using micro-level data**. To do so, we assume that the geographical dimension of innovation ecosystems is indeed important and here we employ econometric techniques drawn from the economic literature on clusters and agglomeration. In the second part of the analysis, **we**

**attempt to determine the impact of, or more precisely the correlation between, ecosystem participation on firm-level outcomes**, such as the tendency to innovate, employment and productivity growth. The crucial assumption in this part of the study is that collaboration between firms and entities such as universities is a signal of ecosystem participation. A more detailed description of the methods and data used in the empirical analyses can be found in Section 2.2.

The results of the analysis are wide ranging, so summarising them is not a straightforward task. First of all**, we observe that cluster measurement techniques do help the researcher in identifying possible ecosystems** and that the flexibility of these techniques can be useful in studying different types of ecosystems. On the other hand, they do not offer a completely hands-off approach, instead the researcher or practitioner needs to provide substantial subjective input to rationalise the results of the statistical models. Regarding the impact of ecosystem participation on different outcomes, **we find a substantial and robust correlation between belonging to an ecosystem and the likelihood to innovate**. Moreover, we find suggestive evidence that firms which belong to an ecosystem are more likely to grow in size, while results are weaker regarding productivity and wage growth. We also study the possible correlation between ecosystem participation and the tendency of employees of involved firms to start their own businesses, finding a negative correlation which perhaps suggests the enhanced ability of firms belonging to ecosystems to retain their employees.

The rest this section is divided as follows: in Section 3.3, we discuss in greater detail the empirical challenges which surround the measurement of ecosystems and their impacts, outlining why our empirical approaches, focused on local clusters and on collaboration patterns, can be helpful. In Section 3.4, we present the results of the agglomeration and cluster analysis, after providing a brief introduction of the techniques used. In Section 3.5 we turn our attention to the analysis of collaborations and firm-level outcomes, based on the CIS data. Finally, we draw some conclusions in Section 3.6.

## 3.3 Empirical challenges of ecosystem analysis

In this section we outline some of the main challenges in respect of the empirical analysis of ecosystems. We abstract from the theoretical side of the matter (such as the need for a precise definition of ecosystems) and instead focus on data-related problems. Firstly, we go over the **challenges faced when we want to measure and identify an ecosystem**, without an *a-priori* knowledge of its presence. Secondly, we describe **the empirical complexity of identifying a causal impact** of participation in ecosystems, even after assuming the ability to measure said participation or whether ecosystems exist in a geographical area. Finally, we propose possible way forward and introduce the approaches we use in our empirical analysis.

Ideally, we would like to be able to identify the existence of an ecosystem, and measure its relevance in terms of, e.g., employment, innovation and economic output, regardless of its geographical scale and of the types of entities belonging to it. This ideal scenario is in most cases however not feasible, with the data typically available. Researchers very rarely have direct access to firm-level information, specifically that needed to identify the actors belonging to an ecosystem, spanning multiple countries, especially when going beyond large firms. This means that we usually need to focus on innovation ecosystems which have a local focus, because otherwise the analysis would miss a substantial part of the ecosystem. Regarding the heterogeneity of actors forming an ecosystem, we need to remember that innovation networks encompass entities such as firms, local and national governmental bodies, as well as research institutes and universities. While data at the firm level are available, at least in Finland, offering a lot of information, things are much harder when looking at, e.g., universities. For example, we do not have extensive data on how significantly university inputs contribute to the innovation activity carried out in a potential ecosystem, let alone the impact of an ecosystem on the university.

Even if we assume that the relevant actors in an ecosystem are firms and that we can restrict our attention to more or less geographically contained ecosystems, we still face multiple challenges**. The typical data available to researchers does not offer information on the explicit links between firms** in terms of supplier-customer relationships and even less on relations such as collaborations in a research project. Moreover, the previous literature on clusters and networks has highlighted the importance of informal contacts between workers of different firms, something which is even harder to measure using the typically available micro data. These considerations point to the fact that **we need to take a step back from individual firms to consider the concept of clusters and industry-level connections**. As we will subsequently argue, the study of interconnected and over-represented industries in a given location can contribute important insights regarding the presence of ecosystems. There are, however, cases where we have more information regarding the degree to which a given firm collaborates with other entities. We can consider this as an approximation of ecosystem participation. While useful, this data is usually restricted to surveys and cannot provide information on specific ecosystems.

The analysis of the impacts of ecosystem participation on the various actors forming them, as well as on the economy where they are located, provides a **set of challenges** even if we assume that we are able to identify and measure the ecosystem in question. Firstly, innovation ecosystems are characterised by a self-organising and gradual lifecycle, without a sudden start and without strong external interventions, at least in their initial stage. Moreover, and even more problematically, **firms participating in an ecosystem self-select**, thus it is hard to argue that the entry of a firm into an innovation ecosystem can be considered as a randomised treatment. The fact that the activity of a given business can be just partially related to an ecosystem, as well as the overall loose definition of participation in an ecosystem, only further increases the level of complexity. For example, even if we can assume that a firm enters, by chance, an ecosystem, it might be hard to measure how much of the firm’s activity is involved in the ecosystem and how strong the ties are, meaning that **we may still not have a clear idea of the strength of the treatment**. The effect of the presence of an innovation ecosystem on the local economy is also very hard to measure, especially in a causal sense. Again, the main obstacle here is the fact that ecosystems are rarely formed on the basis of sudden, random, shocks, rather they tend to start life in light of favourable local conditions. If we accept the approximation of ecosystems by the use of clusters, approaches like the one proposed in Greenstone et al. (2010) can be useful, but their application would require the identification of a focal enterprise starting an ecosystem which is not simple.

## 3.4 Clusters analysis: searching for local ecosystems

The ecosystems literature did not identify geographical concentration as a necessary feature of innovation ecosystems. However**, many works either implicitly assume or explicitly posit that ecosystems are manifest in networks of firms and other entities which are relatively close to each other**. Following this line of thought allows us to rely on numerous approaches to identify the presence of ecosystems. Here, we use co-agglomeration indexes and location quotients, together with micro-level data, described in greater detail in Section 2.2.

In tables 1 and 2, we report the selected industries groups which show a strong degree of spatial co-agglomeration, measured using the index defined in (1). In Table 2 we consider results for the co-agglomeration index based on municipality-level breakdown and 3-digit-level industries, while in Table 2 we use regions as geographical units, while still considering 3-digit industries. Even though we computed the agglomeration Index for multiple years, we report the results only for 2019, the year for which the latest data are available.

*Table 2: Selected group of co-agglomerated industries, computed using (1). On the left column we report the selected industry, while on right column we report some of the industries which display, in relative terms, a large conglomeration index (reported in parenthesis).*

| **Industry** | **Correlated industries ($\gamma_c$ in parentheses)** |
|---|---|
| Support activities for other mining and quarrying | Mining of non-ferrous metal ores (0.12) |
| Manu. of vegetable and animal oils and fats | Manu. of prepared animal feeds (0.12)<br>Manu. of grain mill prod., starches (0.13) |
| Reproduction of recorded media | Sound recording and music pub. activities (0.19)<br>Other information serv. activities (0.20)<br>Motion picture, video and tv programmes prod. (0.24)<br>Tv programming and broadcasting (0.33) |
| Manu. of basic chemicals and fertilizers | Manu. of refined petroleum prod. (0.13) |
| Manu. of pesticides and other agrochem. | Manu. of refined petroleum prod. (0.17)<br>Manu. of soap and detergents (0.23)<br>Manu. of pharma. preparations (0.25) |
| Manu. of steam generators | Installation of industrial mach. and equip. (0.11)<br>Manu. of knitted and crocheted apparel (0.12)<br>Manu. of other textiles (0.14) |
| Warehousing and storage<br>Warehousing and storage | Renting and leasing of motor vehicles (0.11)<br>Freight air transport (0.44)<br>Passenger air transport (0.44) |
| Software publishing | Sound recording and music publishing (0.17)<br>Other information services (0.17)<br>Activities aux. to financial serv. (0.21)<br>Fund management (0.22) |
| Data processing | Market research and pub. opinion polling (0.10)<br>Pension funding (0.10) |
| Monetary intermediation | Activities aux to financial services (0.21)<br>Fund management (0.21)<br>Pension funding (0.28) |

*Table 2. Selected groups of co-agglomerated industries, computed using (1). On the left column we report the selected industry, while on right column we report some of the industries which display, in relative terms, a large co-agglomeration index (reported in parenthesis).*

| **Industry** | **Correlated industries ($\gamma_c$ in parentheses)** |
|---|---|
| Growing of non-perennial crops | Mixed farming (0.13)<br>Manufacture of prepared animal feeds (0.17) |
| Reproduction of recorded media | Motion picture, video and tv programmes prod. (0.15)<br>Tv programming and broadcasting (0.16) |
| Manu. of plastic products | Manu. of bodies for motor vehicles (0.14)<br>Manu. of rubber products (0.15)<br>Manu. of metal forming machinery (0.14) |
| Manu. of basic iron and steel | Manu. of railway locomotives (0.20)<br>Manu. of tubes and pipes of steel (0.20)<br>Mining of non-ferrous metal ores (0.38)<br>Support activity for mining (0.39) |
| Sound recording and music publishing activities | Motion picture, video and tv programming activities (0.22)<br>TV programming and broadcasting activities (0.27) |

Looking at the results in tables 1 and 2, it is important to remember that we are reporting on a (very) small set of industry groups out of the national total. When looking at 3-digit industry-level data, the possible combination of industries which show some degree of conglomeration becomes very large and, in addition, we need also to consider the researcher or policymaker's input to determine which sets are interesting from an ecosystem perspective. Things become even more problematic when considering large geographical units, in our case regions, where a lot of displayed conglomerations might not signal links between industries, but just the wide variety of economic activities carried out in large geographical areas. A clear example here is provided by the strong degree of conglomeration between publishing and TV broadcasting activities, financial and legal services (not reported in the tables). This is due to the fact that these highly concentrated industries are mainly based in the Helsinki area and its region, Uusimaa. Another related example is the substantial degree of conglomeration between hotel activities and mining which is probably due to the heavy presence of those industries in Lapland.

**Despite the need to disentangle a lot of unstructured information and to discard many spurious results, conglomeration analysis can still provide some beneficial signals**. For example, from tables 1 and 2 we can see that the establishments in the sound recording industry, as well as those active in the reproduction of recorded media, are co-agglomerated with businesses in the tv broadcasting industry and in the tv programmes production industry. Even though this group of industries might not be focused on innovation activities, we can argue that it forms a business ecosystem, where establishments of different industries are linked to each other beyond a simple input-output relationship. Another example is offered by the group of finance-related industries, or by the link between the data processing industry and the marketing one. Other clusters, such as that found in Table 2 linking the manufacturing of basic iron and steel with the manufacturing of railway locomotives and of tubes and pipes, are likely to be based on more traditional input-output relationships, even though the presence of ecosystems cannot be ruled out. A final example is offered in Table 1, where we find that establishments in the warehousing industry tend to locate near those in the car rental industry and even more with the ones in the air transport industry. In this case, we can argue that this is due to location advantages, given that car rentals are especially concentrated around airports, and that this group of businesses does not form a proper ecosystem.

To summarise, **conglomeration analysis does not offer an all-in-one solution in terms of identifying the presence of ecosystems, but instead represents a first step which can provide useful preliminary signals.** The results generated by these techniques need to be analysed carefully while substantial input by the user is also required to disentangle spurious co-agglomerations and simple supply chains from potential ecosystems. Moreover, it is important to remember that this kind of analysis does not provide information regarding where the conglomeration is formed.

Next, we look at location quotients, defined in (2), in order to identify potential ecosystems in specific areas, either regions or municipalities. The results are presented in tables 4 and 5. To keep the discussion contained, we report the findings for only a small subset of municipalities and regions (and only some selected industries within them), for 2019, but additional results are available upon request.

*Table 4. LQ of selected industries in various Finnish municipality, computed for the year 2019. It indicates which industries are particularly concentrated in a location.*

| **Municipality (Region in parentheses)** | **Industry (*LQ* in parentheses)** |
|---|---|
| Alajärvi (South Ostrobothnia) | Manu. of wood and of wood products (10.40)<br>Forestry and logging (5.92) |
| Akaa (Pirkanmaa) | Manu. of machinery and equipment (7.97)<br>Manu. of fabricated metal products (4.79)<br>Manu. of rubber and plastic products (3.00) |
| Enontekiö (Lapland) | Travel agency and tour operators (66.67)<br>Accommodation (33.11) |
| Espoo (Uusimaa) | Information service activities (4.02)<br>Computer programming (3.30)<br>Manu. of computer, electronic and optical products (3.16) |
| Haapavesi (North Ostrobothnia) | Manu. of furniture (12.56)<br>Manu. of wood and of products of wood (6.17)<br>Forestry and logging (4.29) |
| Helsinki (Uusimaa) | Programming and broadcasting activities (4.39)<br>Motion picture, video and television programme, sound rec. (4.00) |
| Vantaa (Uusimaa) | Air transport (15.21)<br>Warehousing and support activities for transportation (4.66) |
| Inari (Lapland) | Travel agency, tour operators (55.93)<br>Accomodation (20.95)<br>Sports activities and amusement (6.30) |
| Nivala (North Ostrobothnia) | Mining support service activities (26.90)<br>Manu. of fabricated metal products (9.21)<br>Other mining and quarrying (6.41) |
| Oulu (North Ostrobothnia) | Manu. of computer, electronic and optical products (5.23)<br>Scientific research and development (3.60) |

As with our discussion of the results of conglomeration, we cannot here take the results of tables 4 and 5 at face value, but instead **we need to carefully interpret the findings from an ecosystem perspective**. In particular, some of the clusters found might show industries which are likely not linked to each other. In other cases, the relationship between industries displaying large *LQ* in a given location can be understood in the context of supplier-customer links, without the existence of the collaborative side typical of ecosystems. An example of this kind of cluster is that of the Alajärvi municipality, where we find a substantial agglomeration of establishments involved in the manufacture of wood products and in forestry. In this case, there is a clear input-output relationship between the two industries. A similar situation can be seen in Haapavesi, where in addition to these forestry-related industries, we also find a concentration of businesses in the manufacture of furniture. Again, this type of cluster might not represent the typical characteristics of ecosystems, such as collaboration between firms.  We cannot however rule out the possibility that other ecosystem features, such as the existence of active non-business entities that stimulate collaboration and innovation, are present in these clusters.

*Table 5. LQ of selected industries in various Finnish regions, computed for the year 2019. It indicates which industries are particularly concentrated in a location.*

| Region | Industry (*LQ* in parentheses) |
|---|---|
| South Karelia | Manu. of pulp, paper and paperboard (9.97)<br>Sawmilling and planning of wood (3.82) |
| Southern Ostrobothnia | Manu. of structural metal products (3.63)<br>Manu. of metal forming machinery and machine tools (9.47)<br>Manu. of bodies for motor vehicles, manufacture of trailers (5.73)<br>Processing and preserving of meat and production of meat products (9.66)<br>Support activities to agriculture (3.90)<br>Animal production (3.99)<br>Manu. of dairy products (4.52)<br>Manu. of prepared animal feeds (3.94) |
| South Savo | Manu. of products of wood, cork, straw and plaiting materials (7.38)<br>Silviculture and other forestry (4.64)<br>Support service to forestry (4.09)<br>Logging (3.98) |
| Central Ostrobothnia | Support activities to agriculture (6.86)<br>Manu. of basic chemicals, fertilizers (5.17)<br>Animal production (5.31)<br>Mixed farming (3.52)<br>Manufacture of prepared animal feeds (3.78) |
| Lapland | Hotels and similar (4.61)<br>Other reservation service and related activities (15.97)<br>Amusement and recreation activities (6.16)<br>Holiday and other short stay accommodation (17.95)<br>Other accommodation (4.88) |
| Ostrobothnia | Manu. of general-purpose machinery (9.71)<br>Manu. of electric motors, generators, transformers (7.32)<br>Manu. of bodies for motor vehicles, manu. of trailers (8.29)<br>Manu. of plastic products (3.59)<br>Building of ships and boats (4.89)<br>Manu. of electric lighting equipment (7.93)<br>Manu. of tubes, pipes, hollow profiles and related fittings, of steel (8.69)<br>Manu. of other electrical equipment (3.29) |
| Finland-Proper | Manu. of other chemical products (3.68)<br>Manu. of pharmaceutical preparations (5.48) |

The clusters highlighted in our results could also signal the presence of proper innovation and business ecosystems. A clear example of this is offered by the cluster of tourism-related activities in the municipalities of Enontekiö and Inari, as well as in the Lapland region. In these cases, we see an overrepresentation of industries which are not simply linked by input-output relationships, but rather are characterised by intense collaboration and natural coordination. Another interesting example at the municipal level is Espoo, where we find a strong concentration of establishments involved in ICT, as well as in the manufacture of computers. The presence of these firms, together with the one of universities and research centres, can indicate the existence of an innovation ecosystem in the area. Similar reasoning can be applied to Oulu, where we observe a cluster of businesses in the scientific research industry, as well as in high-tech manufacturing.

Turning to the regional results, an interesting case here is offered by Southern Ostrobothnia, where we find both a cluster of metallurgy-related industries and of businesses involved in agriculture and in the manufacture of food products. Another large cluster related to the food industry is found in Central Ostrobothnia. The connections between establishments in these clusters may be limited to simple supplier-customer relationship, meaning that we cannot consider them as ecosystems. However, one can investigate the economic landscape of these areas and get a better sense of whether there is a stronger degree of collaboration and whether there are actors, such as universities, who do play a role. Further interesting examples can be found in Ostrobothnia and Finland-Proper, where we see an agglomeration of industries which are loosely related to each other. In the first case, we find a large concentration of establishments in a wide variety of manufacturing industries, where we expect substantial innovation and research efforts. In the latter region, we see a cluster of establishments involved in manufacturing of chemicals and pharmaceutical products, two industries which are plausibly linked and that are usually associated with research activity and therefore likely to present collaborations between firms and research entities.

As can be seen from these few examples, **raw measures of concentration like the location quotients can provide initial indications of whether an ecosystem exists in a given area**. Based on the results of these kind of analyses, one can then explore in greater detail the local networks built between firms in the area, as well as whether entities like universities are involved. Similar to our position on looking at conglomeration results, complex concepts such as that of ecosystems are hard to measure and identify just by analysing raw data. Thus, substantial expert judgment, as well as the use of complementary qualitative sources of information, are also required. Given their simplicity and the ease with which they can be applied to very large datasets, cluster analysis techniques provide a useful and, in our opinion, necessary tool to use in the uncovering of innovation and business ecosystems. Comparing the conglomeration index with location quotient-based measures, the latter are likely more preferable in this context, given their ability to link location and industry information, thus providing better guidance in terms of the investigation of ecosystems.

## 3.5 Collaboration analysis: ecosystem participation and firm performance

We now turn to the empirical investigation of firm-level collaboration patterns, in order to investigate the possible impacts of ecosystem participation. Throughout this discussion, **we make the assumption that a firm collaborating during the innovation process with an external entity, such as a competitor or a university, is an indication of it being part of an ecosystem**. Of course, this reasoning can be questioned and we do not argue that it represents a flawless measurement strategy, but it undoubtedly helps us to operationalise the analysis and allows us to study many interesting links between ecosystem participation and firm-level outcomes. To simplify the discussion, for the rest of this empirical exercise we use the terminology regarding collaboration and participation in ecosystems interchangeably. As noted previously in Section 2.2, our main data source for this analysis is the CIS which is then linked with the Statistics Finland business register, as well as with worker-level data.

Before reporting on the results, it is important to remember that we do not intend here to make causal claims. Even if we consider the study of the causal impact of ecosystem participation conceptually possible and as we argued previously, this is not straightforward, the data available to us simply does not allow for that. First of all, most firms are not present in multiple waves of the CIS and those that are included multiple times might either not change their collaboration status or might be included in non-consecutive waves. Moreover, the fact that the questions in the surveys refer to longer time periods (two years before the survey year) means that we cannot pinpoint exactly when firms joined an ecosystem, proxied by the start of a collaboration. Finally, even though we have information on whether a firm collaborates or not with various entities, we do not know the intensity of the collaboration, meaning that we do not have an accurate idea of the treatment intensity. In light of these considerations, it is important to bear in mind that our findings offer some preliminary insights on the possible effects of ecosystem participation and should, ideally, be expanded with additional analyses, both quantitative and qualitative.

### Descriptive statistics

We start by looking at the number of observations for each survey wave, both the total number of firms participating, the ones which change at least once their collaboration status with an external entity (i.e., firms stating that they are collaborating in a given wave and that they are not collaborating in another survey year) and those changing their collaboration status with universities. By collaboration with an external entity, we mean a collaboration with an actor outside the firm’s own business group: this set includes competitors, clients, suppliers, universities, research institutes, consultancy firms and universities and universities of applied sciences (available only for the latest wave). For each type of collaborator, the CIS survey distinguishes between domestic and foreign entities. To keep the analysis contained, we report the findings related to the total collaborations, without separating the results based on the nationality of the collaborator. Finally, it is important to remember that the CIS surveys focus on collaborations created in relation to innovation activity, making them particularly relevant in the innovation ecosystems context. The number of observations available in each CIS waves is reported in Table 6.

*Table 6. Number of firms, number of firms changing collaboration status with external entities, and number of firms changing collaboration status with universities, for each CIS wave.*

| Wave | Total observations | Changing collab. Ext. | Changing collab. Uni. |
|---|---|---|---|
| 2006-2008 | 2337 | 564 | 437 |
| 2008-2010 | 2117 | 505 | 415 |
| 2010-2012 | 2386 | 577 | 440 |
| 2012-2014 | 2273 | 606 | 456 |
| 2014-2016 | 2139 | 588 | 437 |
| 2016-2018 | 2144 | 582 | 418 |
| Total | 13406 | 3422 | 2603 |

As shown in Table 6, the number of observations in the CIS waves is sufficient to make robust analyses, with the number of respondent firms being consistent over time. Regarding the possibility of doing simple panel analyses, the number of observations drops substantially when considering firms which change their collaboration status at least once. While the available sample allows us to estimate fixed effect regressions and thus have an idea of how starting a collaboration (entering into an ecosystem) correlates with firm-level outcomes, the reduction in the number of firms is significant. Due to these considerations, we focus on the cross-sectional part of the exercise, while we relegate the fixed-effect regression analysis to a secondary role.

We now report, in Table 7, the proportion of firms collaborating with an external entity or with a university, for the various survey years. In addition, for the last survey wave, we report the proportion of firms collaborating with a university of applied sciences (AMK). All the results are weighted using the sampling weights reported in the CIS survey, so they are representative for the population of firms.

*Table 7. Proportion of firms collaborating with external entities, universities or AMK, for different CIS waves.*

| Wave | Share collab. With ext. (%) | Share collab. With uni. (%) | Share collab. With AMK (%) |
|---|---|---|---|
| 2006-2008 | 17 | 12.7 | |
| 2008-2010 | 18.1 | 13.7 | |
| 2010-2012 | 16 | 11.7 | |
| 2012-2014 | 18.2 | 11 | |
| 2014-2016 | 22.2 | 13.7 | |
| 2016-2018 | 26.2 | 11.8 | 9.6 |

The results of Table 7 point to the existence of a fairly stable pattern, in terms of collaboration intensity among Finnish firms, especially for links with universities. While we see some variation across years, there are no dramatic changes between the first wave and the last, even though we find a fairly substantial increase in the proportion of firms collaborating with at least one external entity. The jump in the last two waves, especially the last one, is not easily explainable and may be due to temporary factors. Future CIS waves will be able indicate whether this upward trend is confirmed. Related to these results, it is interesting to check whether firms focus on collaborating with one type of entity (unfortunately, we are not able to determine the number of collaborations within a category) or if they have multiple types of partnerships. To see this, we report, in Table 8, on the share of firms collaborating with different numbers of partners, for each survey wave. Note that the maximum number of types of collaborations is six.

*Table 8. Share of firms collaborating with different number of entities, for each CIS wave.*

| Wave | 1 collab. | 2 collab. | 3 collab. | 4 collab. | 5 collab. | 6 collab. |
|---|---|---|---|---|---|---|
| 2006-2008 | 0.5 | 1 | 2.4 | 3.5 | 4.5 | 13.4 |
| 2008-2010 | 0.47 | 1.4 | 2.3 | 2.6 | 5.8 | 12.05 |
| 2010-2012 | 1.3 | 1.5 | 2.1 | 2.5 | 3.04 | 11.3 |
| 2012-2014 | 2.2 | 2.8 | 3.3 | 3.3 | 4.5 | 8.4 |
| 2014-2016 | 4.8 | 4.4 | 3.8 | 3.6 | 2.8 | 9.5 |
| 2016-2018 | 6.8 | 6.8 | 5.5 | 5.2 | 5.7 | 3.2 |

Contrary to what we have seen regarding the share of firms collaborating with at least one external entity, the propensity of companies to collaborate with multiple partners displays some evident time trends. While the percentage of firms collaborating with 3-5 partners is fairly stable over time, we observe some clear declining patterns for the share of firms which collaborate with all possible types of entities during their innovation activities. The opposite holds true for firms collaborating with only one or two types of partners. The former trend is particularly interesting, given that the share of firms collaborating will all six types of categories is more than four times larger in the first wave, compared to the last one. These substantial differences might be explained by changes in the types of firms included in the survey (for example, a higher proportion of small firms which are less likely to collaborate with multiple entities) or by a more accurate level of reporting. In practice, we expect that most firms collaborate with a limited number of partners, rather than with all possible types of entities, given that collaborations can be costly and increasingly so when involving multiple partners. To shed some light on this issue, we regress the number of collaborations for each firm on a set of firm-level characteristics, such as size, age, industry, and a set year dummies. While we do not report those results here, for the sake of brevity, we find that despite the fact that some firm characteristics are clearly linked with the propensity to collaborate with a different number of types of partners, multiple year dummies associated to the different CIS waves present strongly significant coefficients. This finding supports the interpretation of the patterns in Table 8 as being due to more accurate reporting over time, rather than relating to some significant changes in the type of firms sampled.

Even though our main analysis focuses on collaborations with external entities and with universities, we report in Table 9 on the share of firms collaborating with suppliers, competitors, clients, consultancy firms, research institutes and with firms in the same business group, to complete the overview of collaboration patterns. We also look, in Table 10, at the share of firms collaborating with domestic and foreign external partners and universities.

*Table 9. Proportion of firms collaborating with firms in the same group, suppliers, clients, competitors, consultancy firms research institutes, for different CIS waves*

| Wave | Share collab. within same group. (%) | Share collab. with suppliers. (%) | Share collab. with clients (%) | Share collab. with competitors (%) | Share collab. with Consultancy firms (%) | Share collab. with research inst. (%) |
|---|---|---|---|---|---|---|
| 2006-2008 | 8.07 | 15.95 | 15.95 | 13.55 | 12.75 | 10.52 |
| 2008-2010 | 9.82 | 15.64 | 17.31 | 14.12 | 13.38 | 10.37 |
| 2010-2012 | 9.26 | 13.80 | 14.20 | 11.53 | 10.39 | 10.26 |
| 2012-2014 | 9.18 | 14.84 | 15.04 | 9.61 | 10.57 | 8.68 |
| 2014-2016 | 9.83 | 16.78 | 15.90 | 11.33 | 10.80 | 9.13 |
| 2016-2018 | 11.85 | 17.36 | 15.13 | 4.70 | 18.16 | 8.50 |

*Table 10. Proportion of firms collaborating with firms in the same group, suppliers, clients, competitors, consultancy firms research institutes, for different CIS waves*

| Wave | Share collab. with domestic ext. partners (%) | Share collab. with foreign ext. partners (%) | Share collab. with domestic uni. (%) | Share collab. with foreign uni. (%) |
|---|---|---|---|---|
| 2006-2008 | 16.75% | 12.72% | 12.33% | 2.23% |
| 2008-2010 | 17.95% | 11.80% | 13.27% | 2.27% |
| 2010-2012 | 15.81% | 10.64% | 11.32% | 2.93% |
| 2012-2014 | 17.75% | 11.63% | 10.75% | 2.14% |
| 2014-2016 | 21.17% | 13.34% | 12.76% | 3.40% |
| 2016-2018 | 25.59% | 10.90% | 11.53% | 2.63% |

Given that our analysis focuses on collaboration with external partners and universities, we will go over the results in tables 9-10 briefly. Table 9 indicates quite stable collaboration patterns, when looking at collaborations with suppliers, clients and with firms in the same business group (with the latter showing a more substantial increase during the last period). On the other hand, we find a sharp drop in terms of firms collaborating with competitors. Such a strong change needs however to be validated by looking at future waves, to see if it becomes a new trend. The large drop in terms of firms collaborating with competitors is mirrored by a large rise, also during the latest wave, in the share of firms collaborating with consultancy firms. Finally, we observe a steady, but not dramatic, downward trend in terms of firms collaborating with research institutes. Regarding the foreign *vs.* domestic collaborations, it is interesting to see that partnerships with foreign entities are much more common when considering external collaborations, rather than universities. In the first case we see that foreign collaborations are roughly half of domestic ones, while they drop to around 20% when looking at university partnerships. Moreover, the results in Table 10 indicate that the increase in the proportion of firms collaborating with external entities, seen during the last two survey waves, is driven by domestic collaborations.

Next, we depict the overall share of firms involved in collaborations during their innovation process, along different firm-level dimensions. First, we look at the propensity to collaborate by innovation status (i.e., by dividing firms between those which innovate and those that do not), size and age groups, industry (using the technology intensity classification of Eurostat), whether they receive a grant for innovation and whether they belong to a business group (dependent *vs*. independent). The results are reported in the form of bar charts, throughout figures 1-6. The collaborations reported here relate to partnerships with external entities, however similar figures on collaboration with universities are available upon request.

*Figure 1. Share of firms collaborating, by innovation status*

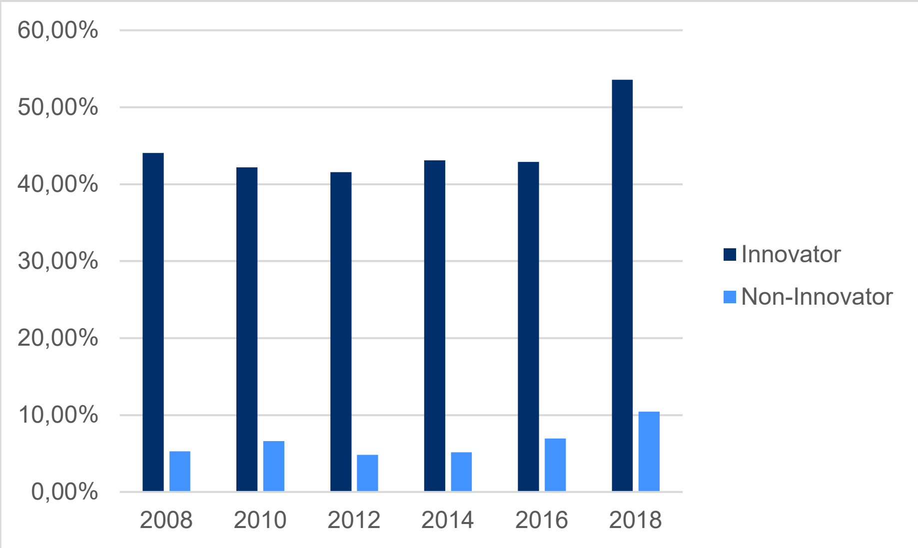



*Figure 2. Share of firms collaborating with external entities, by size class*

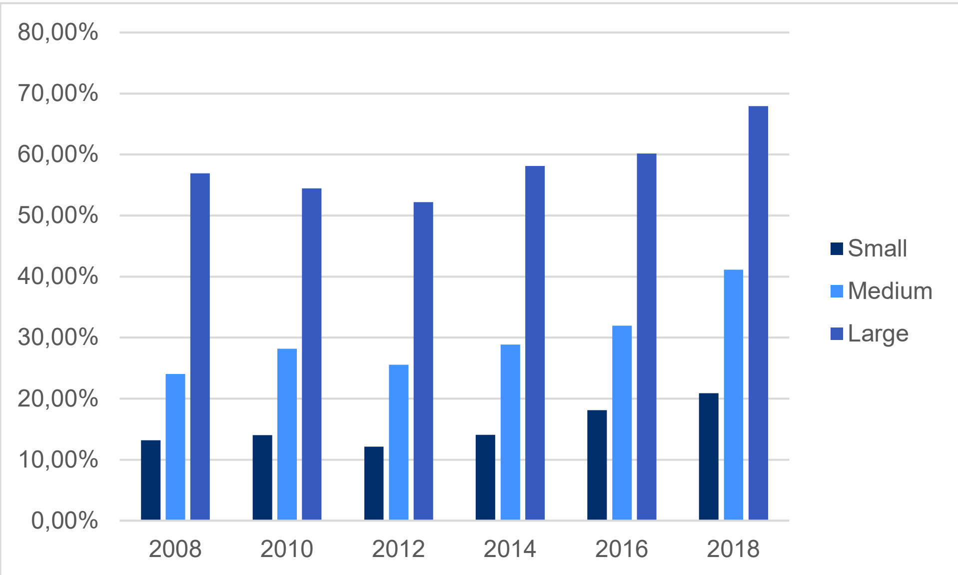


*Figure 3. Proportion of firms collaborating, by age group*

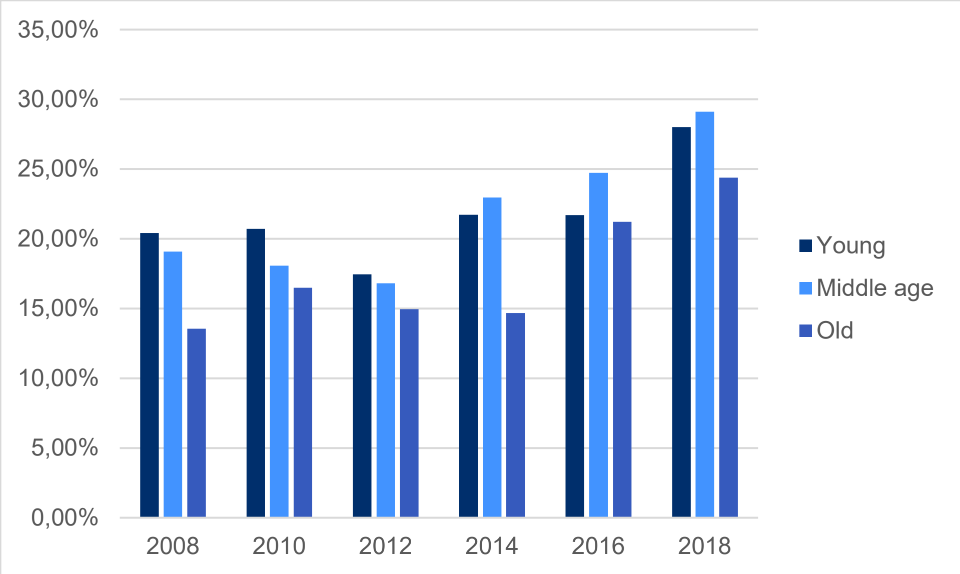



*Figure 4. Proportion of firms collaborating with external entities, by industry*

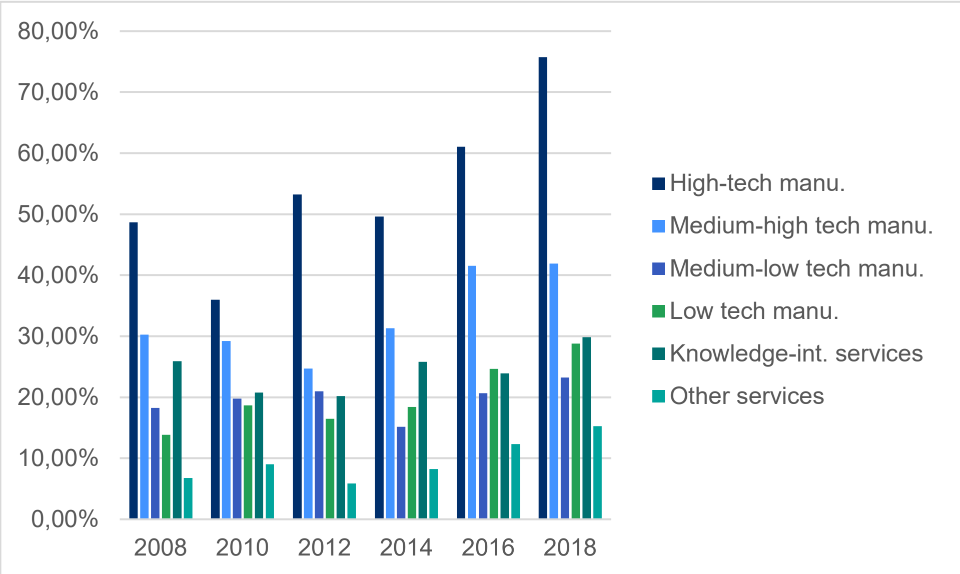


*Figure 5. Proportion of firms collaborating, by grant receiver status*

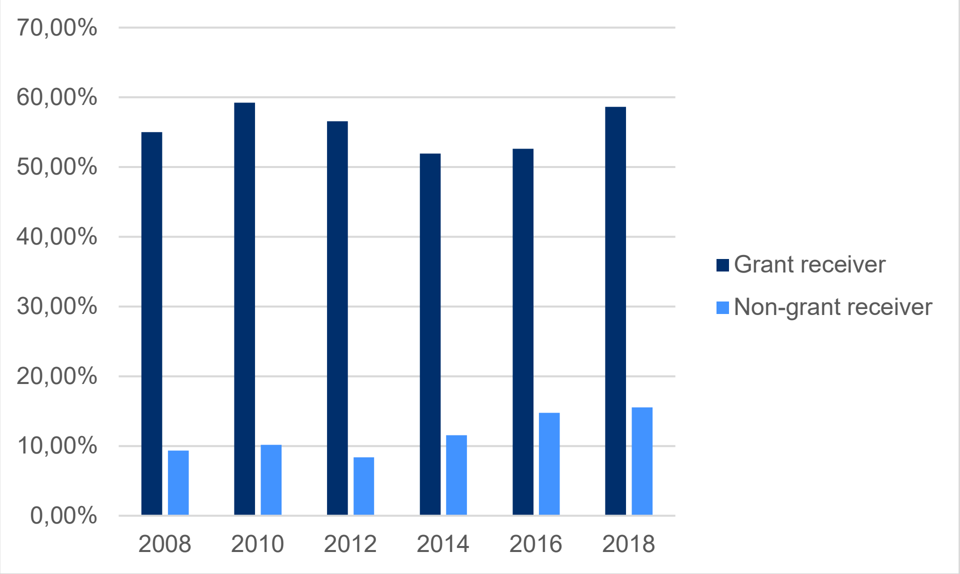
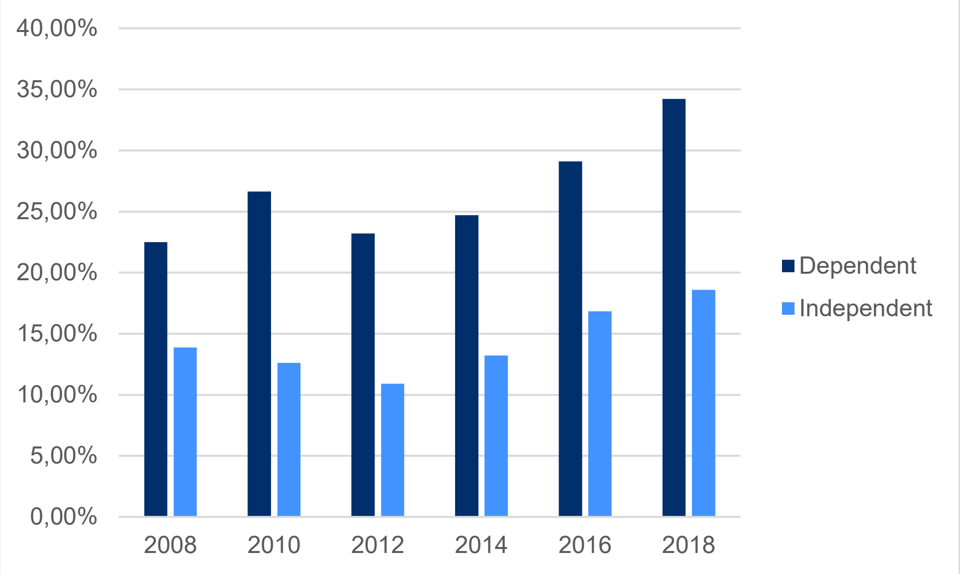



*Figure 6. Proportion of firms collaborating, by dependency status*




The results regarding the proportions of firms collaborating, along different firm-level dimensions, do not offer much in the way of surprising insights. As expected, firms which innovate are much more likely to collaborate (note however that collaborations with the purpose of innovation do not always result in successful innovation activity), larger firms are more likely to establish a partnership with an external entity (probably due to their expected access of better resources to create and maintain collaborative networks), firms in more technologically and knowledge-intensive industries tend to collaborate more (and in general firms in manufacturing establish more innovation-related collaborations). The same goes for firms receiving R&D grants and enterprises belonging to a corporation. The one somewhat surprising result however is that we do not find a positive age gradient in terms of collaboration patterns. Instead, we find the opposite, i.e., younger firms are more likely to collaborate. Older firms are much more likely to be large and thus we would expect them to collaborate more. On the other hand, younger firms might be more interested in establishing partnerships, possibly because they have more to gain in terms of acquiring external knowledge and skills.

We conclude this analysis on the determinants of collaboration, by reporting on the results of a simple logit regression, where the dependent variable is the binary indicator of collaboration, either with external entities or with universities. This kind of exercise allows us to investigate which firms' characteristics correlate with collaboration activity conditional on multiple factors, thus disentangling possible spurious relationships and it permits us to assess the quantitative significance of these correlations. As explanatory variables we include dummies regarding the firm's size class, age group, dependency status, grant receiver status, as well as R&D intensity (R&D expenditures divided by the turnovers) and the share of employees with a university degree. We complete the set of explanatory variables with a set of year and industry dummies. The results are reported in Table 11.

The results of Table 11 mostly confirm the insights we gained by looking at the plots contained in figures 1-6. Before briefly discussing the regression results, it is important to remember that the estimates in the table cannot be viewed as causal and that the size of the coefficients cannot be directly interpreted as the actual increase in the probability of collaborating. More conservatively, they should be seen as signals of stronger or weaker correlations between collaboration and the selected firm-level characteristics. As expected, **medium-sized and large firms are more likely to collaborate**, compared to small ones. Moreover, given size, age, year and industry, **firms which spend more in R&D, receive an R&D grant, or have a relatively high share of employees with university degrees, display a higher propensity to collaborate**.

*Table 11. Logit regression of collaboration with external partners or universities on firm-level characteristics, to identify factors correlated with collaboration.*

| VARIABLES | (1) Collab. Ext. | (2) Collab. Uni |
|---|---|---|
| Medium | 0.580*** | 0.733*** |
| | (0.0600) | (0.0715) |
| Large | 1.484*** | 1.939*** |
| | (0.0738) | (0.0841) |
| Middle-aged | -0.0357 | -0.0839 |
| | (0.0772) | (0.0893) |
| Old | -0.0703 | -0.157* |
| | (0.0696) | (0.0829) |
| Dependent | 0.519*** | 0.681*** |
| | (0.0629) | (0.0755) |
| R&D grant | 1.877*** | 2.016*** |
| | (0.0626) | (0.0713) |
| R&D intensity | 0.0325*** | 0.0293*** |
| | (0.00508) | (0.00423) |
| Share high edu. | 0.00527*** | 0.00689*** |
| | (0.000945) | (0.00104) |
| Year dummies | YES | YES |
| Industry dummies | YES | YES |
| Observations | 13,240 | 13,240 |
| Pseudo R2 | 0.222 | 0.283 |
| Robust standard errors in parentheses | | |
| *** p<0.01, ** p<0.05, * p<0.1 | | |

Regarding firm age, we find the same negative correlation we have observed in the graphs, but it is statistically insignificant when considering external collaborations and only barely significant when looking at university collaborations. In other words, after controlling for a large set of firm-level features, older firms are not less likely to partner up with some external entity. Interestingly, the negative correlation between age and collaboration with AMKs is much more significant and the size of the coefficients is much larger, in absolute values, indicating that older and middle-aged firms, are less likely to collaborate with universities of applied sciences. We do not report the results here, but they are available upon request. To summarise, the findings of this section indicate that larger firms, as well as firms more involved in innovation activity, are more likely to collaborate and thus, based on our initial assumptions, are more likely to participate in ecosystems. While this conclusion may not be surprising, it does reinforce the prior point made that innovation and ecosystem participation are closely linked and that firms consider collaborations to be an essential aspect of the innovative process.

## Outcome analysis

We now move to the study of the correlation between collaboration activity and various firm-level outcomes, such as employment or productivity growth, first by looking at cross-sectional regressions and then at fixed-effect regression. Again, it is important to bear in mind that the data available to us does not allow for causal claims, but the results we obtain can offer us some insights into the potential outcomes of participation in an innovation ecosystem (proxied by collaboration).

We start this discussion by looking at how collaboration with external entities or universities correlates with innovation propensity. As noted previously, the positive relationship between participation in ecosystems and innovating might seem trivial, but we think it still important enough to investigate whether this link is indeed present in the data. As in the previous subsection, we use a logit regression model where we regress a dummy indicating whether a firm innovates (either product, service or process innovation) on a collaboration dummy and a set of controls which include various firm-level characteristics (such as size and industry of operation). We again limit our analysis to collaborations with external entities and with universities, and report the results of these regressions in Table 12.

As seen from Table 12, **the relation between collaboration and successful innovation is positive and statistically strong**. Even taking into account factors such as firm size and age, its investments in R&D and how many of its employees are highly educated, when firms collaborate with an external entity or with a university, they innovate more. Among the controls, it is particularly interesting to see that firm age does not seem to have a significant correlation with innovation, once controlling for the other firm-level characteristics. The estimates we provide cannot be interpreted in a causal way, because firms that collaborate more might be more likely to innovate due to some unobserved factor. Moreover, it might be that firms which innovate attract more partners which want to collaborate, reversing the direction of the relationship. To summarise, we cannot claim that collaborating with external entities induces a firm to innovate more, but the link between our proxy of ecosystem participation and innovation is strong. In the next subsection, we rely on panel data techniques to try to provide additional evidence in favour of a possible cause-effect relationship.

*Table 12. Logit regression of innovation (either product, service or process) on collaboration with external partners or universities and a series of firm-level controls. It shows how collaboration is related to successful innovation.*

| VARIABLES | (1) Innovation | | (2) Innovation |
|---|---|---|---|
| .. | | | |
| Collab. Ext. | 1.795*** | Collab Uni | 1.562*** |
| | (0.0677) | | (0.0857) |
| R&D intensity | 0.139*** | | 0.156*** |
| | (0.0253) | | (0.0283) |
| R&D grant | 1.110*** | | 1.247*** |
| | (0.0752) | | (0.0714) |
| Share high edu. | 0.00475*** | | 0.00494*** |
| | (0.00085) | | (0.00086) |
| Medium | 0.256*** | | 0.291*** |
| | (0.0554) | | (0.0537) |
| Large | 0.545*** | | 0.558*** |
| | (0.0782) | | (0.0784) |
| Middle-aged | -0.0639 | | -0.0607 |
| | (0.0705) | | (0.0684) |
| Old | -0.0556 | | -0.0537 |
| | (0.0623) | | (0.0605) |
| Dependent | 0.228*** | | 0.253*** |
| | (0.0552) | | (0.0536) |
| Year dummies | Yes | | Yes |
| Industry dummies | Yes | | Yes |
| | | | |
| Observations | 13,240 | | 13,240 |
| Pseudo R2 | 0.254 | | 0.224 |
| Robust standard errors in parentheses | | | |
| *** p<0.01, ** p<0.05, * p<0.1 | | | |

While innovation is probably the most important outcome to consider when looking at innovation ecosystems, there are multiple other variables which might be impacted. Next, we consider how collaborating with external entities or universities correlates with employment and labour productivity (sales divided by employment) growth, both one and two years after the survey period (e.g., for the 2008-2010 CIS survey, we consider employment growth up to 2011 and 2012). The list of controls used in this analysis is almost the same as when dealing with innovation, however we add the initial number of employees (and the initial log labour productivity level, when considering productivity growth), to take into account possible reversion to the mean trends. In practice, a firm might experience an idiosyncratic shock which may lead to it having a temporarily larger (or smaller) than normal number of employees, or a higher level of labour productivity after which it would then revert back to its long-term average. The results regarding the regressions of employment and labour productivity growth on collaboration activity are reported in Table 13 and 14, respectively.

*Table 13. Estimates of the pooled cross-sectional regressions of employment growth on collaboration with external partners or universities. Columns (1) and (2) contain results for employment growth one year after the CIS survey, while the results for employment growth two years after the survey are reported in columns (3) and (4).*

| | (1) | | (2) | | (3) | | (4) |
|---|---|---|---|---|---|---|---|
| **VARIABLES** | **Emp. growth (t+1)** | | **Emp. growth (t+1)** | | **Emp. growth (t+2)** | | **Emp. growth (t+2)** |
| | | | | | | | |
| Collab. Ext. | 0.0202** | Collab. uni. | 0.0139 | Collab. ext. | 0.0206* | Collab. uni. | 0.00250 |
| | (0.00877) | | (0.0108) | | (0.0124) | | (0.0146) |
| R&D grant | 0.0569*** | | 0.0602*** | | 0.0801*** | | 0.0864*** |
| | (0.00885) | | (0.00890) | | (0.0126) | | (0.0126) |
| R&D intensity | 0.000242 | | 0.000294 | | -0.000204 | | -8.66e-05 |
| | (0.000612) | | (0.000611) | | (0.000855) | | (0.000853) |
| Share high edu. | - 0.000379** | | -0.000373** | | - 0.000481** | | - 0.000471** |
| | (0.000159) | | (0.000159) | | (0.000198) | | (0.000198) |
| Medium | 0.000805 | | 0.000841 | | 0.0161 | | 0.0158 |
| | (0.0128) | | (0.0128) | | (0.0178) | | (0.0178) |
| Large | -0.0252 | | -0.0255 | | 0.00968 | | 0.0109 |
| | (0.0255) | | (0.0255) | | (0.0344) | | (0.0345) |
| Middle-aged | -0.0643*** | | -0.0643*** | | -0.0769*** | | -0.0770*** |
| | (0.0105) | | (0.0105) | | (0.0137) | | (0.0137) |
| Old | -0.0692*** | | -0.0692*** | | -0.0821*** | | -0.0823*** |
| | (0.00891) | | (0.00891) | | (0.0120) | | (0.0120) |
| Dependent | -0.0193** | | -0.0188** | | -0.0239** | | -0.0231** |
| | (0.00852) | | (0.00851) | | (0.0117) | | (0.0117) |
| Base year emp. | -0.00678 | | -0.00638 | | -0.0233** | | -0.0222** |
| | (0.00773) | | (0.00774) | | (0.0103) | | (0.0103) |
| Year dummies | YES | | YES | | YES | | YES |
| Industry dummies | YES | | YES | | YES | | YES |
| | | | | | | | |
| Observations | 13,103 | | 13,103 | | 10,721 | | 10,721 |
| R2 | 0.025 | | 0.024 | | 0.026 | | 0.025 |
| Robust standard errors in parentheses | | | | | | | |
| *** p<0.01, ** p<0.05, * p<0.1 | | | | | | | |

*Table 14. Estimates of the pooled cross-sectional regressions of labour productivity growth on collaboration with external partners or universities. Columns (1) and (2) contain results for labour productivity growth one year after the CIS survey, while the results for labour productivity growth two years after the survey are reported in columns (3) and (4).*

| VARIABLES | (1)<br>Lab. prod. growth (t+1) | | (2)<br>Lab. prod. growth (t+1) | | (3)<br>Lab. prod. growth (t+2) | | (4)<br>Lab. prod. growth (t+2) |
|---|---|---|---|---|---|---|---|
| Collab. ext. | 0.00925 | Col-lab. Uni. | 0.00119 | Col-lab. Ext. | 0.0131 | Col-lab. Uni. | -0.00826 |
| | (0.00841) | | (0.00965) | | (0.0104) | | (0.0119) |
| R&D intensity | 0.00118** | | 0.00123** | | 0.00131* | | 0.00144** |
| | (0.000577) | | (0.000573) | | (0.000698) | | (0.000694) |
| R&D grant | 0.00121 | | 0.00410 | | 0.00679 | | 0.0137 |
| | (0.00815) | | (0.00823) | | (0.0105) | | (0.0106) |
| Share high edu. | 0.000106 | | 0.000110 | | -1.65e-05 | | -8.47e-06 |
| | (0.000124) | | (0.000124) | | (0.000192) | | (0.000192) |
| Medium | 0.0112 | | 0.0119* | | 0.0168* | | 0.0184** |
| | (0.00701) | | (0.00701) | | (0.00867) | | (0.00870) |
| Large | 0.0238** | | 0.0259*** | | 0.0411*** | | 0.0470*** |
| | (0.00957) | | (0.00970) | | (0.0122) | | (0.0125) |
| Middle-aged | -0.00330 | | -0.00334 | | -0.0162 | | -0.0162 |
| | (0.00960) | | (0.00960) | | (0.0116) | | (0.0116) |
| Old | -0.00385 | | -0.00392 | | -0.0251** | | -0.0252** |
| | (0.00818) | | (0.00819) | | (0.0106) | | (0.0106) |
| Dependent | 0.0115 | | 0.0119 | | 0.0200** | | 0.0210** |
| | (0.00785) | | (0.00785) | | (0.0101) | | (0.0101) |
| Base year prod. | -0.0408*** | | -0.0405*** | | -0.0561*** | | -0.0556*** |
| | (0.00619) | | (0.00619) | | (0.00777) | | (0.00777) |
| Year dummies | YES | | YES | | YES | | YES |
| Industry dummies | YES | | YES | | YES | | YES |
| | | | | | | | |
| Observations | 13,079 | | 13,079 | | 10,683 | | 10,683 |
| R2 | 0.039 | | 0.039 | | 0.036 | | 0.036 |
| Robust standard errors in parentheses | | | | | | | |
| *** p<0.01, ** p<0.05, * p<0.1 | | | | | | | |

Tables 13 and 14 provide us with some interesting insights on the relation between ecosystem participation, employment and labour productivity growth. Starting by looking at some of the controls, we see the familiar reversion to the mean effect, especially when looking at productivity. Firms which are more productive in the base year, i.e., the period when they are included in the CIS, tend to display lower productivity growth for the next few years. The same goes for employment growth, even though this pattern is less pronounced. Regarding R&D investments, we find a significant effect on productivity growth, but not on employment growth. The reverse is true for R&D grants. This can be explained by the fact that firms receiving funding might want to expand, thus they hire new staff, but the outcome of their research process might take more time to materialise, hence the non-significant relation with productivity growth. Another interesting aspect is that firms belonging to a business group display negative employment growth and a longer-term (two years) productivity growth. These are quite common patterns, found in, e.g., Fornaro and Luomaranta (2016, 2017). A final surprising observation discernible from tables 13-14, is that firms with a higher share of employees with a university degree face lower employment growth, something which might be explained by the fact that they have already acquired the skill base required for their business and thus they do not experience relatively higher productivity growth. Of course, this latter aspect may be due to various factors, such as the fact that productivity growth might need a longer time period to be analysed.

Regarding our main variables of interest, collaboration with external entities and with universities, **we find a positive correlation with employment and productivity growth, which is statistically significant only in the case of employment growth**. In particular, enterprises belonging to an ecosystem are more likely to grow in size, but they do not seem to display stronger productivity growth. Note also that the positive relation between collaborations and employment growth holds only when considering collaborations with external entities, while the correlation with university collaboration is much weaker.

We now turn to some employee-related outcomes, namely wage growth (total wage payroll divided by the number of employees) and the proportion of employees that start their own firm. This latter dependent variable is particularly interesting in an innovation ecosystem context. As noted previously, ecosystems are characterised by self-organising dynamics and it is very important to see whether an element of these dynamics (new businesses starting from other entities within the ecosystem) is supported by empirical evidence. In tables 15-16, we report the results for similar pooled cross-sectional regressions, where we consider growth in wages one and two years after the CIS survey, while, in addition, when looking at the entrepreneurial outcome we consider growth within two years (i.e., we do not separate the estimates for one and two years). Again, we look at both the collaborations with external entities and with universities.

*Table 15. Estimates of the pooled cross-sectional regressions of wages growth on collaboration with external partners or universities. Columns (1) and (2) contain results for wage growth one year after the CIS survey, while the results for wage growth two years after the survey are reported in columns (3) and (4).*

| **VARIABLES** | **(1) Wage growth (t+1)** | | **(2) Wage growth (t+1)** | | **(3) Wage growth (t+2)** | | **(4) Wage growth (t+2)** |
|---|---|---|---|---|---|---|---|
| Collab. ext. | -0.00175 | Col-lab.uni. | -0.000671 | Collab. ext. | 0.00139 | Col-lab.uni. | -0.000475 |
| | (0.00617) | | (0.00697) | | (0.00920) | | (0.00861) |
| R&D intensity | 0.00150*** | | 0.00149*** | | 0.00202*** | | 0.00203*** |
| | (0.000406) | | (0.000405) | | (0.000595) | | (0.000596) |
| R&D grant | 0.00432 | | 0.00390 | | 0.00603 | | 0.00664 |
| | (0.00560) | | (0.00567) | | (0.00796) | | (0.00755) |
| Share high edu. | 0.000301*** | | 0.000300*** | | -3.83e-06 | | -2.95e-06 |
| | (0.000102) | | (0.000102) | | (0.000206) | | (0.000207) |
| Medium | 0.00401 | | 0.00391 | | 0.0201** | | 0.0203** |
| | (0.00584) | | (0.00586) | | (0.00862) | | (0.00869) |
| Large | 0.0106 | | 0.0103 | | 0.0270** | | 0.0275** |
| | (0.00795) | | (0.00806) | | (0.0125) | | (0.0128) |
| Middle-aged | -0.00658 | | -0.00658 | | 0.00982 | | 0.00981 |
| | (0.00978) | | (0.00978) | | (0.00922) | | (0.00922) |
| Old | -0.00566 | | -0.00566 | | 0.0138 | | 0.0138 |
| | (0.00911) | | (0.00911) | | (0.0102) | | (0.0102) |
| Dependent | 0.0155* | | 0.0154* | | 0.0180 | | 0.0181 |
| | (0.00862) | | (0.00860) | | (0.0113) | | (0.0112) |
| Base year wage | -3.52e-06*** | | -3.52e-06*** | | -3.52e-06*** | | -3.52e-06*** |
| | (5.34e-07) | | (5.34e-07) | | (6.20e-07) | | (6.19e-07) |
| Year dummies | YES | | YES | | YES | | YES |
| Industry dummies | YES | | YES | | YES | | YES |
| | | | | | | | |
| Observations | 13,031 | | 13,031 | | 10,622 | | 10,622 |
| R-squared | 0.027 | | 0.027 | | 0.013 | | 0.013 |
| Robust standard errors in parentheses | | | | | | | |
| *** p<0.01, ** p<0.05, * p<0.1 | | | | | | | |

*Table 16. Estimates of the pooled cross-sectional regressions of the share of employees becoming entrepreneurs within two years, on collaboration with external partners or universities.*

| VARIABLES | (1) Share of emp. becoming entrepreneurs | | (2) Share of emp. becoming entrepreneurs |
|---|---|---|---|
| Collab. ext. | -0.413** | Collab.uni. | -0.729*** |
| | (0.167) | | (0.178) |
| R&D grant | -0.332** | | -0.278* |
| | (0.168) | | (0.165) |
| R&D intensity | -0.0568*** | | -0.0494*** |
| | (0.008) | | (0.008) |
| Share high edu. | 0.0568*** | | 0.0570*** |
| | (0.010) | | (0.010) |
| Medium | -1.605*** | | -1.585*** |
| | (0.099) | | (0.099) |
| Large | -1.196*** | | -1.077*** |
| | (0.154) | | (0.161) |
| Middle-aged | -0.062 | | -0.0649 |
| | (0.197) | | (0.197) |
| Old | -0.31* | | -0.315* |
| | (0.173) | | (0.173) |
| Dependent | -3.67 | | -3.66*** |
| | (0.215) | | (0.215) |
| Year Dummies | YES | | YES |
| Industry Dummies | YES | | YES |
| | | | |
| Observations | 13,240 | Observations | 13,240 |
| R-squared | 0.229 | R-squared | 0.230 |
| Robust standard errors in parentheses | | | |
| *** p<0.01, ** p<0.05, * p<0.1 | | | |

The estimates in tables 15-16 provide us with further insights into the possible links between ecosystem participation and firm-level outcomes. Firstly, **there does not seem to be a significant relationship between collaboration activities and growth in wages**. This holds for both types of collaboration considered and for both the one- and two-year periods. This weak correlation mirrors what we found regarding productivity which is not surprising given the tendency of wages and labour productivity to follow similar trends.

The results in respect of the share of employees starting their own firm, within two years of the survey are quite interesting. In particular, **we find a strongly significant**

**and negative relationship between collaborating and the tendency for workers to become self-employed**. While at a first glance this result might go against our initial intuition regarding ecosystems, where we expect new firms to start up based on the experience of workers inside the ecosystem, this finding can be read in the light of what kind of entrepreneurship we are observing. In our case, we define as entrepreneurs those individuals who are classified by Statistics Finland as self-employed. This definition includes both employer entrepreneurs and the self-employed who work on their own, possibly part-time. Some of these new entrepreneurs become so due to so-called "push factors", meaning that they start their own firm after facing difficulties in the job market. To disentangle these types of entrepreneurships one would need to look at the performance of the firms founded by these new business owners, but this would require quite a few observations (meaning additional years of data), in order to gain a clear picture.

Going back to our main question, we can interpret the negative coefficient associated with collaboration as a signal that the workers concerned do not face these push factors leading them to exit the firm. This goes hand in hand with the fact that the coefficients associated with R&D intensity and R&D grants, as well as with the medium- and big-size dummies, are also negative. We can read these findings as evidence that more healthy businesses (which tend to be larger and invest more in R&D) are also more likely to be able to hold onto their workers, while firms which may be in more difficult situations see their employees leaving to join other firms or start their own, possibly not that well-performing, businesses. In this view, collaborating firms which we assume are more likely to be part of an ecosystem, are in comparatively better shape. The only finding of Table 15 which does not support this interpretation is the positive and statistically significant coefficient associated with the share of highly educated employees. Firms with more workers with a university degree have a higher share of employees who start their own enterprise. Following our previous reasoning, we would expect the sign of the relationship to be negative because we expect that firms with a higher share of highly educated workers also display better performance levels. This finding might however also be explained by the fact that employees with a university education are more likely to have the required skills to start their own firm, at least in high-tech industries, once we take into account that the firm might be well-performing.

The final aspect we want to touch upon with these cross-sectional regressions is how belonging to an ecosystem might help firm survival, especially among young firms. This can be a particularly interesting point, from an ecosystemic perspective because collaborations and the overall building of networks can be considered crucial for young firms which want to survive in a high-innovation industry. To analyse this issue, we have estimated simple logit regressions, where our dependent variable is a binary indicator of failure. We restrict the sample firms which are less than five-years-old (very young) and less than ten-years-old (young) and define an exit if a firm is not included in the register at some point after the CIS survey (before the last available year, 2019). The set of controls includes firm employment (in logs), log of labour productivity, firm age, as well as industry and survey-year dummies. The results of this exercises are presented in Table 17.

*Table 17. Estimates of the pooled cross-sectional regressions of the share of employees becoming entrepreneurs within two years, on collaboration with external partners or universities.*

| **VARIABLES** | **(1) Exit (very young firms)** | | **(2) Exit (very young firms)** | | **(3) Exit (young firms)** | | **(4) Exit (young firms)** |
|---|---|---|---|---|---|---|---|
| Collab. ext. | -0.433 | Col-lab. uni. | -0.439 | Col-lab. ext. | -0.220 | Col-lab. uni. | -0.0822 |
| | (0.296) | | (0.348) | | (0.174) | | (0.207) |
| Log N. of employ-ees | 0.247** | | 0.254** | | 0.334*** | | 0.329*** |
| | (0.124) | | (0.125) | | (0.0746) | | (0.0751) |
| Log productivity | -0.310** | | -0.318** | | -0.247*** | | -0.250*** |
| | (0.125) | | (0.125) | | (0.0790) | | (0.0779) |
| Age | -0.0414 | | -0.0424 | | -0.0440 | | -0.0438 |
| | (0.0998) | | (0.0999) | | (0.0290) | | (0.0290) |
| Year dummies | 1.794 | | 1.840 | | -2.509** | | -2.519** |
| Industry dummies | (1.668) | | (1.671) | | (1.056) | | (1.044) |
| | | | | | | | |
| Observations | 481 | | 481 | | 1,765 | | 1,765 |
| R2 | 0.128 | | 0.127 | | 0.213 | | 0.212 |
| Robust standard errors in parenthe-ses | | | | | | | |
| *** p<0.01, ** p<0.05, * p<0.1 | | | | | | | |

From the estimates in Table 17 we can see that despite the fact that the correlation between collaboration activity and the survival of young firms goes in the expected direction, namely that firms which collaborate are less likely to exit, the results are not statistically significant. Moreover, it seems that firms with more employees tend to exit the market more often, while the more productive ones are instead more likely to survive and, in addition, we do not find a significant relation with age. These results should however be interpreted with caution, given the very small sample size which also restricts greatly the representativeness of the sample.

To summarise the findings of this section, we observe that in relation to collaboration activity, in our interpretation participation in an ecosystem is tightly linked with successful innovation. Moreover, we find a significant positive relation with employment growth, even though this correlation is weaker. On the other hand, we do not find a significant relationship with productivity and wages growth, while young firms which collaborate are not more or less likely to exit the market, compared to those that do not. Finally, we find that employees of firms which participate in ecosystems are less likely to start their own firm. While this result may seem counterintuitive, because we would expect ecosystems to foster entrepreneurial activity, it may be explained by the fact that firms which collaborate tend to be healthier, hence their workers do not have an incentive to leave.

We conclude our empirical analysis by estimating a series of fixed effect regressions for our main firm-level outcomes of interest, namely innovation, employment, productivity and wage growth. These panel regressions allow us to control for some firm-level unobservable characteristics which we might not be able to take into account in a cross-sectional setting. In practice, **these techniques imply that we only consider ‘within-firm’ variation, thus we are estimating the relation between starting (ending) a collaboration and the outcome of interest**. To compute these estimates, we need to rely on firms which exhibit temporal variation, both in terms of collaboration and outcome (thus we can only consider firms innovating in certain periods of their lifetime), meaning that we end up dropping many observations. Moreover, the interpretation of the findings should still be correlational, given that we are not able to control for some unobservable characteristics which evolve over time. For example, a firm might become more prone to start collaborations and innovate over time, for some characteristics which we are not able to measure.

We start by reporting, in table 18, the results of the fixed effect regressions, where the dependent variable is a binary indicator of whether a firm innovates and the explanatory variables are the collaboration indicator (with external entities or universities), R&D intensity, the share of employees with university degrees and the binary indicator of whether a firm has received R&D-related grants. Moreover, we include a set of year fixed effects.

*Table 18. Fixed effect (panel) logit regression of innovation (either product, service or process) on collaboration with external partners or universities and a series of firm-level controls.*

| VARIABLES | (1) Innovation | | (2) Innovation |
|---|---|---|---|
| Collab. ext. | 1.727*** | Collab. uni. | 1.564*** |
| | (0.0722) | | (0.0910) |
| R&D grant | 1.371*** | | 1.633*** |
| | (0.116) | | (0.110) |
| R&D Int | 0.0606*** | | 0.0690*** |
| | (0.0123) | | (0.0122) |
| Share of high edu. | -0.000581 | | -0.00164 |
| | (0.00381) | | (0.00360) |
| Firm fixed effects | YES | | YES |
| Year dummies | YES | | YES |
| Observations | 2,015 | Observations | 2,015 |
| Pseudo-R2 | 0.358 | Pseudo-R2 | 0.267 |
| Standard errors in parentheses | | | |
| *** p<0.01, ** p<0.05, * p<0.1 | | | |

The first thing to note from Table 18 is the large drop in observations we face when moving to a panel setting. This reduction in data availability can reduce substantially the precision of our estimates, so the findings presented here should be taken with caution. In the case of innovation, we find that collaboration activity still has substantial correlation with the outcome variable. This means that **firms which start to collaborate are also much more likely to start innovating**, reinforcing our previous conclusion that ecosystem participation seems strongly associated with effective innovation.

We now present, in tables 19-21, the results for the fixed effect regressions on employment, productivity and wage growth. As for innovation, the set of controls include R&D intensity and a grant receiver indicator, the share of highly educated employees, industry dummies and the base year value of the outcome of interest, to control for reversion to the mean trends.

*Table 19. Estimates of the fixed-effect (panel) regressions of the share of employees becoming entrepreneurs within two years, on collaboration with external partners or universities.*

| **VARIABLES** | **(1) Emp. growth (t+1)** | | **(2) Emp. growth (t+1)** | | **(3) Emp. growth (t+2)** | | **(4) Emp. growth (t+2)** |
|---|---|---|---|---|---|---|---|
| Collab. ext. | 0.0154 | Collab. uni. | 9.09e-05 | Col-lab. ext | 0.00526 | Collab. uni. | -0.0119 |
| | (0.00983) | | (0.0105) | | (0.0148) | | (0.0165) |
| R&D Intensity | 0.00138 | | 0.00150 | | -0.00138 | | -0.00125 |
| | (0.00145) | | (0.00145) | | (0.00257) | | (0.00255) |
| R&D grant | 0.00521 | | 0.0123 | | 0.0333 | | 0.0404* |
| | (0.0136) | | (0.0137) | | (0.0214) | | (0.0211) |
| Base year emp. | -0.236*** | | -0.235*** | | -0.407*** | | -0.406*** |
| | (0.0326) | | (0.0326) | | (0.0439) | | (0.0440) |
| Share of high edu. | -0.000618 | | -0.000623 | | 0.000370 | | 0.000366 |
| | (0.000523) | | (0.000526) | | (0.000331) | | (0.000334) |
| | | | | | | | |
| Firm fixed effects | YES | | YES | | YES | | YES |
| Year dummies | YES | | YES | | YES | | YES |
| | | | | | | | |
| Observations | 3,560 | | 3,560 | | 2,917 | | 2,917 |
| R2 | 0.098 | | 0.096 | | 0.148 | | 0.148 |
| Robust standard errors in parentheses | | | | | | | |
| *** p<0.01, ** p<0.05, * p<0.1 | | | | | | | |

*Table 20. Estimates of the fixed-effect (panel) regressions of labour productivity growth on collaboration with external partners or universities. Columns (1) and (2) contain results for labour productivity growth one year after the CIS survey, while the results for labour productivity growth two years after the survey are reported in columns (3) and (4).*

| | (1) | | (1) | | (1) | | (1) |
|---|---|---|---|---|---|---|---|
| VARIABLES | Lab. prod. growth (t+1) | | Lab. prod. growth (t+1) | | Lab. prod. growth (t+2) | | Lab. prod. growth (t+2) |
| | | | | | | | |
| Collab. ext | 0.0143 | Col-lab. uni. | 0.0148 | Col-lab. ext | 0.0169 | Col-lab. uni. | -0.00412 |
| | (0.0103) | | (0.0119) | | (0.0137) | | (0.0157) |
| R&D Intensity | -0.00295 | | -0.00295 | | -0.000197 | | -3.49e-05 |
| | (0.00247) | | (0.00247) | | (0.00302) | | (0.00302) |
| R&D grant | -0.00337 | | -0.00195 | | -0.0242 | | -0.0147 |
| | (0.0158) | | (0.0159) | | (0.0228) | | (0.0235) |
| Base year prod. | -0.438*** | | -0.439*** | | -0.729*** | | -0.729*** |
| | (0.0521) | | (0.0523) | | (0.0568) | | (0.0565) |
| Share of high edu. | 0.000112 | | 0.000109 | | -0.000414 | | -0.000424* |
| | (0.000286) | | (0.000285) | | (0.000257) | | (0.000252) |
| | | | | | | | |
| Firm fixed effects | YES | | YES | | YES | | YES |
| Year dummies | YES | | YES | | YES | | YES |
| | | | | | | | |
| Observations | 3,558 | | 3,558 | | 2,914 | | 2,914 |
| R2 | 0.181 | | 0.181 | | 0.272 | | 0.271 |
| Robust standard errors in parentheses | | | | | | | |
| *** p<0.01, ** p<0.05, * p<0.1 | | | | | | | |

*Table 21. Estimates of the fixed effect (panel) regressions of wage growth on collaboration with external partners or universities. Columns (1) and (2) contain results for wage growth one year after the CIS survey, while the results for wage growth two years after the survey are reported in columns (3) and (4).*

| | (1) | | (2) | | (3) | | (4) |
|---|---|---|---|---|---|---|---|
| VARIABLES | Wage growth (t+1) | | Wage growth (t+1) | | Wage growth (t+2) | | Wage growth (t+2) |
| | | | | | | | |
| Collab. ext | 0.0120** | Collab. uni. | 0.0123* | Col-lab. ext | 0.0158 | Collab. uni. | 0.0180* |
| | (0.00620) | | (0.0067) | | (0.0104) | | (0.0097) |
| R&D intensity | 0.00166** | | 0.0016** | | 0.00369** | | 0.00367** |
| | (0.00069) | | (0.0006) | | (0.00149) | | (0.00152) |
| Base year wage | -0.672*** | | -0.674*** | | -0.816*** | | -0.819*** |
| | (0.069) | | (0.069) | | (0.0994) | | (0.0980) |
| R&D grant | -0.0103 | | -0.00915 | | -0.0131 | | -0.0128 |
| | (0.0074) | | (0.007) | | (0.0125) | | (0.0119) |
| Share of high edu. | 0.00015 | | 0.0014 | | -0.0007*** | | -0.0007*** |
| | (0.00024) | | (0.00024) | | (0.00013) | | (0.00013) |
| | | | | | | | |
| Firm fixed effect | YES | | YES | | YES | | YES |
| Year dummies | YES | | YES | | YES | | YES |
| | | | | | | | |
| Observations | 3,557 | | 3,557 | | 2,911 | | 2,911 |
| R2 | 0.044 | | 0.042 | | 0.068 | | 0.066 |
| Robust standard errors in parentheses | | | | | | | |
| *** p<0.01, ** p<0.05, * p<0.1 | | | | | | | |

Based on the results of the cross-sectional analysis and also due to the large reduction in the number of observations, it is not surprising to see that the coefficients related to the collaboration indicator are not statistically significant. However, the direction of the relation is the expected one, i.e., firms that start collaborating are usually those with positive employment and productivity growth. Moreover, it is surprising to see that the panel regression results indicate a significant positive link between collaboration activity and wage growth, contrary to the cross-sectional setting.

**The results of the panel analysis generally confirm the main findings of the cross-sectional regressions**. We find that there is a strong link between collaborations and successful innovations, while the evidence on the correlation with employment and productivity growth is weaker, even though there are signs of a positive relationship. For wage growth, we find a positive and significant correlation with ecosystem participation.

## 3.6 Summary and ways forward

While heavily studied in theoretical settings and in small empirical analyses, mostly in terms of case-studies, innovation ecosystems have not been the focus of larger scale statistical exercises. The heterogeneity of the definitions of ecosystems, the inherent uniqueness characterising them, as well as the large variety of entities composing them, renders the application of statistical methods challenging. Things become even more complicated when considering impact analyses, given the self-selection and organic dynamics typical of ecosystems. In this exercise, **we rely on strong assumptions in order to offer a concrete contribution regarding the measurement of innovation ecosystems and the study of their impact on firm-level outcomes**.

For the first part of the analysis, we rely on simple indicators of industry conglomeration and of local economic clusters, to take a step towards the identification of ecosystems from raw firm-level data. This decision is based on the assumption that, at least some extent, innovation ecosystems are characterised by geographical concentration due to the fact that the informal sharing of skills and knowledge between the various entities forming the ecosystem requires a degree of proximity. Of course, this assumption does not necessarily apply to all innovation ecosystems. While the findings of our analyses highlight the importance of expert judgment when screening the results of the statistical techniques we adopt, we do find some interesting examples of clusters which can be identified as ecosystems. For example, we find a cluster of industries related to tourism in Lapland, as well as a strong concentration of activities related to ICT in the city of Espoo. Overall, **we believe that indicators of clusters can be a helpful first step in the measurement of ecosystems** which needs then to be followed and validated by the use of additional quantitative and qualitative information.

Regarding the study of the possible impacts of ecosystems participation on firms, we rely on the CIS surveys to identify firms which have collaborated with external entities (with special attention given to collaboration with universities) during their innovation-related activities. The assumption we make here, i.e., that firms that collaborate with partners such as universities, competitors, or clients, are part of an innovation ecosystem. This assumption is strong and can lead us to consider firms which are not part of an ecosystem, while at the same time to exclude firms which participate in an ecosystem via more informal relationships. This kind of premise does however allow us to quantify the correlation between ecosystem participation and a large set of firm-level outcomes, leveraging on the abundance of information provided by the CIS surveys. **We find a strong link between collaboration and innovation**, even when moving to a more restrictive panel setting, **while we observe a weaker correlation with employment and wages growth** which shows a statistically significant relationship only in certain specifications. The positive correlation between collaboration activity and successful innovation might seem trivial at a first glance, but in essence it indicates that the main purpose of innovation ecosystems is achieved. On the other hand, **we do not find any significant relation between ecosystem participation and productivity growth**. When looking at the possible relation between collaboration activity and the likelihood of employees leaving the firms they work for, to start their own business, we find a negative correlation. While this can be surprising, given that we might expect functioning ecosystems to stimulate entrepreneurial activity, it can be explained by the relatively better conditions of collaborating firms, something which we suggest might incentivise their employees to stay.

Our analysis is far from conclusive with significant work still to be done to pursue our objectives. As noted previously, integrating our cluster studies with narrative and anecdotal evidence can be a useful exercise. To conclude, we want to provide a few suggestions regarding possible approaches and new data that could be helpful in measuring innovation ecosystems and their impacts. Firstly, despite being costly and providing a benefit mostly in the mid-to-long term, **greater effort should be made to survey firms in order to investigate the diffusion of ecosystem participation**. Surveys where participation in ecosystems is explicitly referenced are quite rare (a notable example is provided in Deschryvere and Kim, 2016) and representative surveys which would provide definitive information on whether firms are part of ecosystems would allow the user to bypass a lot of approximations and measurement issues.

Another interesting avenue of research regarding the measurement of ecosystems is the use of **textual analysis techniques to uncover possible links between firms and other entities**. For example, the application of text mining methods to company statements can help to identify an innovation-related project carried out with a university, or strategic collaborations with competitors or customers, something which can signal the presence of an ecosystem. A further possible approach to the identification of firms who are potentially participating in ecosystem is to rely on predictive techniques. In practice, using prior knowledge, one can first look at firms which are known to form an ecosystem and analyse the characteristics of these enterprises. Of course, this step is not trivial, given that the register-based data are anonymised, thus permission to identify the firms of interest is required. Subsequently, a simple model using firm-level attributes to predict participation in ecosystems can be estimated and applied to the population of firms to identify possible ecosystems. Potentially useful firm-level predictors can be size, age, industry and patent activity, as well as closeness to firms belonging to the same industry or to industries which are typical customers or suppliers. One can go even further and use high-dimensional econometric techniques to handle situations where there are a lot of predictors and little guidance in terms of which variables to include in the model. Regarding the impact of ecosystems, the use of more detailed surveys can offer better measurements, but if we want to conduct longitudinal analyses, we need multiple waves including the same set of firms, something which requires time. **Even if we were able to track firms entering and exiting ecosystems, causal claims are still hard to make**, due to self-selection problems and the fact that ecosystem participation cannot be considered a treatment in the usual fashion. If a looser approximation of innovation ecosystems, such as clusters, is deemed sufficient, one could rely on historical factors to exploit random variation behind the birth of ecosystems which would then allow for causal analysis. The study in Greenstone et al. (2010) offers an example of this approach.

# 4 Ecosystems as part of innovation policy in Finland and selected peer countries

## 4.1 Ecosystems in the context of Finnish innovation policy

In Finland, one of the primary drivers of national innovation policy is the intensification of competition between different ecosystems of companies and other actors on a global scale. The National RDI Roadmap (2020) states that in order to strengthen, broaden and increase the impact of innovation policy, business and research networks need to be grouped into larger ecosystems. In order to strengthen, broaden and increase the effectiveness of the competence spearhead, research and the networks that utilise it must be grouped into larger competence centres and ecosystems. The realisation of international exports and growth targets requires a more comprehensive, ecosystem-based approach to development, closer cooperation between the public and private sectors in RDI and internationally attractive development and experimentation environments (see also TEM 2017). Innovation ecosystems are thus seen to play a significant role in making the government's goal of raising Finland's research and development spending to 4% of GDP, by 2030, possible. The importance of innovation ecosystems in relation to these long-term goals is strongly linked to the diversification of Finland's economic structure and improvements in productivity development. Addressing societal challenges requires risk-sharing between companies and the public sector, as well as an increasingly strong partnership between different actors. In Finland, an ecosystem-based innovation policy has also been justified in response to the challenges of transformative innovation policy, such as the systemic challenges related to the coordination of demand and policy-learning.

There are several different national policy instruments in Finland which support innovation cooperation between different actors. Business Finland funds ecosystem and RDI partnership projects with several instruments such as the funding for **leading companies and ecosystems (Veturi)**[3] and **growth engines (Kasvumoottorit)**[4]. Business Finland offers partnership funding for research, development, and innova-

[3] https://www.businessfinland.fi/en/for-finnish-customers/services/funding/funding-for-leading-companies-and-ecosystems
[4] https://www.businessfinland.fi/en/for-finnish-customers/services/funding/growth-engines/starting-support-for-the-growth-engine-platform-company-by-provision-of-capital-loans

tion projects in leading companies' ecosystem themes. The Leading company initiative was launched in 2020 as a challenge competition The aim is to challenge global leading companies to solve major future challenges, to increase significantly their RDI investments, to create new jobs and to build new high-value business ecosystems in Finland. The maximum available funding per leading company is EUR 20 million. In addition, Business Finland can provide funding up to EUR 50 million to the leading company's partners during a period of five years. In contrast, **Growth Engine programme** is implemented through an enterprise-driven partnership model between companies, research organisations and public actors which strives to find solutions to global market disruption and create new growth sectors in Finland. The state accelerates the creation and development of Growth Engine platform companies by providing capital loan financing for the preparation of projects. The funding is intended for developing the business operations of Growth Engine platform companies and preparing network impacts. Growth Engines often need so-called platform companies (e.g., data operators) that can solve problems related to the creation and growth of the ecosystem.

The Academy of Finland will advance the national goals highlighted in the National RDI Roadmap especially with its **Finnish Flagship Programme (Lippulaivaohjelma)**[5], **research infrastructure funding**[6] and **Special funding for RDI partnership networks**[7]. The Academy of Finland's Flagship Programme is an instrument that supports high-quality research and increases the economic and societal impact emerging from the research. The Finnish **Flagships** represent an effective mix of close cooperation with business and society, adaptability and a strong commitment from host organisations. International collaboration is an integral part of the Flagships' activities. The Flagships create future know-how and sustainable solutions to societal challenges and promote economic growth by, for example, developing new business opportunities. The Academy of Finland also provides funding for **research infrastructures** which are instruments, equipment, information networks, databases, materials and services that serve to facilitate research, promote research collaboration and reinforce research and innovation capacity and know-how. Research infrastructures are seen as an integral part of an internationally attractive research and innovation environment and support creation and development of innovation ecosystems. In addition, in 2020, the Academy of Finland provided **special funding for RDI partnership networks**. The aim of this special funding in 2020 for RDI partnership networks was to support and promote the networking of higher education institutions and government research institutes with the business sector in order to boost the societal impact of high-quality research.

[5] https://www.aka.fi/en/research-funding/programmes-and-other-funding-schemes/flagship-programme/
[6] https://www.aka.fi/en/research-funding/programmes-and-other-funding-schemes/research-infrastructures/
[7] https://www.aka.fi/en/research-funding/apply-for-funding/calls-for-applications/apply-now2/special-funding-for-rdi-partnership-networks/

Furthermore, the Ministry of Economic Affairs and Employment has granted special **funding for the development of growth ecosystems**[8]**.** The goal is to identify new emerging growth sectors and ecosystems and to prepare studies on ecosystem initiatives. The funding aims to promote new types of partnership models and the growth of ecosystems. The Ministry of Economic Affairs and Employment supports **European Digital Innovation Hubs (EDIHs)**[9] which are part of the EU's new Digital Europe Programme. The EDIGs function as service points that boost digital investment and, in particular, the digitalisation of SMEs. Also, separate **ecosystem agreements**[10] have been drafted in cooperation with state and cities to strengthen innovation activities. The agreements have been made with 16 urban areas and the objective of the agreements is to build innovation ecosystems, in other words, to intensify cooperation within networks, strengthen key competences and increase effectiveness of RDI activities.

## 4.2 Innovation policy and ecosystems in peer countries

This study has examined the current state of innovation policy in four European reference countries, in particular, through documentary data and additional interviews, on how innovation ecosystems and their role are reflected in the innovation policies and instruments of the reference countries. The country cases covered were the United Kingdom (in particular the Catapult programme), Belgium (in particular the Flanders Make strategic research centre), Sweden (in particular the strategic innovation programmes, / SIP) and Denmark (in particular the innovation networks).

**The UK's** innovation policy emphasises the creation of a general framework and an approach that supports the national innovation system. A key instrument of innovation policy is the Catapult network of technology and innovation centres which operates between companies and research actors. The purpose of the catapults is to accelerate the practical application of research and the development, scaling and commercialisation of technology. Instead of a transformative innovation policy and societal challenges, for example, attracting people and individual talent, researcher mobility and supporting entrepreneurship are more commonly highlighted, though the themes of the Catapults are in fact more cross-sectoral than branch-specific (i.e. "Cell and Gene Therapy, Compound Semiconductor Applications, Connected Places, Digital

[8] https://tem.fi/valtionavustukset-kasvuekosysteemien-kehittamiseksi
[9] https://tem.fi/en/digital-innovation-hubs
[10] https://tem.fi/en/-/agreements-between-state-and-cities-to-speed-up-innovations-in-carbon-reduction-digitalisation-and-wellbeing

Energy Systems, High Value Manufacturing, Medicines Discovery, Offshore Renewable Energy, Satellite Application"). An important consideration of the recently completed evaluation of the activities of the Catapults is that there is a clear need to develop the collection of higher quality, more qualitative and quantitative data on the activities of the Catapults. It is argued that the very notion of Key Performance Indicators (KPIs) needs to be clarified, to ensure the ability to identify possible key impact pathways (BEIS 2021, p. 16) and to steer policy accordingly. In addition, there is also a need to move to more long-term monitoring and review of effectiveness (perhaps more in line with OKR – Objectives and Key Results focus of innovation policy).

In the UK, the focus is clearly on ecosystems as an element of industrial policy in the post-Brexit era, as it is stated that the different elements that characterise innovation, e.g., discovery, invention, development and adoption, cannot be readily and cleanly separated and therefore there is a need for the whole ecosystem of businesses, government, R&D-performing organisations, finance providers, funders, international partners and others to come together. The 2020 R&D Roadmap set out the importance of this broad system and how it should be nurtured. The main focus of this Strategy is on finding the best ways to support private sector innovation by making the UK attractive for talent and investment and making the most of the UK's research, development and innovation system (UK Innovation strategy 2021, p.7).

Doubts have been expressed that the UK's innovation policy direction might be leaning towards a more traditional industrial strategy approach with less prioritisation given to science-based innovation policy with less targeted priorities and more general science funding. Some have even argued that there are echoes of innovation policy "returning to the 1980s and 1990s, for example in science parks or industrial villages"[11].

**Danish** innovation policy has focused on network- and cluster-based thinking, respectively. National innovation clusters and its funding supports networks with diverse actors and activities linked to national strengths and emerging major (industrial) sectors. A nationally uniform model for monitoring activities and results has been built for these clusters and networks, but it is not viewed as very successful particularly in terms of producing high social impacts, as the evaluation of the Danish national innovation system states that the challenge from the point of view of effectiveness is the lack of a comprehensive national innovation strategy, in which case even innovation networks do not have jointly communicated effectiveness objectives and models.

[11] https://www.researchprofessionalnews.com/rr-news-political-science-blog-2021-3-uk-innovation-policy-is-stuck-between-forward-and-reverse/;
https://www.foundation.org.uk/Blog/2021/UK-science,-technology-innovation-policy-after-Bre

In contrast to the emphasis on the national perspective, the implementation of innovation policy in **Belgium** is highly decentralised with responsibility for effectiveness lying, primarily, with regional actors, such as *Flanders Make*, established in 2014 as a strategic cluster research centre. The Research Centre has a clear operating method and a model for organising cooperation with universities and companies in RDI which has proved to be effective, for example, in building cooperation between SMEs and the research community. The broader goal in terms of effectiveness is industrial renewal, but here too effectiveness is measured more by traditional performance and input indicators with broader societal goals not reflected in the analysis of effectiveness.

In **Sweden**, innovation policy represents the strongest strategic, co-ordinating and determined approach encountered amongst the countries reviewed, a policy which seeks to coordinate measures at the policy level, while leaving the executive authorities a lot of leeway in terms of implementation. The most socially significant challenges are identified as a starting point in innovation policy. For example, in cooperation programmes, the themes include climate change, skills and lifelong learning, digital economic restructuring and health and life sciences. According to Regeringskansliet (2021) The shift to transformative innovation policy and ecosystem thinking is seen as a response to institutional deficiencies and the lack of systemic objectives.

Sweden's innovation programmes are seen to play a role in the implementation of systemic social change and transition, thereby also reflecting the move from more output-driven key performance indicators to more impact-driven objectives and key results, or a more mission-oriented “societal change” ethos, rather than an indicator- and audit-driven “tick box” culture (Vinnova 2021).[12]

The goal of influencing social change presents an interesting special feature of innovation programmes (SIPs) and the examination of their effectiveness. Indeed, the latest evaluation of innovation programmes (Åström, Arnold, & Olsson 2020) also raises the social impact of the programmes and their transition effects, such as those on the green and digital transitions. An interesting aspect of monitoring and measuring systemic change is the identification and evaluation of the functions of “change-making”. The evaluation has highlighted the commitment of major national actors to the objectives of the programme and, more generally, the creation of a joint mission. In this case, attention is also paid to the setting and formulation of common goals, the building of coalitions, the processes of creative destruction and learning out and to reflexivity (learning from practice).

[12] See also https://www.vinnova.se/nyheter/2021/12/enda-vagen-till-hallbar-forandring--ett-missionsorienterat-arbetssatt/

There are other strongly mission-driven innovation policies implemented internationally, e.g., Dutch innovation policy is steered from an excellence-driven or market-driven industrial policy towards a mission-oriented one while Israel also supports ecosystem-driven funding and impact models (so-called “Israeli Impact Investment Ecosystems) (Sepponen et al. 2021, p. 18-20 and 32).

## 4.3 Summary of directions for innovation policy

In the European context, the concept of the ecosystem is less visible in the innovation policies of the peer countries analysed. The traditional cluster approach is more strongly emphasised. Ecosystem concept does however seem to have more currency as a heuristic device when analysing the interactions and collaborative environments of companies and industrial players. In EU innovation policy, the importance of ecosystems is again linked to industrial policy in particular and reflected in the shift towards a stronger focus on collaboration and interdependence between sectors, actors in innovation value chains and linked to societal challenges (from climate change to ageing and carbon neutrality to urbanisation). The EU's new industrial strategy includes an initiative on industrial ecosystems, where the needs of such ecosystems are to be addressed. In the EU context, these industrial ecosystems are seen as analytical tools, drawn around traditional industries without further delimiting and defining which actors are included in these ecosystems[13].

The language of ecosystems is also a new element in the Commission’s approach, fuelled, perhaps, by the fact that the concept does not yet have a commonly accepted meaning across the Member States. Industrial and other ecosystems, are defined according to the NACE classes used by the Sector-Reina statistics. In addition, there are, currently, no common indicators describing the state and evolution of ecosystems and the effectiveness of the measures. This emphasises the need for developing a common approach to the review of innovation ecosystems and the common indicators and measurement methods.

Comparative and country-specific analysis focuses on the contextual nature of policy instruments. Whilst in the Finnish policy context ecosystems are perceived as collaborative structures for companies and other stakeholders, enabling them to work collectively towards strategic goals by addressing shared challenges, often within a governance structure that consists of a board of representatives of the member companies and a neutral body that facilitates networking and coordination activities within the

[13] Comprising cluster collaborations around fourteen identified industrial ecosystems: Tourism, Mobility-Transport-Automotive, Aerospace & Defence, Construction, Agri-food, Energy Intensive Industries, Textile, Creative & Cultural Industries, Digital, Renewable Energy, Electronics, Retail, Proximity & Social Economy, and Health https://clustercollaboration.eu/in-focus/industrial-ecosystems/definition

ecosystem and in line with the common strategy between the partners in the ecosystem in question (Zegel et al. 2021, p. 6), similar institutional support is not always in place or it is articulated differently elsewhere. Ecosystems are seen as addressing key challenges related to innovation, internationalisation, human capital and capital and entrepreneurship and as providing a framework supporting the dynamics and collaboration activities needed to address nationally shared policy problems. From the outside it is difficult to assess how the trend towards ecosystem policy is reflected in the thinking of peer countries. There does however seem to be at least some degree of similarity or interdependence between ecosystem thinking and the holistic or systemic nature of societal impact in the policy instruments and innovation policy guidance instruments of the comparator countries. It should be noted, however, that policy objectives generally represent a more traditional range of innovation policies and reviews of effectiveness (e.g., RTD contributions, geographical cooperation between SMEs and research, patents etc.,) rather than indicators and frameworks aiming at climate policy, digitalisation or understanding the transition associated with lifelong learning or related systemic modelling and monitoring.

The Swedish approach to innovation policy in particular relies on a heavy mission orientation and societal impacts focus. The description and the Nordic Council of Ministers' five criteria for selecting missions below reflects its key characteristics (Nordic Council of Ministers (2020, p. 29)).

1. **Missions are bold and inspirational and are used to tackle urgent grand challenges**. Missions are not about addressing low-hanging fruit, requiring technical and/or single solutions. Missions aim to bring about change across a system in a way that benefits society by addressing the complex, the systemic and the urgent. Missions thus have a clear transformative agenda designed to enhance the public good.

2. **Missions provide clear direction for action by setting measurable and time-bound goals.** Missions should have clear criteria that make it easy to determine whether the mission is a success. For example, we know that a mission to end child obesity in a particular area is a success when no child is classified as being above a healthy weight. A mission also needs to have a clear timeframe for action. Missions take time, so make sure that the time limit for the mission allows sufficient time to develop networks, experiment and innovate. The end outcome and date should be tangible, in order to inspire action and to make it operational.

3. **Missions use innovation and innovation policy to achieve ambitious but realistic change.** Missions provide clear direction for a solution, but they do

not assume that we know what those solutions are. This means that innovation and an innovative mindset are key to the success of missions. Importantly, missions ensure that resources, agendas and policies are aligned to foster innovation directed at a determined goal. This alignment is an important change of emphasis in policy terms, since innovation policy has traditionally been neutral with regard to social output of innovation.

4. **Missions rely on people's participation and input and they can bring people and organisations together to work in new ways**. As the government has the authority to take the lead in defining innovation outcomes, this gives them a central role in mission approaches. Since missions set a direction that subsequently steers the allocation and targeting of public funding and resources, public participation is also crucial in the development of a mission-oriented approach ensuring that everyone has their say.

5. **Missions rely on multiple paths offering multiple and alternative solutions to achieve the intended goals.** A mission is never a single project. Missions seek multiple parallel solutions to a challenge, as well as a portfolio of supportive measures, such as policy interventions, measures to deploy and diffuse innovation and close collaboration with the end-users of innovation. The portfolio approach can both help to buffer the inherent risk, failure and uncertainty of the innovation process and to maximise the lessons learned in the process.

To summarise, ecosystems relate to innovation policy and its choices in a number of ways. **Firstly**, in the Finnish innovation policy, innovation ecosystems are collaborative structures providing a platform for cooperation, incentives and resources directing companies, research organisations and intermediaries towards the same objective or mission. **Secondly**, innovation policies are strongly path-dependent and the shifts in emphasis, let alone funding principles, are seldom very radical or indeed swift. Many of the "innovation ecosystems" of today seem to be identical to the "innovation clusters" of yesteryear. **Thirdly**, innovation ecosystems are relatively weak in terms of their powers to steer or guide policy as, on the one hand, in some cases national policies predominate (most clearly obviously in the post-Brexit UK) and "innovation ecosystems" are more important as heuristic devices to analyse interactions between companies, rather than impact policies. **Fourthly**, the heuristic value of ecosystems relates in particular to the nature of interactions and the characteristics of collaboration between the stakeholders in an innovation ecosystem. This may render the traditional indicators (or cluster policy) irrelevant or at least insufficient. The added value then may lie in depicting, analysing and anticipating emergent solutions and the system characteristics of transitions.

# 5 A framework for examining the impacts of innovation ecosystems

## 5.1 Defining the effectiveness and impacts of innovation and innovation policy

The innovation ecosystem is a relatively recent concept that research has only recently begun to conceptualise. The development of ecosystems and related policy instruments is an even more recent trend and, as such, there are currently no ready-made frameworks in the research literature enabling us to examine innovation ecosystems and their impact. Nevertheless, previous research and observations on, for example, innovation systems, clusters, innovation networks and related externalities also provide important starting points for examining the impacts of innovation ecosystems. Table 22 summarises the fundamental perspectives of innovation policy offering a general framework encompassing the relevant perspectives when examining the impacts of innovation ecosystems.

*Table 22. General framework for examining the impacts of innovation ecosystems.*

| **Fundamentals of innovation policy** | **Impacts at micro level** | **Impacts at macro level** | **Key aspects in reviewing the impacts of innovation ecosystems: What is the impact of innovation ecosystems on…** |
|---|---|---|---|
| Market failures | Firm-level (productivity) growth<br><br>Dissemination of information | Economic and productivity growth;<br>Economic restructuring;<br>Welfare | **… the amount and form of RDI investments, and innovation outputs?** |
| System failures | Strengthening competence and innovation capacity<br><br>Generation and efficient use of information for commercialisation (deployment)<br><br>Dissemination of innovation | Functionality of the innovation system and its structures ("information infrastructure and institutions") | **… combining resources, know-how and capabilities<br><br>and the organisation and processes of innovation (especially cooperation and learning between actors) and thus the faster emergence, uptake and diffusion of innovation?** |
| Transformational failures | Innovation strategy: setting the direction and creating demand for innovation | Addressing societal challenges (systemic change) | **…the orientation and strategies of innovation activities (cf. societal challenges)?** |

A more traditional starting point for examining impacts is the perspective drawing on the notion of market failures. In this context it is essential to look at how companies and societies can be made to invest more in innovation that benefits society more broadly by addressing market failures and how innovation ecosystems play a role in investment. This perspective delves deeper into the systemic nature of innovation activities emphasises the effects of innovation ecosystems on 1) the innovation capacities, resources and know-how of actors, 2) the organisation and processes of innovation activities and thus, 3) the faster emergence, uptake and diffusion of innovations. The latest trend is to look at effectiveness from the perspective of societal change. An important question here is how innovation activities can be directed towards solving significant societal challenges and what impact innovation ecosystems have on the content orientation and strategies of RDI activities.

Although studies on the impacts of innovation ecosystems addressing the above aspects in detail, are not yet available, initial reflections on the importance of innovation ecosystems for stakeholders are emerging. For example, Knockaert, Deschryvere & Lecluyse (2019) note that the majority of Finnish innovative companies have stated that they belong to more than one innovation ecosystem and report that these innovation ecosystems have had a positive impact on the company's operations. The data consisted of 473 companies that received funding from Business Finland.

In addition to their economic impact, the impact of innovation activities has often highlighted the emergence of social and environmental impacts. However, the challenge in looking at these perspectives is that, although there are many indicators for both, linking them to the results of innovation is often challenging (Valovirta et al. 2014; Hjelt et al. 2011).

The criteria for examining ecosystems however remain rather underdeveloped internationally. The commonly used indicators for international RDI policy comparisons are largely focused on the analysis of R&D investment and the macro-level system, and provide little focus on identifying the societal impacts of innovation ecosystems (see also the EU Innovation Scoreboard[14]). It is perhaps even more challenging to address the causal relationships between innovation policy and quantitative performance measures. Until recently, very few studies assessing the impacts of innovation activities (e.g., R&D subsidies) has aimed at measuring the achievement of the main goal of innovation policy: the aggregate growth or welfare impacts of innovation policy (see, e.g., Einiö et el., 2022)

[14] EU Innovation Scoreboard. https://ec.europa.eu/info/research-and-innovation/statistics/performance-indicators/european-innovation-scoreboard_en

An additional challenge in examining the impacts of innovation ecosystems is the need to identify more closely the range of actors and precisely whose impacts are being analysed. In addition, innovation policies that support the development of ecosystems are moving away from previous thinking which identified certain sectors or entities as targets for action. Ecosystem thinking starts more strongly from cross-cutting themes and each ecosystem's own starting points.

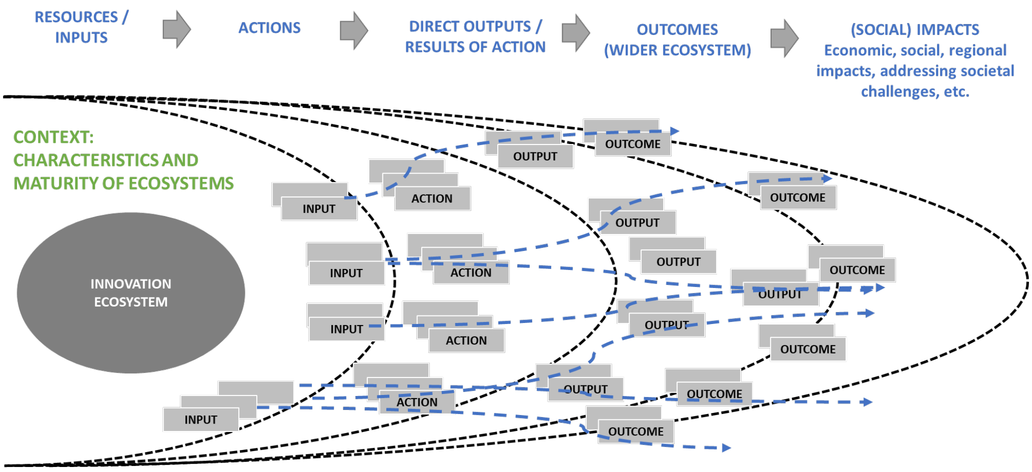
## 5.2 Modelling the impacts of innovation ecosystems

Our approach here highlights the multidimensional and multi-level examination of innovation ecosystems, as the impacts must be viewed from the perspective of the ecosystem actors, the ecosystems themselves and the social significance of these ecosystems. Moreover, three specific aspects must be taken into account when examining the impacts of innovation ecosystems:

1. Structural (ecosystem actors and shaping institutions),
2. Functional (vision, goals of different parties, capabilities of actors, cooperation relationships and dynamics of cooperation) and
3. An evolutionary perspective (the stage of development and maturity of the ecosystem, i.e., birth and evolutionary dynamics).

Innovation ecosystems are analysed utilising an impact-based perspective. The impact assessment framework is used as a tool for structuring the effects and possible indicators of innovation ecosystems. The aim of building the model is to outline and model the emergence of the intended and estimated effects and impacts. The core idea is to outline logical paths that may have interdependencies and/or possible causalities. These paths connect inputs, actions, outcomes and impacts. It is typical of innovation ecosystems that impacts arise through complex impact dynamics over a long period of time. However, the model helps to understand the logic of impacts and to identify those themes and situations where it is necessary to be patient with the impacts that arise. The construction of the impact model aims to outline the emergence of the desired and possible impacts. The simple illustration of modelling the impacts of innovation ecosystems is presented in the figure 7. The idea here is to examine innovation ecosystems holistically and identify the different pathways utilised by innovation ecosystems to attain societal goals.

*Figure 7. Impact assessment framework as a tool for modelling and structuring the impacts of an innovation ecosystem.*



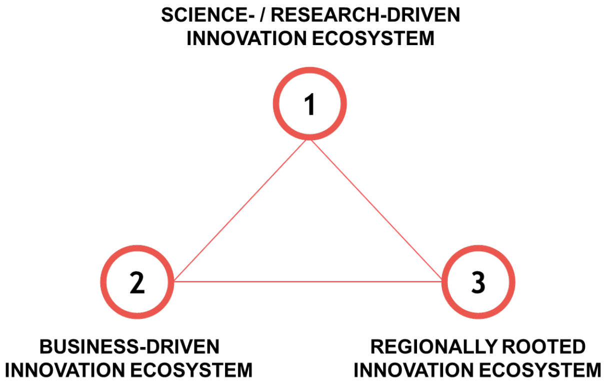

It is important to study and identify different ecosystems and their goals. In this case, in addition to the direct economic effects, the impacts must also be reflected very broadly in qualitative terms. In order to create a better understanding of the benefits, functioning and impacts of innovation ecosystems, it is important to gather together information from a wide range of sources.

## 5.3 Framework for reviewing the case studies

Based on the existing innovation ecosystems literature, it was decided to select innovation ecosystems with different starting points for a more detailed examination. In this work, the case study was based on an extensive review of ecosystems that have been supported by national innovation policy and financial instruments. The aim of this review was to examine innovation ecosystems that are of particular policy interest. In addition, the idea was to analyse various perspectives on the impacts of innovation ecosystems.

This work ended up classifying innovation ecosystems into three strands: 1) science / research-based, 2) business-oriented and 3) regionally-rooted innovation ecosystems (Figure 8). The starting point for a science / research-based innovation ecosystem is, for example, cutting-edge research, critical know-how and experts, or infrastructure and cooperation to generate and utilise know-how. The business-driven innovation ecosystem is built on a business ecosystem driven, for example, by market demand and joint investment or the pooling of resources to generate and disseminate innovation. A regionally-rooted innovation ecosystem is built on the basis of a regional cluster or knowledge cluster. The idea here is to harness regional resources to support the development path of a particular or several ecosystems towards globally significant innovation.

*Figure 8. The classification used in this study to review innovation ecosystems.*




As presented in chapter 4.1 there are several different national policy instruments in Finland which support innovation cooperation between different actors. All innovation ecosystems supported through these instruments were reviewed and a representative sample of different types of innovation ecosystems was selected for this study according to separately agreed criteria. Altogether, during the implementation of this study, there were several potential case studies:

- 6 Leading Companies' Ecosystem (Veturi)
- 20 Growth Engines (Kasvumoottorit)
- 10 Applications for the European Digital Innovation Hubs (EDIHs)
- 17 Ecosystem agreements with 16 urban areas to strengthen innovation across a variety of themes
- 10 Flagship ecosystems (Finnish Flagship Programme, Lippulaivaohjelma)
- 10 Consortiums which received special funding for RDI partnership networks in 2020
- 29 Nationally significant research infrastructures

The decision over the selection of the case studies was made with the steering group. The following aspects were emphasised in the case selection criteria. An ecosystem has, at least so some extent, an identifiable set of various actors (identifiable entity), a common goal (value creation to generate innovation) and longer-term cooperation ("not just one project"). Furthermore, the idea was to find a balance between different types of cases: e.g., research-driven / business-driven / regionally-rooted innovation ecosystems. In addition, ecosystem development and maturity were also considered: 1. Early stage, 2. Experimental phase, 3. Expansion / stabilisation phase, 4. Renewal phase. Some of the most relevant policy themes and interests were also emphasised, such as green transition, digitalisation and industrial renewal. The following table (table 23) shows the innovation ecosystems that were selected.

*Table 23. Selected case studies. (See also appendix 2)*

| | |
|---|---|
| **SCIENCE- / RESEARCH-DRIVEN INNOVATION ECOSYSTEM** | • **FINNCERES – COMPETENCE CENTRE FOR THE MATERIALS BIOECONOMY**. The aim is to produce scientific research data on biomaterials and to develop several new bio-based material solutions that can be used to develop significant biomaterial innovations in the future. The ecosystem is coordinated by **Aalto University** and **VTT Technical Research Centre of Finland** Ltd and funded by Academy of Finland (**Finnish Flagship Programme**) |
| **BUSINESS-DRIVEN INNOVATION ECOSYSTEM** | • **EXPAND FIBRE ECOSYSTEM:** Accelerating the development of sustainable bioproducts. The aim is to develop sustainable bio-based products for mass production, to create new business concepts and to bring the new products to international markets. The R&D entity is launched and implemented by **Fortum** and the **Metsä Group** and co-funded by Business Finland (Veturi, **Leading companies' ecosystem**). ExpandFibre is also closely connected to the FinnCERES ecosystem<br><br>• **INDUSTRIAL 5G ECOSYSTEM**: Unlocking Industrial 5G Beyond Connectivity / **System-on-Chip (SoC).** The aim is to develop 5G industrial products, services and solutions in several different vertical industry sectors. Of the 6 sub-ecosystems, System-on-Chip Hub (SoC Hub) was examined in greater detail. The ecosystem was launched and is managed by **Nokia** and the main implementer of SoC Hub sub-ecosystem is **the University of Tampere.** The ecosystem is co-funded by Business Finland (Veturi, **Leading companies' ecosystem**). |
| **REGIONALLY-ROOTED INNOVATION ECOSYSTEM** | • **ENERGYVAASA -CLUSTER.** A broader review of the EnergyVaasa cluster and energy technology cluster's importance for the development of different types of business-driven innovation ecosystems was carried out. EnergyVaasa represents a broad umbrella for cooperation in the energy sector. EnergyVaasa cooperation grew out from **Technology Centre Merinova**'s initiative back in 2001 with Merinova still responsible for the coordination of cluster operations.<br>  o **WÄRTSILÄ SMART MARINE ECOSYSTEM.** The case study was chosen to concretise the links between a business-driven innovation ecosystem and energy technology RDI cooperation in the Vaasa area. The goal of the **Wärtsilä's** Smart Marine ecosystem is to lead the industry transition towards carbon neutrality and intelligent shipping in cooperation with partners and other actors in the industry. |

In the following chapters we present a short introduction to our case studies, the most important findings and a model of the impacts of each innovation ecosystems.

# 6 Case studies on the impact assessment of innovation ecosystems

## 6.1 Research-driven innovation ecosystems

### FinnCERES

The FinnCERES -flagship ecosystem was examined in this study. FinnCERES aims to produce scientific research data on biomaterials and to develop several new bio-based material solutions that can be used to develop significant biomaterial innovations in the future. This ecosystem produces top-quality scientific research information and contributes to the development of the business based on them. The goal is to re-define the Finnish bioeconomy and build a bioeconomy ecosystem in Finland, primarily for the utilisation of forest biomass in high value-added products. Ultimately the ecosystem aims to promote a systemic change at the society level, where the new bioeconomy extensively changes the way society works. This is expected to contribute to goal attainment in respect of sustainable development aims at both the national and international scales.

FinnCERES, as with other flagship ecosystems, has been funded by Academy of Finland. FinnCERES has received funding since 2018 and it is scheduled to run until at least 2026. The ecosystem is led and coordinated by Aalto University and VTT Technical Research Centre of Finland Ltd. These organisations have launched the competence centre, which forms the foundation for the ecosystem. More than 20 domestic and foreign organisations are involved in the ecosystem (see Appendix 2, p 114). These include research institutes, universities and companies. The ecosystem is also connected to international cooperation and research networks. FinnCERES' main decision-making body is the steering group. The practical management of FinnCERES is carried out through the 12-member executive team.

FinnCERES' operations were preceded by extensive types of cooperation and research work between the actors involved. For example, Aalto University and VTT have worked closely in the field of biomaterials and the ecosystem is a continuation of previous research collaborations. In the past, however, cooperation has generally only concerned individual actors and their cooperation networks. The FinnCERES ecosystem has brought together different kinds of organisations into the same collaboration network creating a unified and common perspective on the goals set for the collaboration. The chances to achieve wider impacts are better when cooperation involves actors from different sectors of society and pooling of their resources.

A key starting point for the operation of the ecosystem is to gather together a wide range of ‘state-of-the-art’ know-how for parallel RDI activities and to acquire significant information and know-how relating to the operation of the ecosystem. Both domestic and international networks have been taken into account here. After this the aim is to make the cooperation between the actors more efficient and to generate joint research-projects aimed at new innovations. Through this the ecosystem tries to accelerate the development of sustainable bio-based products and to broadly disseminate and scale the research results to different actors.

The FinnCERES ecosystem seeks to have far-reaching impacts on society. As such, its activities and means of producing the desired impacts consist of different types of things. Essentially these are as follows:

- Generation of a wide range of research results, on the basis of which new innovations, products and business concepts begin to emerge.
- Developing education contents, knowledge and skills and thereby contributing to the emergence of longer-term and wider-ranging impacts.
- Using scientific information to have a broad influence on society, its different actors and in decision-making and legislation.
- Obtaining and sharing information through international networks and scaling up the impacts to the international level.

FinnCERES consists of four research themes which are future biorefineries, clean air and water, lignocellulosics beyond plastics and electronics, optics and energy applications. In cooperation between various actors, research is being conducted to expand the use of bio-based materials in various application areas, like electronics, energy storage, optics, textiles, packaging and biocomposite products. Furthermore, the ecosystem directs activities to influence the education system and its educational contents and tries to develop them with the goals of the ecosystem in mind. As more information from scientific research is generated, the aim is to introduce this information back into various education contents. In addition to this, ecosystem actors are active in several international cooperation networks related to producing scientific information or promoting the new bioeconomy. As ecosystem actors produce a significant amount of relevant scientific information this information is used to influence the decisions steering societal development and the bioeconomy.  FinnCERES can be described as an information ecosystem in which the creation of innovations is one of the key parts of its activities.

A further important aspect of the ecosystem is its cooperation with Business Finland's funded Expand Fibre - Leading companies' ecosystem (Veturi instrument). Expand Fibre is a business-driven ecosystem that is closer in its operations to applied research and commercialisation (described in greater detail in the next section). The FinnCERES - ExpandFibre cooperation aims to cover the journey from basic research to applied RDI activities and the launch of new bioproducts. For FinnCERES, the Expand Fibre ecosystem is one path that is utilised to commercialise research results. These ecosystems have also worked jointly to promote jointly selected research actions and their actors work closely together through ecosystem activities (e.g., joint seminars and events).

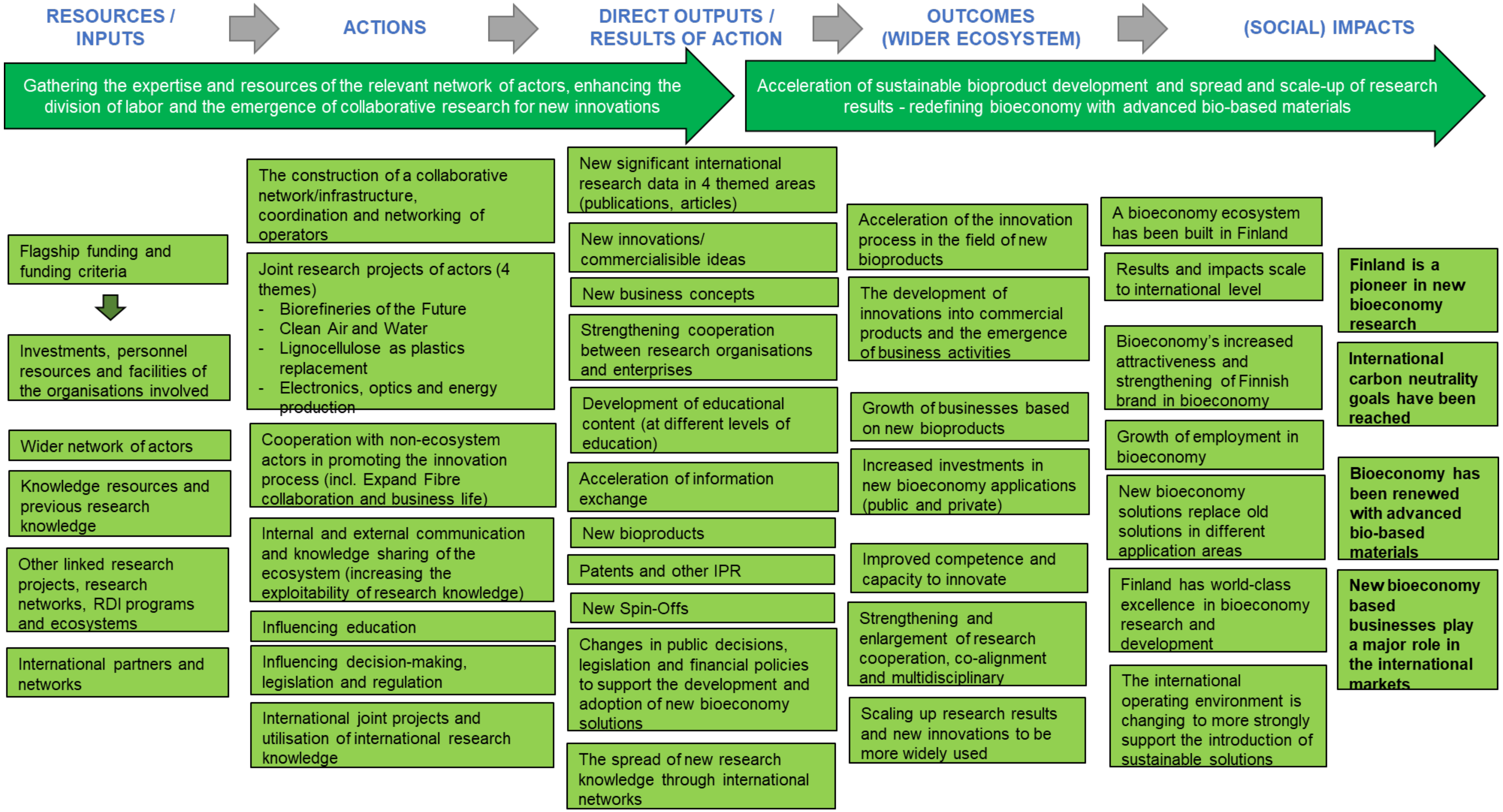
The two other main paths to commercialisation are cooperation and the evaluation of the business potential of new innovations with existing companies and the promotion of new spin-offs.

From the impact model (Figure 9) five different impact paths can be detected in the operations of the FinnCERES ecosystem. Through these paths and their combined effects, the main impacts of the ecosystem are reached.

- Strengthening and promoting networking and cooperation in research and innovation activities
- Generating new ideas for innovations, scaling and disseminating these ideas
- Development of competencies and know-how
- Generating societal impacts, influencing decision-making and removing obstacles for development and strengthening demand
- International research collaboration, gathering and disseminating of information and staying at the forefront of global development

As the goal of the FinnCERES innovation ecosystem is to promote the realisation of a broader change at the system level, through which the operations of societies will take greater account of sustainable development, these impact paths are expected to have a broader impact both nationally and globally. The time span in which an ecosystem seeks to achieve visible effects is 5-15 years. However, the timing of noticeable impacts varies across the various different impact paths. For example, new innovations may emerge quickly, while societal change may take much longer. It should also be noted that the impacts are chain-linked and some of the impacts are a prerequisite for others. For example, new innovations and new knowledge also contribute to wider societal impacts.

*Figure 9. FinnCERES' impact logic and model based on the case study data.*



## 6.2 Business-driven innovation ecosystems

In this study, a closer look was taken at two business-driven innovation ecosystems. These were Business Finland Leading companies (Veturi) ecosystems Expand Fibre and Nokia 5G: Unlocking Industrial 5G Beyond Connectivity –ecosystem (Nokia 5G) and its sub-ecosystem System on a Chip Hub.

### Expand Fibre

Expand Fibre -programme is a business-driven innovation ecosystem launched in 2020. The leading companies in the ecosystem have received 20 million euros funding from the Business Finland Veturi instrument to launch the ecosystem. In addition, Business Finland has promised to fund the organisations in the ecosystem with additional 50 million euros. Through these instruments and funding, Business Finland supports companies to increase their own investments in R&D as well as the cooperation of large companies with smaller companies and research institutes in research and development. The goal is to generate new world class innovations that will con-tribute to the competitiveness and growth of Finnish businesses and the economy as a whole.

The goal of the Expand Fibre ecosystem is to develop sustainable bio-based products for mass production, to create new business concepts and to bring the new products to international markets. A key feature in the ecosystem is that it is driven and all thematic areas are promoted by two large Finnish companies working together. The leading companies are Fortum (a large Finnish energy sector company) and Metsä Group (a large Finnish forestry company). Expand Fibre involves more than 70 other organisations from a wide range of industries and it is an open innovation ecosystem in which actors are involved on an open access basis. Compared to the research-driven FinnCERES ecosystem, a wider range of companies from different industry sectors, are involved in this ecosystem. Ecosystem operations involve companies from 25 different industries. In addition to this, the ecosystem involves universities and research institutes, interest group and foreign companies (see Appendix 2, p 116).

The background to the launch of the Expand Fibre ecosystem was the expected / already visible market growth for new bio-based products. Individual actors and sector-specific networks have only limited opportunities to conduct the RDI activities required by new sustainable bio-based product markets. There was a need for more extensive multidisciplinary cooperation and the pooling of expertise and resources. Through the ecosystem cooperation new innovations can be created using different areas of expertise and by meshing different skills in joint projects. At the same time, in a wider cooperation context, business can also be scaled up and the bioeconomy promoted more effectively.

Ecosystem participants have previously been active in implementing R&D projects related to the ecosystem theme with funding from Business Finland. More than half of the organisations had received Business Finland funding in the period 2015-2021 and had participated in programmes related to ecosystem themes. In addition to this, for example the leading companies in the ecosystem have had and continue to have a number of their own R&D programmes related to the ecosystem theme. The ecosystem is thus built on the continuation of previous R&D activities and continues to benefit from other ongoing R&D activities.

The Expand Fibre ecosystem is also underpinned by many previous collaborative networks. However, with the ecosystem, cooperation in R&D activities has strengthened and has also become more comprehensive across different sectors. This renders it possible to make use of a wider range of know-how and to obtain relevant information from different sectors. The distinguishing factor marking out this cooperation effort from previous ones is the expansion of cooperation to cover several industries, harnessing different types of knowledge and abilities for cooperation, as well as promoting the more open exchange of information and more agile learning. In addition, a large-scale ecosystem brings more power and (neutral) visibility to help propel the cooperation effort forwards.

At the core of the ecosystem's activities are cross-sectoral RDI projects focusing on applicable research and commercialisation activities across a wide range of application areas. There are in 7 thematic areas: textiles, biocomposites, packages, lignin-based products, hemicellulose products, straw fractionation and other fibre products.

One important area of Expand Fibre is its cooperation with the Academy's Flagship ecosystem FinnCERERS in sharing information, as well as a jointly defined set of common goals and a roadmap to those goals. Expand Fibre receives information about new innovations from the FinnCERES ecosystem and, similarly, shares the results of its own research with FinnCERES providing information on business needs to the science-based ecosystem. Both ecosystems thus contribute to the building of the bioeconomy ecosystem and to the redefinition of the bioeconomy.

Compared to a research-driven ecosystem, a business-oriented ecosystem is more directly concerned with delivering applicable solutions and commercialisable innovations. This also means that it is expected to have a more direct and faster impact on businesses (business growth, new business models and new businesses). In the business-oriented ecosystem, the focus is not only on developing innovation, but more visibly also on reforming businesses and value networks to meet the needs of the new bioeconomy. This means the introduction of new business models, the growth of investments in new businesses, the emergence of new cooperation efforts between various actors, improving the capability and know-how required for new business models and changes in the operations of value networks are all in focus for these ecosystem operations.

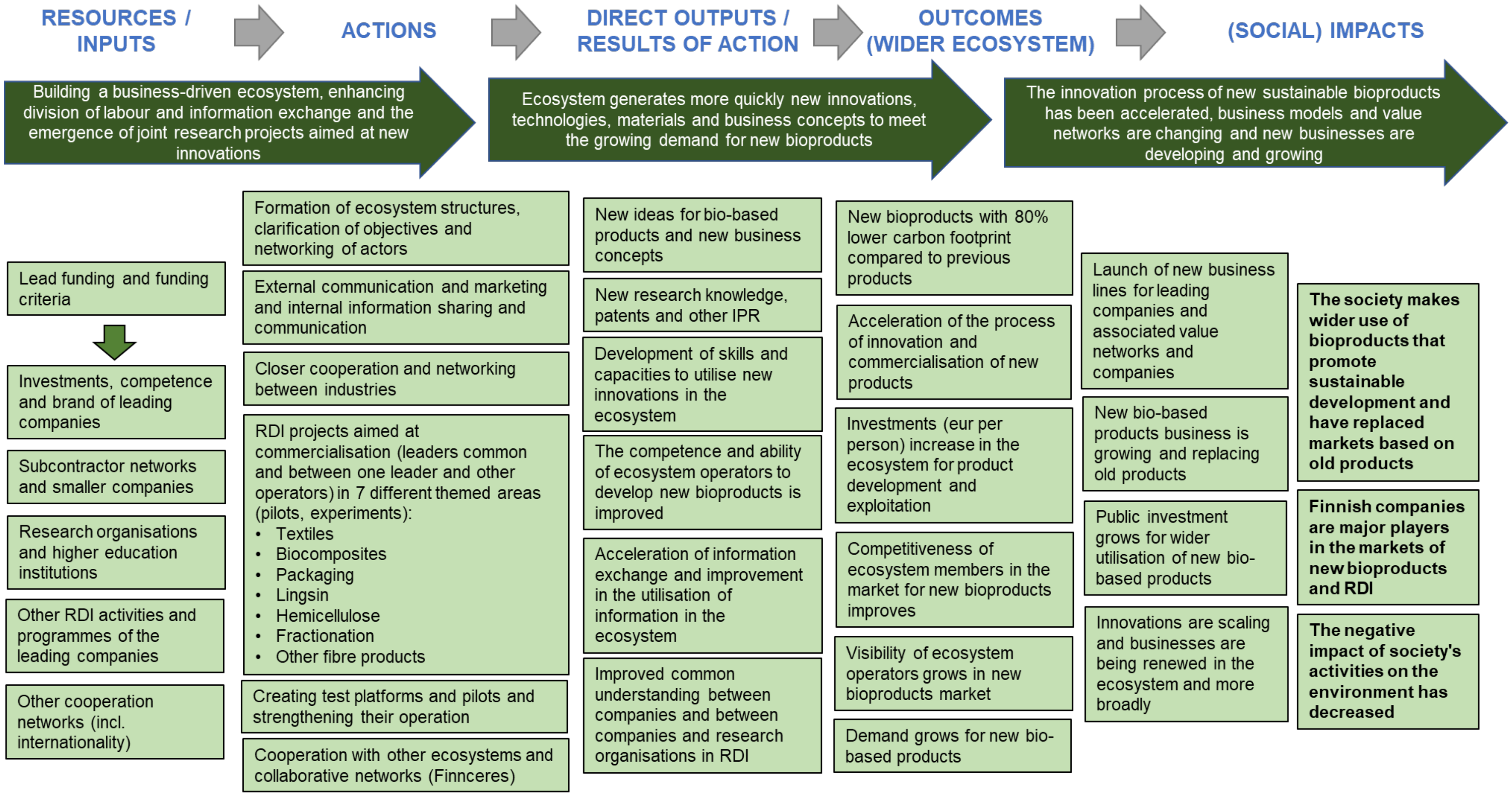
It should be noted though, that while in a business-driven ecosystem, impacts are expected to be more focused on businesses themselves, they are also expected to have impacts for both broader sustainability and society goals (growth of the economy and employment etc.).

Based on the findings above and on the impact model (Figure 10), the following impact paths can be detected in the Expand Fibre ecosystem

- Strengthening cross-sectoral networking and cooperation and enhancing the exchange of information
- Applied research & development, testing, piloting and commercialisation of new products based on innovations created
- Improving the capacity and capability in the value network to launch and collaborate in new business areas
- Cooperation with other networks

The timespan for the expected impacts is, moreover, shorter than in the research-based ecosystem. In the case of Expand Fibre, the impact is estimated to occur over a period of 5 to 10 years.

*Figure 10. Expand Fibres impact logic and model based on the case study data*



## SoC -Hub: Unlocking Industrial 5G Beyond Connectivity

The 5G network technology developer Nokia has launched the *Unlocking Industrial 5G Beyond Connectivity* innovation ecosystem which aims to develop 5G industrial products, services and solutions in several different vertical industry sectors. The ecosystem has received Business Finland Veturi instrument funding and is one of the leading company-based ecosystems. During the period 2020-2023, the ecosystem aims to promote the large-scale utilisation and commercialisation of digital solutions in various industries in cooperation with ecosystem actors. There are 6 separate sub-ecosystems under the Nokia 5G ecosystem that share information between them.

Out of the 6 sub-ecosystems, System-on-Chip Hub (SoC Hub) was examined in greater detail here. SoC Hub is the first sub-ecosystem that was launched and it consists of two parts: a co-innovation consortium project to develop chip technology and solutions (Business Finland Veturi funding) and an ecosystem coordination project (European Regional Development Fund (ERDF) funding). Its operations are located primarily in Tampere. The main implementers of SoC Hub are the Tampere University (management and coordination of chip development, dissemination of information, coordination of actors) and Business Tampere (ecosystem building). In addition, a number of other large and small companies are also involved in the ecosystem (see Appendix 2, p 118). Efforts have been made to include both technology developers and technology-utilising companies in the ecosystem.

The reason behind the launch of the SoC Hub ecosystem is the need to respond to the increasing demand and accelerating development of system-on-chips (especially integrated into products, production equipment, applications, etc.) and to increase the competitiveness and sovereignty of Finland and Europe in chip production. Internationally, the importance of system-on-chips has been emphasised and significant investments have already been made into their development. Finland has developed strong ‘know-how’ in this field over time but in recent years this know-how has fragmented and Finland’s development capacity has begun to lag behind. The various technology areas involved are no longer brought together and their actions have no longer been coordinated. In addition, education has no longer focused on system-on-chips as strongly as previously. In previous years, Finnish businesses have been largely dependent on foreign designed micro chips.

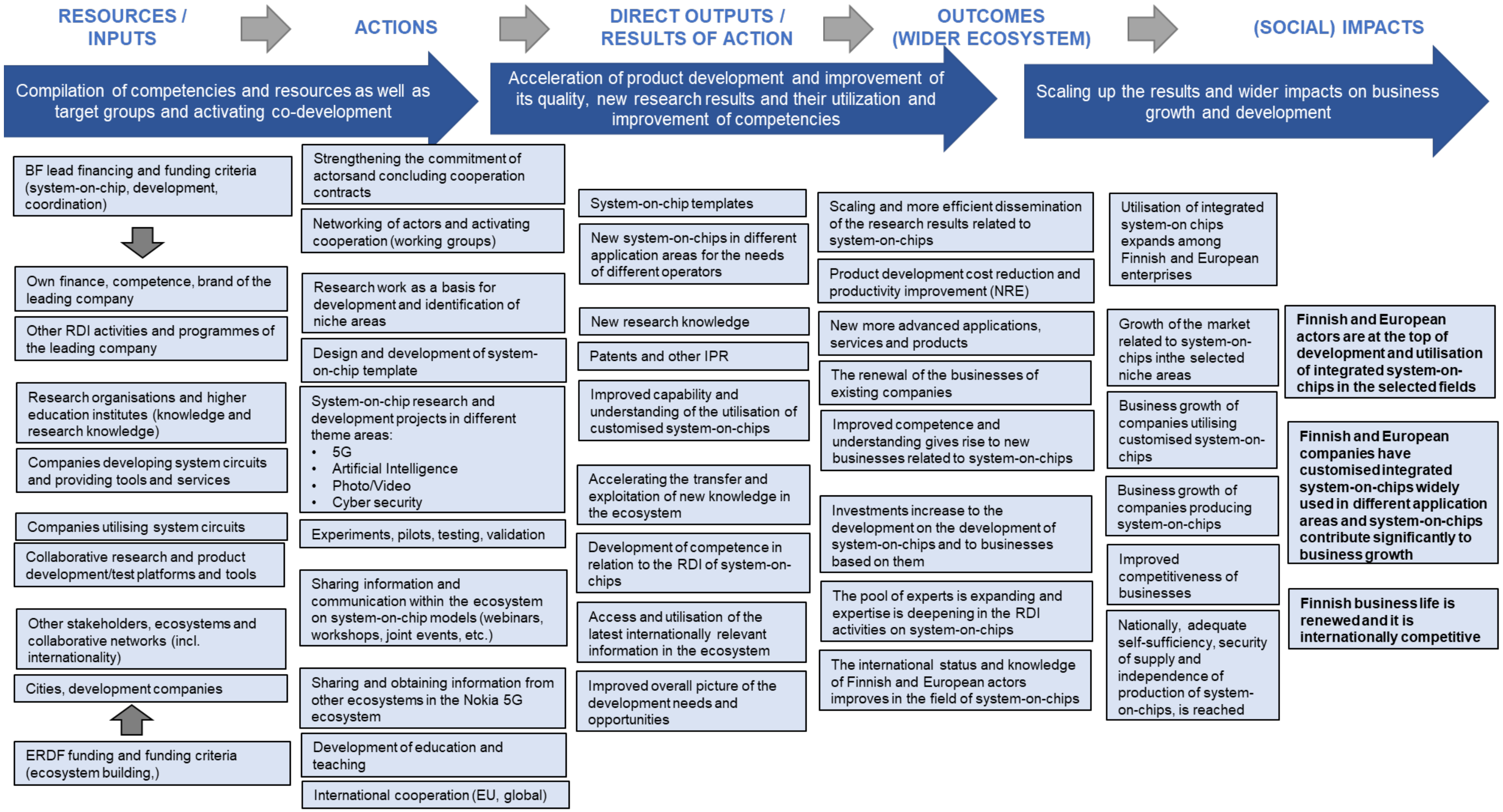
In order for Finland to be able to rise to a better position in the development of system-on-chips, a structure that brings together and effectively coordinates these actors is required. The SoC Hub ecosystem has been built to address this need. Over a period of three years, the SoC Hub will strengthen the development and utilisation capabilities in respect of the development of system-on-chips in Finland, developing three system-on-chip test prototypes. Based on the test chips, system-on-chips can be refined for different application areas like 5G, artificial intelligence, image / video and cyber security. These chips can also be tailored to the needs of different organisations and integrated into their applications. In Finland, it is not possible to carry out development work on the same scale as large international operators do. For this reason, finding and investing in carefully selected 'niche' application areas that are important for Finnish actors is central to Finnish system-on-chip development work. In international competition, it is not economically viable in Finland to produce chips for a wide range of needs. In a narrow area though, there are opportunities to succeed and gain a share of these markets. The overall aim of the sub-ecosystem is to improve the position of Finland and Europe in the development of system-on-chips.

SoC Hub brings together existing know-how, promotes co-development and upgrades development capabilities to world-class standards. The ecosystem brings together both know-how related to the development of system-on-chips and those users who would be able to improve their products and services and processes with system-on-chips tailored specifically to their needs. After this, the basic template system-on-chip development can begin in cooperation between the actors. A key point here is also to specify the application areas in which system-on-chips could be developed and to start the co-development projects. A main result of the ecosystem thus far is the creation of a template circuit (aiming for one chip per year) that can be varied to meet the needs of different companies.

The ecosystem strives to improve the quality of system-on-chip development and to enhance and accelerate their development for business needs. Scaling the results for wider use and the introduction of the results more widely in Finnish companies are seen as essential impacts. Nokia's broader 5G ecosystem and 5 other sub-ecosystems provide a key platform for this. Nokia's 5G ecosystem both provides information for the use of the SoC Hub while the Soc Hub sub-ecosystem distributes it for the use of other subsystems. Alongside and on the basis of these activities, the ecosystem also seeks to develop education related to the development of system-on-chips and the ability of companies to take advantage of the opportunities brought by tailored system-on-chips. The expected time for impacts in respect of this ecosystem is 3-10 years. Based on the case analysis and the impact model presented below (Figure 11), the following impact paths can be identified from the SoC Hub ecosystem:

- Strengthening networking, cooperation in research and development activities
- Deployment and scaling of RDI results (e.g., collaboration with the wider Nokia 5G ecosystem)
- Development of know-how and competencies in the development of system-on-chips
- Improving the capacity and capability to utilise system-on-chips in a wider range of industry sectors

*Figure 11. System on a Chip Hub impact logic and model based on the case study data*



## 6.3 Regionally-rooted innovation ecosystems

### EnergyVaasa

Over the years, a significant energy technology cluster has formed in the Vaasa region. The strengths of the cluster are related, in particular, to smart energy solutions, shipping, marine solutions, sustainable energy, flexible energy development and digitalisation. Energy and environmental technologies have become an important driver of Finland's exports and the Vaasa region's energy technology is of great importance as part of this export sector. By the end of 2025, new investments in energy technology infrastructure worth approximately EUR 1.2 billion are planned for the Vaasa region. This case study is focused on RDI cooperation in the Vaasa region's energy sector - more specifically on EnergyVaasa cooperation. EnergyVaasa cooperation represents a broad umbrella for cooperation in the energy sector, within which one can identify strong, more targeted innovation ecosystems formed around leading companies (see Appendix 2, p 120).

The object of a more detailed analysis has been the organisation list obtained from Merinova Technology Centre. These organisations are committed to EnergyVaasa cooperation, i.e., organisations with whom Merinova has a cooperation or cluster agreement. The list includes 66 organisations, of which 53 are companies and the rest are either higher education institutes, development companies or public organizations. The aim here was to analyse the significance of EnergyVaasa cooperation for the RDI activities for various actors. EnergyVaasa's roots go back to 2001, when the Merinova Technology Centre was active in bringing together key actors in the energy sector from Vaasa. EnergyVaasa was initiated by members of Merinova's Board of Directors which included Wärtsilä, ABB and the City of Vaasa. The purpose of the EnergyVaasa group was originally in to generate ideas for the projects of the national Centre of Expertise Programme (OSKE) and to create development and demonstration platforms in the energy sector in Vaasa.

A key driver for broader and closer energy sector cooperation in RDI in recent years is that meeting climate goals, reducing greenhouse gas emissions and saving energy on a global scale requires new, broader, cross-sectoral cooperation rather than more traditional sectoral cooperation. Based on the collected data, the different actors have a fairly good idea of what is meant by EnergyVaasa as an entity. Companies, universities and public sector organisations recognise and share EnergyVaasa's publicly stated common goal while various other actors share similar goals in terms of RDI cooperation. This is a good starting point for deeper RDI cooperation.

As a result of strong business-driven development and RDI investments, export-oriented firms, as well as cooperation between the public sector and the education and research sector supporting these business-driven activities, a very significant international energy cluster has been built in the Vaasa region. The role of active companies as well as the city and development companies and universities in the development of energy technology and RDI cooperation has been significant. In the Vaasa region significant efforts have been made to harness regional resources to broadly support the development of the energy sector and the development of globally significant innovation ecosystems.

Based on surveys and interviews with various actors, the importance of EnergyVaasa appears to be a supportive in strengthening the innovation ecosystems built around the leading companies. From the perspective of regional development, the long-term utilisation of various financial instruments and programme funding in strengthening RDI cooperation has been essential (e.g., the Centre of Expertise Programme (OSKE), the Innovative Cities (INKA) programme and most recently the Vaasa Ecosystem Agreement and the Structural Funds and national RDI funding). Companies operating in the Vaasa area have been actively involved in various ecosystems and RDI projects and have utilised various RDI funding opportunities.

There are many types of cooperation between the organisations involved in the EnergyVaasa cooperation, through which the concentration of energy technology in the entire region has developed and strengthened. The data show that EnergyVaasa companies have a lot of cross-RDI cooperation with each other (the companies mention the same RDI partners). Cooperation takes place both at the level of concrete RDI projects and at the level of RDI policy programmes. The development platforms of the city of Vaasa as well as public procurement and cooperation forums have contributed to accelerating RDI cooperation. The leading companies in the region are themselves active in participating in the development of EnergyVaasa cooperation and are proactive in joint investments and the construction of development environments in the region. One good example has been the Vaasa Energy Business Innovation Centre (VEBIC), a multidisciplinary research and innovation platform for energy and sustainable development established in 2018 at the University of Vaasa. VEBIC plays an important role in RDI cooperation between the public, private and research sectors and in the supporting innovation ecosystems. Funding for laboratories comes from both the private and public sectors. VEBIC has two interconnected research programmes, three research laboratories and one training laboratory.

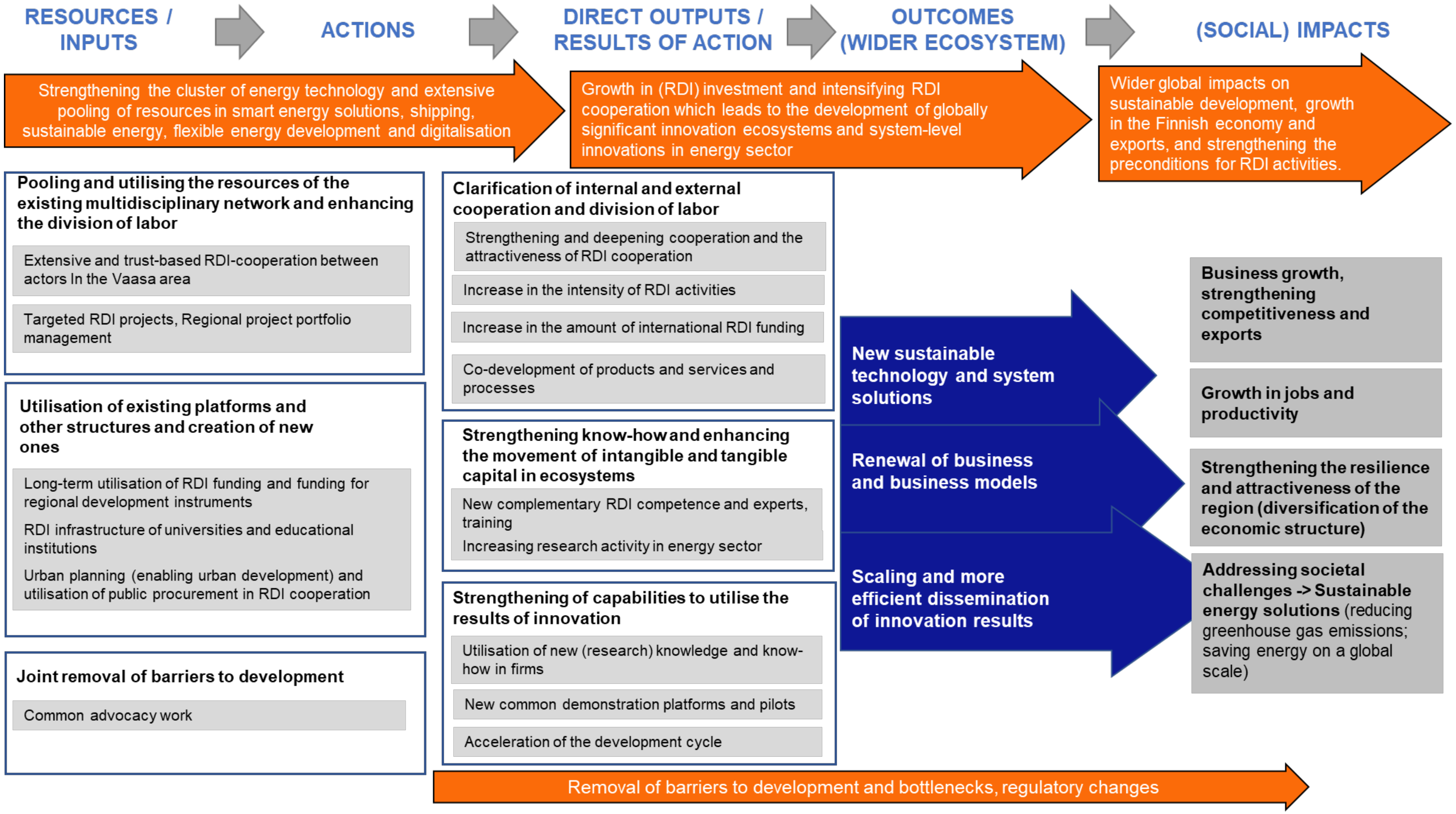
The most recent significant example of system-level cooperation between energy companies operating in the Vaasa region is the EnergySAMPO ecosystem. The goal here is to build a world-class energy-related ecosystem in Finland over the next 10 years. The cooperation model supports the development of energy systems on a large scale and aims to combine the know-how of companies, universities and the public sector. ABB, Wärtsilä, Hitachi Energy, VEO, Danfoss, VNT Management and Vaasan Sähkö companies are committed to the co-development of system-level energy solutions. The aim is to create a co-financed strategic RDI cooperation platform for energy technology, involving actors locally and nationally: companies and research actors, as well as the state and investors. Together the companies invest 200 MEUR in R&D annually. RDI operations are based on system-level energy simulation for interested target countries. By understanding the challenges of the system, extensive collaboration can be used to innovate potential system-level solutions, applications, and provide total solutions. This, in turn, requires extensive research and development, prototyping, piloting and solutions for test products, subsystems and the system level. The wider cooperation developed here builds on past experience, such as the Aurora Botnia, which is a ship built in 2021 and incorporates technology from several EnergySAMPO organisations and is one of the world's most efficient and environmentally friendly vessels.

The review of the EnergyVaasa cooperation opens up a wide variety of parallel development paths and cooperation and cooperation entities at many different levels which have, at the same time, supported and strengthened the innovation ecosystems built around the leading companies.  It is however important to recognise that all cooperation is not coordinated and does not take place under the ‘flag’ of EnergyVaasa, nor is it all geographically in Vaasa. In this case study the following significant impact paths were identified through which the wider impacts of a regionally-rooted innovation ecosystem can be described.

- Strengthening wider innovation ecosystems to generate new sustainable technology and systems solutions
- Renewal of corporate business and business models
- Accelerating the development cycle of (energy technology) innovations and faster diffusion and scaling of innovation requirements.
- Increased investment in the Vaasa region and organisations (strengthening the concentration of energy technology and increasing international interest;)
- Removal of barriers to development and bottlenecks (strengthening demand, opening up new markets and removing barriers to development)

An essential aspect in examining any regionally-rooted innovation ecosystems and their impact is that the time horizon for analysing the development and wider impacts runs to decades and requires an understanding of the broader context. The regional context brings a much broader perspective in respect of the impacts of the innovation ecosystem. In Vaasa, the energy sector cluster has been built over decades, although the success stories of individual companies and innovations may emerge more quickly. EnergyVaasa's impact logic and model are illustrated in greater detail in the following figure (Figure 12).

*Figure 12. EnergyVaasa's impact logic and model based on the case study data.*



### Wärtsilä Smart Marine ecosystem

In parallel with the case study on EnergyVaasa, one innovation ecosystem formed around a leading company was reviewed in greater detail. Wärtsilä's sustainable and intelligent maritime RDI cooperation and the Smart Marine ecosystem was selected for more detailed review. The case study concretises the links between a business-driven innovation ecosystem and energy technology RDI cooperation in the Vaasa area. Ambitious environmental goals have been set for the maritime industry and the goal of the Smart Marine ecosystem is to lead the industry transition towards carbon neutrality and intelligent shipping in cooperation with partners and other actors in the industry.

In 2017, Wärtsilä presented its vision for an intelligent marine ecosystem to revitalise the future of shipping. Wärtsilä's goal is to enable the transition to sustainable shipping through intelligent technology. The demand for clean and flexible energy and the need for efficient and safe transport are increasingly influencing customers' behaviour. This forms the basis for Wärtsilä's vision of a Smart Marine ecosystem and a future for 100% renewable energy.

As a key driver in building an innovation ecosystem, Wärtsilä has a need to reduce greenhouse gas emissions and meet the requirements of, for example, the European Union's Fit for 55 package. In addition, the demand for clean and flexible energy and the need for efficient and safe transport are constantly growing. In order to respond to this development, wider ecosystem cooperation is needed so that RDI investments are profitable and that different actors know where and how different technologies can be utilised and scaled.

Wärtsilä is building the Smart Marine ecosystem and related RDI activities out of its own interests and on a global scale, but achieving the goal of a shift towards carbon neutrality in the shipping industry requires a broader ecosystem. International success requires closer and deeper RDI cooperation with existing technology partners and a wide range of other actors. This means working with the public sector as well as universities and other companies, including competitors. Joint projects include agreements aimed at accelerating the ongoing digitalisation of the maritime industry, developing autonomous shipping and exploring the use of new technologies and alternative fuels to promote carbon neutrality.

The importance of the Vaasa area for Wärtsilä stems from strong and natural cooperation with the nearest suppliers, customers and partner companies in the Vaasa area, as well as Vaasa universities and the city. Wärtsilä actively cooperates with other companies, universities and the public sector in the energy sector in the Vaasa region and sees regional cooperation in the Vaasa region as providing a strong basis for the development and cooperation of its own ecosystem. In Vaasa, confidential cooperation enables rapid progress towards pilots and demonstrations and the launch of significant RDI cooperation entities.

Wärtsilä has made significant investments in its RDI operations in Vaasa. The company built a Smart Technology Hub research, product development and production centre which is a concrete platform for co-development and RDI operations as well as piloting products and solutions in Vaasa. Various actors, such as companies, start-ups, universities and educational institutions, are being sought for cooperation and the Hub is also connected to Wärtsilä's other centres of excellence. In addition, the developed Smart Partner Campus cooperation concept provides a structure, community and practices for open innovation in Vaasa with local and, more broadly, international partners.

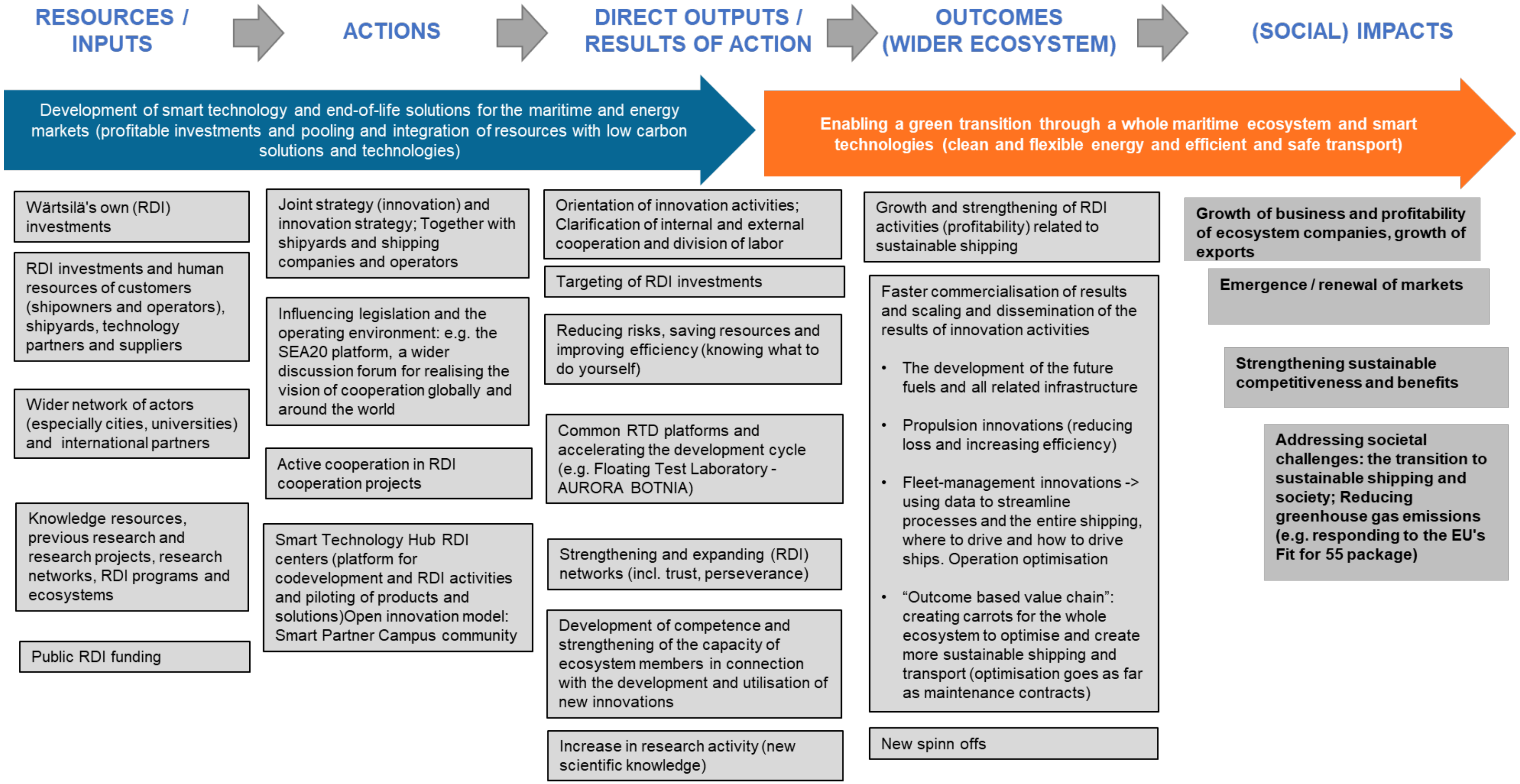
The importance of the Vaasa area is also well highlighted in the construction of the floating test laboratory, Aurora Botnia ferry. Cooperation with NLC Ferry, Wasaline and other actors in the Vaasa area has enabled the development of a new generation ship and the piloting of new technology. Wärtsilä's hybrid propulsion solution makes the ship one of the most environmentally friendly passenger ships in the world. This will significantly reduce emissions in Kvarken. At the same time, the ship acts as a floating test laboratory for several different companies and is connected to Wärtsilä's Smart Technology Hub.

The case study of Wärtsilä's business-driven innovation ecosystem identified the following key impacts (Figure 13):

- Reduction of risks, saving and efficiency of resources and allocation of RDI contributions
- Strengthening capabilities will utilise the results of innovation in business (through more open, confidential cooperation and accelerating common RDI development platforms and development cycles)
- Faster commercialisation of results and scaling and dissemination of the results of innovation activities

The importance of the innovation ecosystem is based on the fact that investing in ecosystem cooperation brings savings to Wärtsilä, as the cooperation provides more accurate information on where to invest, helps to identify risks and also to assess one's own strengths and potential in complementary resources. Cooperation with partners is essential in developing technologies that meet the changing requirements of the market and in accelerating the development cycle. The trend in RDI activities has been evolving towards more open and confidential cooperation models which also bring the end customer closer to discussing possible system solutions.

*Figure 13. Wärtsilä's Smart Marine ecosystems impact logic and model based on the case study data. The impact model has been built especially from the perspective of Vaasa's operations and cooperation.*



## 6.4 Summary and ways forward - Possibilities for measurement and evaluation of the impacts of innovation ecosystems

The ecosystem perspective is still evolving and the case study ecosystems are relatively young. The case study organisations emphasise the importance of innovation ecosystems. Despite this, it was difficult for all actors to identify the added value and separate impacts of the ecosystem. Acting as part of an ecosystem and building and developing an ecosystem requires very holistic thinking in innovation activities. This means moving from the more traditional development of individual products, services and processes to a broader cooperative problem-solving process. In this case, many factors must be taken into account, both at the beginning of the innovation chain and relating to how it is possible to make innovations spread and succeed and to create completely new markets.

### Observations on different types of innovation ecosystems and their impacts

Based on the case studies, the importance of innovation ecosystems relates in particular to the following issues. Firstly, in terms of **goals and objectives**, innovation ecosystems aim to respond to societal challenges, changes in the operating environment and market needs in all respects through broader and more comprehensive RDI cooperation. In terms of resources, the aim is to make more efficient use of existing networks and platforms. Secondly, with regard to changes in **activities and capabilities**, the aim is to strengthen co-creation and more transparent RDI activities, so that information can flow more openly and more organisations can win by sharing and utilising of knowledge. The aim here is to promote fast-cyclical RDI cooperation which shortens the pilots' journey to the market and allows the results of innovation to be scaled more efficiently through ecosystem cooperation. In addition, pooling resources will also provide more power to remove barriers to innovation, for example in terms of regulation.

The conceptual definition of an innovation ecosystem in this work has been based on the premise that actors must have some kind of identifiable common goal. In an innovation ecosystem, this is related to shared value creation, i.e., to the creation and exploitation of new knowledge. A common goal uniting actors was identified at least to some extent in all case ecosystems. The ecosystems aim for large-scale and socially significant impacts, but the organisational goals are related to issues on different levels. The actors are part of the ecosystem on the basis of very different interests, and therefore it is better to say that the goals are parallel. The interests of different organisations meet and intersect especially around certain more specific themes and points. The identification of a unifying goal is based on a common (facilitated) process or forum in which these goals can be discussed and the significance of RDI cooperation can be understood. In order to achieve each organisation's own stated goal, it is essential that a common need has been identified to bring together existing know-how and resources and promote wider co-development.

All actors may not however recognise that they are part of an innovation ecosystem. This finding highlights the stratification of innovation ecosystems. **The actor structure** of innovation ecosystems often evolves from a more limited core towards broader ecosystem cooperation. The case study innovation ecosystems involve several different types of actors (companies and their subcontracting networks, research actors, the public sector, etc.). In an innovation ecosystem, not all actors cooperate in RDI, but various interdependencies form around the core. One very important perspective with regard to innovation ecosystems is the more detailed structural examination of the cooperation network: How cooperation expands to cover several different industries and actors and how the resources and capabilities of different types of actors can be harnessed for cooperation.

In particular, when looking at the data on RDI projects, it was noticed that **active companies and organisations in Finland are involved in many different consortia and ecosystems**. In addition, VTT and many universities provide, for example, essential links between different innovation ecosystems. The case studies also show that there is a growing desire in firms to increase cooperation with universities and research institutes, but the rigidity of cooperation is seen as a challenge in many respects. The rigidity is particularly evident in agreements and the slow pace of cooperation. Similarly, public or private development platforms or research infrastructures are seen as important, but it takes a lot of effort to get value and benefits, something which may reduce the potential for collaboration.

It is essential to pay attention first and foremost to **strategic forms of cooperation**, such as the construction of a common strategic vision, the creation of roadmaps and cooperation agreements. Secondly, the importance and construction of **social interactions** needs to be taken into account which means building strong trust, facilitated cooperation and innovation platforms and partnership models, etc. Innovation ecosystems do not function as an ecosystem on their own, but must be consciously built, strengthened and developed. This requires the continuous strengthening of trust between actors as well as direct agreements between actors. Data sharing, common platforms and data management, for example, are also playing an increasingly important role.

Functionally and structurally, the analysis also identifies innovation ecosystems operating with different logic and principles. **The operational logic** is very different depending on whether it is an open or a closed innovation ecosystem. In particular, it is important to expect a more open logic of the innovation ecosystem from publicly supported innovation ecosystems, at least in some respects, such that the ecosystem is constructed according to the open principle. **Ecosystems evolve over time** and therefore the different stages of their life cycle must also be taken into account when examining impacts. From a public support perspective, some results of actions are expected to emerge within a few years and beyond. But impacts emerge over different timespans and in many respects only after the end of several years of public funding. The impact logic must therefore take into account the initial differences and the “length of the journey” in relation to the main objectives.

Based on the case studies, certain typical features can be identified in the impact logic of innovation ecosystems. The starting point for **a science-based innovation ecosystem** is, for example, cutting-edge research, critical know-how and experts, or infrastructure and cooperation to generate and utilise know-how. In this case, research organisations are often found in a leading role here. A knowledge ecosystem becomes an innovation ecosystem when the users of knowledge and the perspective of commercialisation through companies or other actors are also involved. The typical results of this process are the production of research results which are then utilised to create commercialised products. The desired results and impacts are also however more broadly related to the dissemination of knowledge and skills and new capabilities through, for example, education. The time interval for the effects to occur is, in principle, longer. The case study strongly highlighted the need to build the research base over time as it is often over a decade before the impacts become more widespread.

**The business-driven innovation ecosystem** is typically built on a business Ecosystem, driven by market demand and the pooling of resources to generate and disseminate innovation. The typical driver here is also a partnership to share the risks associated with generating innovation. In this case, the key actors are companies with a significant interest in grasping the opportunities or challenges, changes in the operating environment and emerging needs from the market. In addition, the capability to bring together a wider ecosystem and a broad range of other companies and research organisations, as well as public sector actors, is required. The desired results and impacts are more directly related to business growth and commercial products, services and applications. When looking at business-oriented innovation ecosystems in particular, the commercialisation of innovations is often closer, while the goals and time horizon for the impacts to occur are from a few years to five years. It should be noted, however that, in addition to business impacts, publicly funded business ecosystems are usually also expected to have wider societal and, for example, environmental impacts.

**A regionally-rooted innovation ecosystem** is built on the basis of a regional cluster. The idea here is to harness regional resources to support the development path of a particular or several ecosystems towards globally significant innovation. The region's (leading) companies and their strong RDI investments play a key role in the emergence of ecosystems. Public sector support and commitment to business-led development are also very important. Companies’ cooperation and co-investments with higher education institutes in RDI infrastructure and public procurement and forums provided by the city to support cooperation also play an important role. From a regional development perspective, the objectives and impact analysis focus on a wide range of issues while the starting point for strengthening innovation ecosystems stems from both the growth of the regional economy and the needs for systemic change. The results and impacts from a regional perspective are perhaps however more indirectly related to the strengthening of innovation ecosystems and the renewal of companies' business and business models, the emergence of new companies and the removal of investment barriers and bottlenecks. In this case, the focus is strongly focused on strengthening demand, opening up new markets and removing obstacles to development.

The ecosystem literature often also highlights start-up ecosystems. Due to the focus on innovation ecosystems in this study, the start-up perspective is slightly differently related to research-driven, business-driven and regionally-rooted innovation ecosystems. New business can be created either through start-ups or existing ones and can be linked to a particular business-driven or research-driven innovation ecosystem. On the other hand, start-up activity may be strongly regionally concentrated, in which case it could be linked to examination of a regionally-rooted innovation ecosystem. Therefore, the start-up ecosystem was not presented here as a separate classification for the purposes of this study.  It should however be noted that the data from the selected case studies did not significantly address the objectives that are related to the emergence of new start-ups. The reason for this is partly due to the fact that the start-up perspective was not at the heart of the case innovation ecosystems and their desired impacts, and partly also because these potential impacts were not separately examined in the case study section.

## Possibilities for measurement of innovation ecosystems

Both the statistical analyses and case studies show that **a broad knowledge base is needed to identify ecosystems and assess their impacts**. Firstly, the identification of innovation ecosystems is an essential question - how and to what extent can ecosystems be identified. Local actors play a key role in identifying ecosystems, and universities, research institutes, cities and other regional development actors can provide in-depth knowledge on existing and potential innovation ecosystem which complements the statistical reviews. In Finland, different instruments and funding for innovation policy have supported different types of entities and their collaboration and inevitably led to the creation of “ecosystems”, but it is also important to look at what kinds of innovation ecosystems may emerge without public funding.

It should be noted that the examination of the impacts of innovation ecosystems is motivated from a different perspective when it comes to innovation policy and public finance compared to the ecosystems and the actors themselves. In this study, the focus of the review and measurement of impacts is motivated from the innovation policy perspective. As already outlined in Chapter 6, in addition to more traditional micro- and macro-level perspectives, **the focus should also be on the meso-level impacts**. This changes the focus towards the interactions between different actors and generated knowledge flows or spillovers in and outside the ecosystems and to the wider societal benefits generated. From a measurement point of view, case studies have shown particularly well that the development of ecosystems requires a long time span and that the timespan is also highly dependent on the nature of the ecosystem.

The case studies did not provide many straightforward indicators. Rather, they highlighted certain common essential perspectives for evaluating innovation ecosystems and perspectives that should be monitored and examined more closely. In addition, the case studies highlighted the existence of various aspects relating to different types of innovation ecosystems. These common perspectives and examples of indicators to be considered when measuring different types of ecosystems are summarised in Annex 3 (Tables 23, 24, 25 and 26). Measuring the impacts of innovation ecosystems shifts the focus from individual indicators to broader entities and the impact pathways highlighted in case studies. All in all, the diversity of indicators and the existence of different indicators at different stages of the life cycle must be taken into account: from the preconditions of the ecosystem to the competitiveness of the national economy.

In the initial phase, as well as in terms of **resources and inputs**, it is important to look at the basic conditions for the success of an innovation ecosystem: Are the ‘critical’ building blocks for success in place? From the perspective of the preconditions, the utilisation of wider resources and the characteristics of the innovation ecosystem, such as the number and diversity of actors, must be examined. In terms of **activities,** it is important to focus on how the common path has been identified and communicated to the various parties and whether the common goals are being followed in some way. It is also worth looking at the activities from the perspective of the structure of the ecosystem, what kinds of cooperation agreements and international networks and partnerships have started to emerge? More traditional performance indicators are also relevant here, such as the people and organisations involved in RDI cooperation, projects, facilitated opportunities and those involved in co-development.

In the medium term and when looking at the **results** of operations, it is important to pay attention to changes in and the growth of the ecosystem and to the development of capabilities. For example, how companies' RDI investments develop and what is the significance of the ecosystem. In other words, where, for example, companies put their money and what role does the ecosystem play as part of these organisations’ strategies. Does the cooperation result in a joint offering of values or values associated with different actors? The internationalisation of Finnish networks is one of the essential aspects in the examination of ecosystems. The results of joint investments and platforms, as well as demonstrations and pilots, are also important. The importance of ecosystems was recognised particularly in relation to the acceleration of the innovation cycle, though this should be verifiable, at least from the perspective of companies. There is also the question of how (researched) information is utilised, e.g., in business development and commercialisation. In addition, the results are also reflected in the national and international attractiveness of the ecosystem.

When looking at **outcomes**, one can start with more traditional indicators such as innovations including, e.g., new products patents and other IPR, or new companies. The uptake, diffusion and scaling of innovations as a contribution to the ecosystem is also a very important aspect here. The effects are also reflected, for example, in the growth of foreign investments, risk financing and experts. Especially from the perspective of long-term **impacts**, the renewal of the business sectors, productivity growth and international competitiveness are essential. On top of these more traditional indicators, the ecosystem perspective also highlights a particularly important, but at the same time very challenging, perspective on the qualitative examination of innovation. This means a qualitative assessment of, for example, how significant innovations are from the perspective of society or a particular industry and how nationally and internationally significant solutions and breakthroughs are. The role of the public sector is also essential in linking ecosystem work to regulation and standardisation work. In this context, it is also both a question of strengthening Finland's position and attractiveness internationally and of the importance of the innovation ecosystem in relation to global challenges.

# 7 Conclusions and recommendations

## 7.1 Key conclusions

### Starting points for measuring the impacts of innovation ecosystems

**There are many problems associated with studying the effectiveness of innovation ecosystems. The previous research literature does however provide a useful starting point enabling the identification of innovation ecosystems and the essential aspects required in the examination of the effectiveness of innovation ecosystems.**

As illustrated in the literature review (a summary is provided in the main text, while a more detailed survey is presented in the appendix), the previous literature on innovation ecosystems has not yet provided a generalisable way to measure ecosystems and their impacts. The statistical analysis we have carried out in this report is an attempt to partially fill this void by relying on approximations in order to measure ecosystems from raw firm- and plant-level data and to examine the correlation between ecosystem participation (in this case approximated by collaboration patterns) and various firm-level performance outcomes. In terms of measurement, we show that the use of standard statistical measures to identify industry clusters can be a helpful, albeit not sufficient, first step in detecting innovation ecosystems. Indicators of clusters can be used to detect ecosystems, followed and validated by the use of additional quantitative and qualitative information.

**In terms of the impacts of ecosystems, while we cannot identify causal links in our statistical analysis, as we noted in Section 3.3., we do observe a strong correlation between participation in innovation ecosystems and successful innovation activity.**

We also find some positive relation between external RDI-cooperation and other firm-level performance outcomes such as employment and wages growth, but the links found here are much weaker. Statistical analyses show that external RDI co-operation increases with firm size, something which also highlights the important role of large companies in these ecosystems. External cooperation was not however found to have had a direct connection with, for example, the propensity of company employees to start their own companies and thus the possible emergence of start-ups as a result of the cooperation. Moreover, previous studies have usually also pointed to a positive ecosystem impact on their participants, while the evidence regarding aggregate effects is much weaker. It should also be noted that more findings point towards the beneficial impact of clusters and knowledge networks on the overall economic performance of their area.

## Innovation ecosystems as part of innovation policy - what is changing?

**Innovation policy, both nationally in Finland and at the EU level, is increasingly motivated by large-scale societal changes and their acceleration (so-called mission-based and transformative innovation policy) which also changes the focus of examining and evaluating the effectiveness of innovation policy.**

Responding to broad societal changes and developments requires multidisciplinary cooperation in RDI activities rather than the more traditional type of sectoral cooperation, as well as the pooling of resources and expertise of different actors. At best, different ecosystems can respond to significant societal changes and challenges. Solving major challenges requires systemic solutions that are larger than those achievable by individual actors alone as well as the identification of common goals and objectives, even if there is competition and cross-cutting goals between different actors.

Therefore, the examination of impacts requires a stronger focus on the interdependencies and interactions between different actors in innovation ecosystems and the results of the interactions between these different actors. A broad, in-depth innovation policy cannot be measured (only) through system-level input-impact indicators. The transition from a macro-level approach to clusters and from individual industries to the more sophisticated development of ecosystems requires a much better understanding of the logic of impacts from policy implementation. In addition to economic performance, it is more about strengthening knowledge and innovation capacity, knowledge transfer, the dissemination of innovation and the role of innovation ecosystems in promoting the goals of green transition and sustainable development, for example.

**Based on the case studies, the added value of ecosystems in relation to more traditional approaches to innovation policy seems to stem from the fact that they aim for wider, more comprehensive impacts.**

What the case studies of innovation ecosystems outlined above have in common is the effort to accelerate innovation processes and knowledge transfer (RDI cooperation aiming at a faster cycle) and to scale up the effects and benefits of innovation activities more widely in society. The basic idea in these innovation ecosystems is the utilisation of cross-sectoral cooperation and the resources and platforms of a wide range of actors. The concrete change in activities is described in particular by co-developing and more open RDI activities.

Innovation ecosystems are however built from very different starting points. Essentially, the pathways to the broader impacts of innovation are generally somewhat different, depending on whether we examine science / research-based, business-based or regionally-rooted innovation ecosystems.

## Towards the measurement of innovation ecosystems and different impact paths

**In addition to looking at the more traditional micro- and macro-levels, the impacts of innovation ecosystems should also be examined from the perspective of the emergence of 'meso-level' impacts in particular.**

From the perspective of society and innovation policy, when examining and measuring the impacts of innovation ecosystems, attention must be paid to the importance of innovation ecosystems in **increasing and facilitating RDI cooperation**. In this case, it is a matter of streamlining the flow of information and the development cycle. Thus, an important impact aspect here is knowledge spillovers and the accumulation of know-how through a wider pooling of resources and capabilities and of strengthening interaction between RDI activities. Secondly, attention should also be paid to the importance of innovation ecosystems in generating wider societal innovations and accelerating societal change. This means moving more strongly towards the **qualitative (and to some extent quantitative) examination of innovation**: how the ecosystem and the resulting innovations benefit society and how the effects of innovation activities scale in society.

**The assessment of innovation ecosystems must be based on the impact paths set by each ecosystem itself. From the perspective of innovation policy, the impact paths should be viewed from the perspective of the wider societal impacts they generate.**

Creating systemic solutions in innovation ecosystems requires systematic and logical internal processes – common processes in which pathways from inputs to outputs, outcomes and impacts are communicated. These impact paths must be identified and led by (key) actors in ecosystems. The time horizon for the emergence of different impacts differs between ecosystems as well as between the different impact paths of individual ecosystems. Therefore, it is important to consider different time spans in relation to the expected impacts.

Tailored impact-path thinking and the building of a shared deeper understanding of the impacts sought by innovation ecosystems provides one approach to identifying and measuring impact. At the same time, this paves the way for a model for implementing an impact-driven innovation policy and towards an interactive innovation policy.

## Development of measurement and monitoring of the impact of innovation ecosystems as part of national innovation policy

**The systematic and long-term monitoring of ecosystems is required in order to support instruments to develop the credibility, transparency and development of innovation ecosystems in national innovation policies.**

There are many hopes and expectations for ecosystems from the perspective of innovation policy. However, the desired and expected impacts are still difficult to verify. From the point of view of the effectiveness and credibility of innovation policy there remains a need for transparent and credible methods for identifying ecosystems and criteria for funding, as well as a stronger focus on collecting data on effectiveness. More comprehensive information is needed on the participation of actors, such as universities, in various ecosystems.

A broad knowledge base and a holistic perspective are required to examine and assess the effectiveness of innovation ecosystems. Combining statistical reviews of ecosystems and their significance and structure with narrative and expert-based reviews provides a useful starting point for ecosystem identification. Nevertheless, we acknowledge that the causal analysis of the impacts or effectiveness of innovation ecosystems is currently not feasible even with current state-of-the-art statistical techniques.

**Instruments aimed at strengthening and developing ecosystems can be justified, especially from the perspective of transformative innovation policy. The new 'ecosystem policy' does not however provide a complete solution nor does it eliminate the need for other innovation policy instruments.**

As insufficient information currently exists on the long-term impacts of ecosystem development instruments, support for innovation ecosystems and policy instruments needs to be monitored nationally, particularly in terms of their additionality and exclusionary effects. Instruments for the strengthening and development of ecosystems are generally justified from the point of view of transformative innovation policy, as other financial and policy instruments may not be as effective in pursuing these objectives. Thus, it is necessary to ask what will be lost if resources are directed or transferred from other sites into the development of ecosystems? The risks here involve e.g., the emergence of market failures. The allocation of public support to fewer actors may provide an unfair competitive advantage to subsidised firms in ecosystems and thus, ultimately, have adverse effects on competition.

**The ecosystem perspective in the broad sense then is still evolving. Finland does however have the opportunity to strengthen cooperation in the implementation of mission-based and transformative innovation policies with other EU countries  from the perspective of examining effectiveness.**

In the European context, the ecosystem concept is less visible in the innovation policies of other countries than it is in Finland. However, the mission-oriented and transformative approach in innovation policy are linked to the importance and development of innovation ecosystems also in other EU-countries. Societal change (e.g., sustainability shift) requires greater societal ownership, commitment and pooling of resources in RDI. This opens up many opportunities to strengthen the synergies between national and EU innovation policies and, more specifically, international cooperation in the development of ecosystems and impact assessment.

## 7.2 Recommendations

**Recommendation 1: Innovation ecosystems take a long time to emerge and they need to be nurtured and supported by adopting a long-term approach to innovation policy.**

For national level actors, including the ministries, this also requires that policies to strengthen innovation ecosystems are designed in a more systematic and goal-oriented fashion. They need to be based on research, assessment and an understanding of how ecosystems function, as well as a shared strategic understanding of what is expected to emerge as a result. The dialogue on goals and expectation management is also important in the context of the whole network. It is also important to make clear what is expected of innovation ecosystems in terms of their impacts, as well as clarifying the various more specific ecosystem-specific pathways to impacts.

In addition to the policy designers, funding instruments also need to address the ecosystem perspective. The need for clear definitions and the necessary alignment of policies are particularly relevant to the dialogue between RDI financing organisations in relation to their monitoring of instruments. For example, Business Finland's ecosystem funding and the Academy of Finland's flagships and RDI infrastructure funding, the ecosystem agreements coordinated by the Ministry of Economic Affairs and Employment and the funding of circular economy ecosystems and knowledge platforms, all pursue slightly different goals. A more broadly aligned view of ecosystems and impacts would help stakeholders to pursue similar goals. Innovation policy would also be based on better and more accurate information on the ecosystems that are being supported by various instruments. In addition, this would stimulate policy-learning.

It is through these instruments that the actual impacts emerge. Therefore, it is necessary to strengthen a common understanding of the impacts that have arisen across the spectrum of innovation policy stakeholders. A more extensively shared understanding and knowledge base, even perhaps a consensus, on how ecosystems respond to systemic and transformation gaps and how innovation ecosystems enable the broader use and accumulation of RDI resources in the national economy remains a priority. This requires the preparation and implementation of an innovation policy and its instruments that are inclusive, openly and actively discussed and help to provide a common understanding across the national innovation system.

Strategic support for such a consensus and diagnostic should be the responsibility of national innovation policy at the government level. The short-term nature of RDI policy is a major problem for both achieving and examining impacts and for taking into account the different time perspectives required in the development of ecosystems. In terms of impacts, the time perspective should be modified accordingly, but at the same time a systematic mid-term review is required.

**Recommendation 2: Achieving broad societal impacts requires innovation policy instruments that strengthen innovation ecosystems based on different impact paths and starting points (science, business and regionally-rooted innovation ecosystems).**

All funding organisations should require monitoring and a commensurable knowledge base on the key impacts and results. In Finnish innovation policy, the organisations responsible for directing and monitoring funding and its effectiveness have been built to support and strengthen different types of (innovation) ecosystems. Based on this study, it seems justified to conclude that the instruments are linked to different pathways and starting points (knowledge/science-based, business-related and regional innovation ecosystems). The instruments can also have mutually re-enforcing effects. It is important to steer the whole set of instruments through impact targets and to ensure that the instruments and the ecosystems they support form an integrated whole. Policy objectives and ecosystems that support these objectives, including broad systemic change and transitions, should not be too vaguely defined in order to be operationalised and verified.

The knowledge infrastructure should be better aligned with the ecosystem perspective. Stakeholders can gain information on ecosystems which helps them to better align their own activities. The idea of impact paths and alternative routes to societal change can therefore, potentially at least, make visible the impact logic of ecosystems. This involves the actions and steps required, stakeholders to be heard and engaged, as well as designing interventions and engaging and mobilising networks and coalitions, as described for instance in connection with the Swedish case study elsewhere in this report (‘Technological Innovation Systems’ of SIP). The infrastructure required is only partially in place or provided by the policy interventions or governance structure, there are also competences, resources and capabilities which individual companies, research organisations and others bring with them and are independent of the policies and funding instruments in place. The government and its innovation policy can thus indirectly contribute to the emergence and development of such ecosystem resources.

**Recommendation 3: Innovation ecosystems receiving public funding should be expected to formulate their expected impacts and impact paths (including the impacts and key results and their possible causal connections).**

This means a more detailed opening up of the impact logic from inputs and activities to the expected results and the links to the long-term effects. Modelling helps to better assess the impact and significance of RDI funding and serves as a tool for ecosystem actors themselves. Tailored impact-path thinking and building a shared understanding of the impacts sought by innovation ecosystems is one opportunity and the first step to identifying the impacts and measuring them. The impact models exemplified in the cases reported in this study provide examples of measurable perspectives and indicators that can be used as inspiration if such methods are to be taken more broadly into use.

**Recommendation 4: Verification of the effectiveness of innovation ecosystems requires cooperation between RDI funders and the development of nationally harmonised monitoring methods.**

In order to support the implementation of national innovation policy and the various instruments for the development of innovation ecosystems, joint systematic monitoring of ecosystems and their effectiveness by the funding organisations should be strengthened. At the national level, it would be necessary to invest, at least initially, in sufficiently limited impact assessments of innovation ecosystems, as well as international comparisons. Combining statistical analyses and surveys, together with narrative descriptions and peer-reviewed processes, provides a starting point for ecosystem identification and the examination of impacts. In addition, national surveys and especially the monitoring of RDI funders can provide additional information on whether companies are a part of an ecosystem and how important they are to these different actors. New data sources and methods are welcomed here.

In terms of the forward steps we need to take in order to better study and understand innovation ecosystems and their impacts empirically, we offer a few potential examples in Section 3.6. Briefly, we argue that an effective study of ecosystem impacts would need better data, ideally based on surveys which are targeted at identifying which firms belong to an ecosystem. One possibility here would be to extend the CIS survey (which covers European countries) to detect ecosystem participation in Finland, or more broadly among the EU countries. The major challenges that would render a causal analysis difficult, for example the self-selection issue underlying ecosystem participation, however remain and thus one should weight attentively the cost of carrying out these kinds of surveys with their potential benefits.

There are also a few more general issues to be taken into account when examining innovation ecosystems. Firstly, if we want to evaluate the usefulness of public support and funding, we should try to identify what kind of innovation is being undertaken in the innovation ecosystems studied and which entities benefit from it. In the case that innovations benefit exclusively the ecosystem participants, it could be argued that public support for such ecosystems is wasteful from a societal welfare point of view as there are no substantial benefits from knowledge diffusion to other actors in the economy. Another issue, from a local perspective, is that too strong a focus on and/or support for a local ecosystem could disincentivise potential innovative entrepreneurial activity outside the scope of the existing ecosystem. In other words, subsidising incumbent companies in the ecosystems might reduce the entry of (innovative) companies and adversely affect competition. Finally, the typical tendency of innovation ecosystems to revolve around one pivotal entity, such as a large company, should push public entities to better monitor the potentially harmful effects on competition when assessing the overall impacts of ecosystems.

**Recommendation 5: Finnish RDI funders and ecosystem actors should intensify international cooperation to improve the impacts of innovation ecosystems.**

Ministries and RDI funding organisations (especially the Ministry of Economic Affairs and Employment and the Ministry of Education and Culture, the Ministry of Finance, the Academy of Finland and Business Finland) should strengthen EU cooperation at the policy level and with Eurostat and the key reference countries regarding data (including Statistics Finland), in order to identify potential areas of closer collaboration and mutual learning. The mission-based innovation policy and the transformative approach are in many ways also linked to the importance and development of innovation ecosystems in other EU-countries and EU innovation and industrial policy. Moreover, Finland plays a pioneering role in the development of ecosystems which offers Finnish innovation ecosystems and organisations opportunities to concretely strengthen international cooperation. From the perspective of impact assessment and data, the statistical analysis carried out as part of this study provides good examples and starting points for wider international cooperation on the identification, comparison and in-depth examination of ecosystems. The Joint European Community Innovation Survey (CIS) also provides a potential common point of reference and data for benchmarking. It would also be important here to take forward the use, usability, aggregation and comparability of different data at the EU level from the point of view of identifying and analysing ecosystems together, in order to identify potential future policy initiatives across the EU.

# Bibliography

Aarikka-Stenroos, L. & P. Ritala (2017). Network management in the era of ecosystems: Systematic review and management framework. *Industrial Marketing Management*, *67*, 23–36.

Acs, Z. J., Autio, E., & Szerb, L. (2014). National systems of entrepreneurship: Measurement issues and policy implications. *Research Policy*, *43*(3), 476-494.

Acs, Z. J., Estrin, S., Mickiewicz, T., & Szerb, L. (2018). Entrepreneurship, institutional economics, and economic growth: an ecosystem perspective. *Small Business Economics*, *51*(2), 501-514.

Adner, R., & Kapoor, R. (2010). Value creation in innovation ecosystems: How the structure of technological interdependence affects firm performance in new technology generations. *Strategic management journal*, *31*(3), 306-333.

Anselin, L., Varga, A., & Acs, Z. (1997). Local geographic spillovers between university research and high technology innovations. *Journal of urban economics*, *42*(3), 422-448.

Åström, T., Arnold, E. & J. Olsson (2020). Meta-evaluation of the second round of strategic innovation programmes after six years. *Vinnova Rapport VR 2020:19*.

Autio, E., & Thomas, L. (2014). *Innovation ecosystems* (pp. 204-288). The Oxford handbook of innovation management.

Azoulay, P., Graff Zivin, J. S., & Wang, J. (2010). Superstar extinction. *The Quarterly Journal of Economics*, *125*(2), 549-589.

Basole, R. C. (2009). Visualization of interfirm relations in a converging mobile ecosystem. *Journal of information Technology*, *24*(2), 144-159.

Basole, R. C., Russell, M. G., Huhtamäki, J., Rubens, N., Still, K., & Park, H. (2015). Understanding business ecosystem dynamics: A data-driven approach. *ACM Transactions on Management Information Systems (TMIS)*, *6*(2), 1-32.

Bergman, E. M., & Feser, E. J. (2020). Industrial and regional clusters: concepts and comparative applications.

Borrás, S. (2009) The Widening and Deepening of Innovation Policy: What Conditions Provide for Effective Governance? *CIRCLE Working Paper 2/2009*, 1–28.

Bosma, N., Content, J., Sanders, M., & Stam, E. (2017). Time series and panel data analysis of GEDI and growth performance indicators.

Brenner, T. (2017). *Identification of clusters: An actor-based approach* (No. 02.17). Working Papers on Innovation and Space.

Bruns, K., Bosma, N., Sanders, M., & Schramm, M. (2017). Searching for the existence of entrepreneurial ecosystems: a regional cross-section growth regression approach. *Small Business Economics*, *49*(1), 31-54.

Buzard, K., Carlino, G. A., Hunt, R. M., Carr, J. K., & Smith, T. E. (2020). Localized knowledge spillovers: Evidence from the spatial clustering of R&D labs and patent citations. *Regional Science and Urban Economics*, *81*, 103490.

Ceccagnoli, M., Forman, C., Huang, P., & Wu, D. J. (2012). Cocreation of value in a platform ecosystem! The case of enterprise software. *MIS quarterly*, 263-290.

Clarysse, B., Wright, M., Bruneel, J., & Mahajan, A. (2014). Creating value in ecosystems: Crossing the chasm between knowledge and business ecosystems. *Research policy*, *43*(7), 1164-1176.

Delgado, M., Porter, M. E., & Stern, S. (2010). Clusters and entrepreneurship. *Journal of economic geography*, *10*(4), 495-518.

Delgado, M., Porter, M. E., & Stern, S. (2014). Clusters, convergence, and economic performance. *Research policy*, *43*(10), 1785-1799.

Deschryvere, M., & Kim, Y. (2016). The role of ecosystems for start-ups: A comparative study between Korea and Finland. *STI Policy Review*, *7*(2), 35-59.

Einiö, E., Koski, H., Kuusi, T. ja Lehmus, N. (2021). Innovation, reallocation, and growth in the 21st century. *Publications of the Government´s analysis, assessment and research activities* 2022:1. Helsinki, Finland.

Ellison, G., & Glaeser, E. L. (1997). Geographic concentration in US manufacturing industries: a dartboard approach. *Journal of political economy*, *105*(5), 889-927.

Ellison, G., Glaeser, E. L., & Kerr, W. R. (2010). What causes industry agglomeration? Evidence from conglomeration patterns. *American Economic Review*, *100*(3), 1195-1213.

Feser, E. J., & Bergman, E. M. (2000). National industry cluster templates: A framework for applied regional cluster analysis. *Regional studies*, *34*(1), 1-19.

Fornaro, Paolo, and Henri Luomaranta. *Job creation and the role of dependencies*. No. 44. ETLA Working Papers, 2016

Fornaro, Paolo, and Henri Luomaranta. *Small and medium firms, aggregate productivity and the role of dependencies*. No. 47. ETLA Working Papers, 2017.

Gomes, L. A. V., Ana Lucia Figueiredo Facin, A. L. F., Salerno, M. S. & Ikenami, R. K. (2018). Unpacking the innovation ecosystem construct: evolution, gaps and trends. *Technological Forecasting & Social Change, 136*, 30-48.

Granstrand O. & M. Holgersson (2020). Innovation ecosystems: A conceptual review and a new definition. Technovation 90–91, February–March 2020. doi.org/10.1016/j.technovation.2019.102098

Greenstone, M., Hornbeck, R., & Moretti, E. (2010). Identifying agglomeration spillovers: Evidence from winners and losers of large plant openings. *Journal of Political Economy*, *118*(3), 536-598.

Hjelt, M., Luoma, P., Pesola, A., Saario, M., Kämäräinen, V., Maksimainen, A., Vesa, J. (2011). Selvitys Tekesin toiminnan vaikutuksista yhteiskunnan ja ympäristön hyvinvointiin. Gaia Consulting Oy & Nordic Healthcare Group Oy.

Järvi, K., & Kortelainen, S. (2017). Taking stock of empirical research on business ecosystems: a literature review. *International journal of business and systems research*, *11*(3), 215-228.

Kaihovaara, A., Haila, K., Noro, K., Salminen, V., Härmälä, V., Halme, K., Mikkelä, K., Saarnivaara, V-P. & H. Pekkala (2017). Innovaatioekosysteemit elinkeinoelämän ja tutkimuksen yhteistyön vahvistajina. *Valtioneuvoston selvitys- ja tutkimustoiminnan julkaisusarja* 28/2017.

Knockaert, M., Deschryvere, M., & Lecluyse, L. (2019). The relationship between organizational interdependence and additionality obtained from innovation ecosystem participation. *Science and Public Policy*, 46(4), 490-503. https://doi.org/10.1093/scipol/scz002

Laasonen, V., Kolehmainen, J. & Sotarauta, M. (2020) The complexity of contemporary innovation policy and its governance in Finland. *Innovation: The European Journal of Social Science Research*, doi.org/10.1080/13511610.2020.1842176

Laasonen, V., Ruokonen, H., Talvitie, J., Lähteenmäki-Smith, K., Kolehmainen, J., Ranta, T., Järvelin, A. & Piirainen, K. (2019). Selvitys innovaatioympäristöjen ja -ekosysteemien menestystekijöistä sekä julkisen sektorin rooleista kehityksessä. In *Opetus- ja kultturiministeriön julkaisuja* (2019:32)

Lafuente, E., Szerb, L., & Acs, Z. J. (2016). Country level efficiency and national systems of entrepreneurship: a data envelopment analysis approach. *The Journal of Technology Transfer*, *41*(6), 1260-1283.

Lai, Y., & Vonortas, N. S. (2019). Regional entrepreneurial ecosystems in China. *Industrial and Corporate Change*, *28*(4), 875-897.

Malmberg, A. and Maskell, P., 2002. The elusive concept of localization economies: towards a knowledge-based theory of spatial clustering. *Environment and Planning A: Economy and Space*, *34*(3), pp.429-449.

Manzini, R. B., & Luiz, D. S. C. (2019). Cluster identification: A joint application of industry concentration analysis and exploratory spatial data analysis (ESDA). *Competitiveness Review: An International Business Journal incorporating Journal of Global Competitiveness*, *29*(4), 401-415.

Marshall, Alfred. "Industry and trade." (1920).

Mercan, B., & Goktas, D. (2011). Components of innovation ecosystems: a cross-country study. *International research journal of finance and economics*, *76*(16), 102-112.

Moore, J. F. (1993) Predators and Prey: A New Ecology of Competition. *Harvard Business Review May-June 1993*; 71(3):75-86.

Nepelski, D., Van Roy, V., & Pesole, A. (2019). The organisational and geographic diversity and innovation potential of EU-funded research networks. *The Journal of Technology Transfer*, *44*(2), 359-380.

Nordic Council of Ministers (2020). Cookbook for systems change – Nordic innovation strategies for sustainable food systems. https://pub.norden.org/nord2020-048/nord2020-048.pdf

O'Donoghue, D., & Gleave, B. (2004). A note on methods for measuring industrial agglomeration. *Regional studies*, *38*(4), 419-427.

Peltoniemi, M., & Vuori, E. (2004, September). Business ecosystem as the new approach to complex adaptive business environments. In *Proceedings of eBusiness research forum* (Vol. 2, No. 22, pp. 267-281).

Phelps, C., Heidl, R., & Wadhwa, A. (2012). Knowledge, networks, and knowledge networks: A review and research agenda. *Journal of management*, *38*(4), 1115-1166.

Porter, M. (1990). The Competitive Advantage of Nations. *Harvard Business Review 68*, 2 (March–April 1990): 73–93.

Porter, M. (2003). The economic performance of regions. *Regional studies*, *37*(6-7), 549-578.

Regeringskansliet (2021). https://www.regeringen.se/regeringens-politik/regeringens-strategiska-samverkansprogram/

Scaringella, L., & Radziwon, A. (2018). Innovation, entrepreneurial, knowledge, and business ecosystems: Old wine in new bottles? *Technological Forecasting and Social Change*, *136*, 59-87.

Scholl, T., & Brenner, T. (2016). Detecting spatial clustering using a firm-level cluster index. *Regional Studies*, *50*(6), 1054-1068.

Sepponen, S., Hjelt, M., Moisio, M., Suominen, F., Halonen M., (2021). Kansainvälinen vertailu kestävän kehityksen tavoitteista innovaatio- ja yrityspolitiikassa. *Työ- ja elinkeinoministeriön julkaisuja* 2021:22. Helsinki, 2021.

Sipola, S., Puhakka, V. & Mainela, T. (2016) "A Start-Up Ecosystem as a Structure and Context for High Growth", Global Entrepreneurship: Past, Present & Future (Advances in International Management, Vol. 29), Emerald Group Publishing Limited, Bingley, pp. 179-202. https://doi.org/10.1108/S1571-502720160000029012

Stabell, Charles B., and Fjeldstad, Ø. (1998). Configuring value for competitive advantage: on chains, shops, and networks. Strategic Management Journal 19(5), 413-437.

Stam, E., & van de Ven, A. (2019). Entrepreneurial ecosystem elements. *Small Business Economics*, 1-24.

Stam, F. C., & Spigel, B. (2016). Entrepreneurial ecosystems. *USE Discussion paper series*, *16*(13).

Stangler, D., & Bell-Masterson, J. (2015). Measuring an entrepreneurial ecosystem. *Kauffman foundation research series on city, metro, and regional entrepreneurship*, *16*.

Suominen, A., Seppänen, M., & Dedehayir, O. (2019). A bibliometric review on innovation systems and ecosystems: a research agenda. *European Journal of Innovation Management*.

Szerb, L., Lafuente, E., Horváth, K., & Páger, B. (2019). The relevance of quantity and quality entrepreneurship for regional performance: the moderating role of the entrepreneurial ecosystem. *Regional Studies*, *53*(9), 1308-1320.

The Department for Business, Energy and Industrial Strategy (BEIS) (2021). Catapult Network Review How the UK’s Catapults can strengthen research and development capacity. BEIS Research Paper Number 2021/013.

The National RDI Roadmap (2020). Kestävän ja kehittyvän yhteiskunnan ratkaisuja tuottava Suomi. 23.4.2020
Updated 14.12.2021. https://okm.fi/tki-tiekartta

Tsujimoto, M., Kajikawaa, Y., Tomitab, J. & Matsumoto, Y. 2018. A review of the ecosystem concept — Towards coherent ecosystem design. *Technological Forecasting & Social Change*, 136, pp. 49-58

Tsvetkova, A. (2015). Innovation, entrepreneurship, and metropolitan economic performance: empirical test of recent theoretical propositions. *Economic Development Quarterly*, *29*(4), 299-316.

UK Innovation Strategy 2021.
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1009577/uk-innovation-strategy.pdf

Valkokari, K., Hyytinen, K., Kutinlahti P. & M. Hjelt (2020). Yhdessä kestävää kasvua - ekosysteemiopas. VTT Technical Research Centre of Finland. DOI: 10.32040/2020.Ekosysteemiopas.

Valovirta, V., Lehenkari, J., Lehtoranta, O., Loikkanen, T., Suominen, A., Bodewes, H., Mostert, B., Zegel, S., van der Veen, G. 2014. The impact of Tekes activities on wellbeing and environment. Tekes, Helsinki.

Vedula, S., & Kim, P. H. (2019). Gimme shelter or fade away: the impact of regional entrepreneurial ecosystem quality on venture survival. *Industrial and Corporate Change*, *28*(4), 827-854.

Whittington, K. B., Owen-Smith, J., & Powell, W. W. (2009). Networks, propinquity, and innovation in knowledge-intensive industries. *Administrative science quarterly*, *54*(1), 90-122.

Zegel, Ploeg, Guznajeva, Romanainen, Salminen, Piirainen & Kettinen (2021): World-class ecosystems in the Finnish Economy

# Annexes

## Appendix 1. Interviews

| Name | Organisation |
|---|---|
| **Background interviews:** | |
| Paolo Casini | European Commission, DG GROWTH |
| Sylvia Schwaag-Serger | Lund University / Swedish Government Agency for Innovation (VINNOVA) |
| Marc Engels | Flanders Make |
| Mika Pikkarainen | Ministry of Economic Affairs and Employment |
| Petteri Kauppinen, Erja Heikkinen, Matti Kajaste | Ministry of Education and Culture |
| Jari Hyvärinen | Business Finland |
| Erkki Ormala | Aalto University |
| Jari Kuusisto | University of Vaasa |
| Kirsi Hyytinen, Katri Valkokari | VTT |
| Hannu Karvonen, | VTT |
| Mari K. Niemi | E2 Research |
| Jatta Jussila, Tiina Laiho | CLIC Innovation |
| | |
| **Case FinnCERES:** | |
| Tekla Tammelin | VTT |
| Monika Österberg | Aalto |
| **Case Expand Fibre:** | |
| Heli Virkki | Fortum |
| Katariina Kemppainen | Metsä Group |
| + 18 respondents the digital survey:<br>- 13 companies<br>- 1 universities / research institutes<br>- 3 city / business development organisation<br>- 1 regional council | |
| **Case Unlocking Industrial 5G Beyond Connectivity / SoC hub:** | |
| Jarkko Pellikka | Nokia |
| Timo Hämäläinen, Suvi Lammi | University of Tampere |
| Seppo Haataja | Business Tampere |
| + 6 respondents to the digital survey:<br>- 5 companies<br>- 1 universities / research institutes | |
| **Case EnergyVaasa and Wärtsilä Smart Marine:** | |
| Anna-Kaisa Valkama, Mika Konu | Merinova Oy Ab |
| Stefan Råback, Riitta Björkenheim, Kristoffer Jansson | VASEK |
| Stefan Damlin | Vaasan Sähkö |
| Susanna Slotte-Kock | City of Vaasa |
| Kenneth Widell | Wärtsilä |
| + 21 respondents to the digital survey:<br>- 16 companies<br>- 2 universities / research institutes<br>- 2 city / business development organisation<br>- 1 regional council | |

# Appendix 2. Innovation ecosystem case studies

## 1. FinnCERES

The FinnCERES ecosystem consists of actors at three-levels: The host organisations, co-create partners and other key collaborators. There are over 20 organisations involved in the ecosystem and through their own networks many more. The host organisations are VTT Technical Research Centre of Finland Ltd, Aalto University and Academy of Finland and its Flagship programme.

Co-creation partners are mainly different kinds of companies in the bio-sector. Other key collaborators include foreign organisations and networks with which FinnCERES cooperates or to which it is connected.

The figures below show the background information of actors in the FinnCERES ecosystem. FinnCERES is characterised by its strong international cooperation and connection to cooperation networks. The figures show the actors involved in FinnCERES in the summer of 2021. It should be noted that since then the number of actors has grown.

*Figure 14. FinnCERES (case study), organisation types involved.*

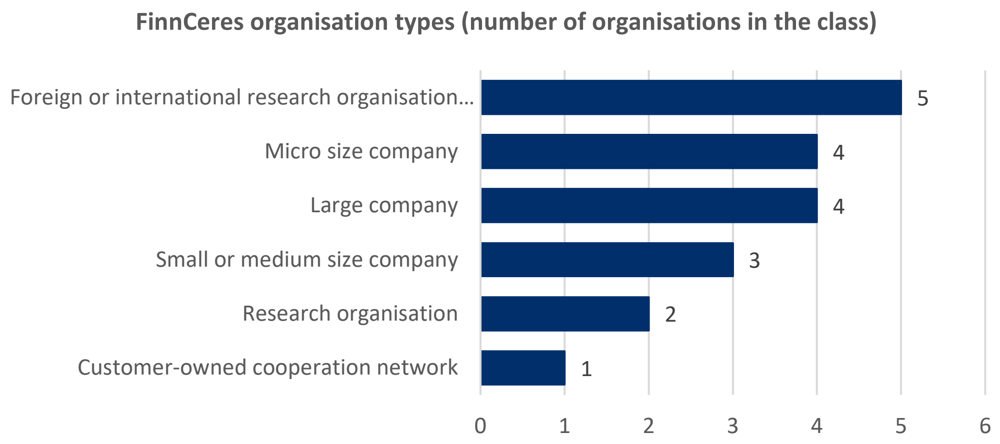


*Figure 15. FinnCERES (case study), number of employees in the organisations involved in the ecosystem.*

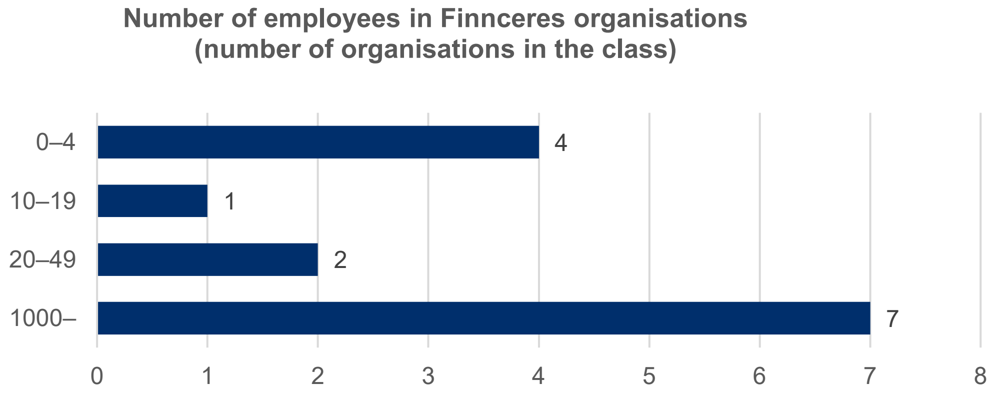



*Figure 16. FinnCERES (case study), industry sector of organisations involved in the ecosystem.*

# 2. Expand Fibre

The Expand Fibre ecosystem is built around two major Finnish companies, Fortum and the Metsä Group. These companies with the ecosystem and Expand Fibre programme steering groups lead and coordinate the actions of the ecosystem. The ecosystem actions consist of RDI-projects, management and utilisation of the ecosystem database and other ecosystem activities (events, seminars, etc.). In total, by the beginning of 2022, more than 70 organisations were involved in the ecosystem. The ecosystem is constantly evolving and growing with the number of organisations likely to grow further in the future.

The Expand Fibre ecosystem involves companies of different sizes, universities and universities of applied sciences, research institutes, associations and foreign actors. Companies are the largest group of actors involved, in terms of numbers. The Expand Fibre ecosystem includes a wide range of companies from various industries. There are companies from over 25 industry sectors in the ecosystem. Smaller companies have a background in research and development, business services, design and small-scale manufacturing, and e.g., from industries focused on marketing and advertising. The industry sector of the larger companies is primarily manufacturing industry and the management of large corporations. A significant number of domestic and foreign research organisations are also involved in the ecosystem. The figures below show the background information of actors in the Expand Fibre ecosystem.

*Figure 17. Expand Fibre (case study), organisation types involved.*

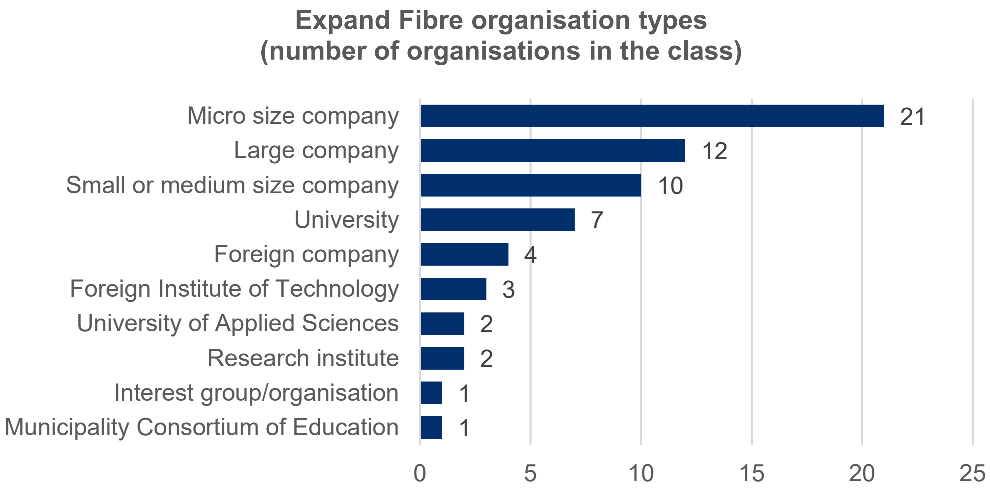


*Figure 18. Expand Fibre (case study), number of employees in the organisations involved in the ecosystem.*

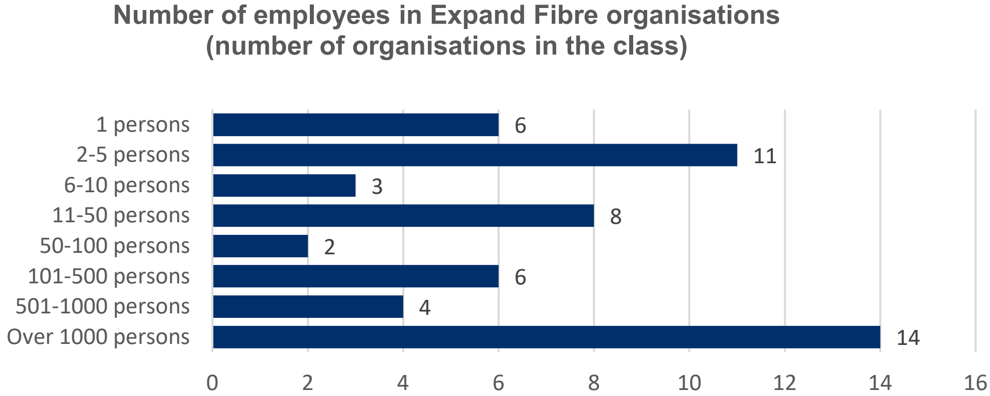
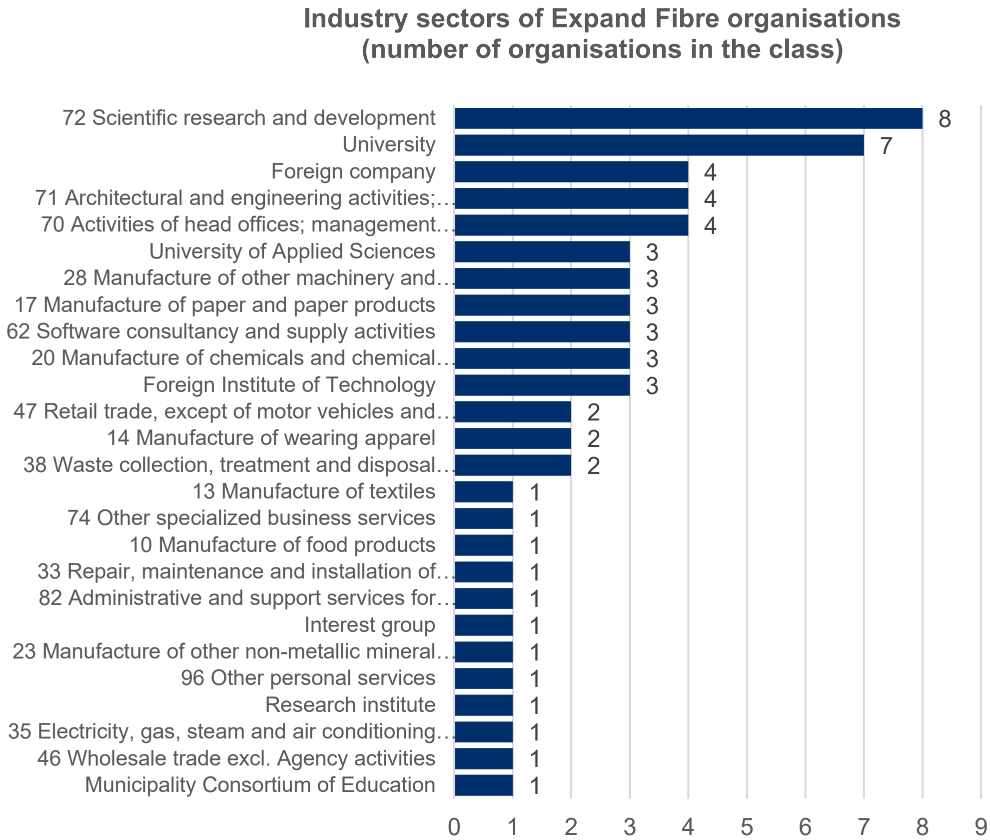



*Figure 19. Expand Fibre (case study), industry sector of organisations involved in the ecosystem.*



# 3. Unlocking Industrial 5G Beyond Connectivity / System on a Chip Hub

The System on a Chip Hub sub-ecosystem is part of the larger Nokia's Unlocking Industrial 5G Beyond Connectivity -ecosystem. There are five other sub-ecosystems in the larger Nokia's leading companies' ecosystem. Central to the operation of the SoC HuB sub-ecosystem is the sharing and obtaining of information from other sub-ecosystems.

The University of Tampere is the key leader in SoC HuB's ecosystem research, while Business Tampere coordinates the ecosystem's operations. The ecosystem is still partly under development and the number of actors is growing. By the end of 2021, about 10 different organisations were involved in the ecosystem. These include both large companies and SME's.

Identified target group roles in the innovation ecosystem are as follows: companies providing microcircuits or related services, companies that use programmable circuits or standard processors in their products and services and microcircuit design tool manufacturers and consultants. Furthermore, identified indirect target groups are, companies that do not have their own physical product or service yet, investors and education and research organisations.

*Figure 20. System on a Chip Hub (case study), organisation types involved.*

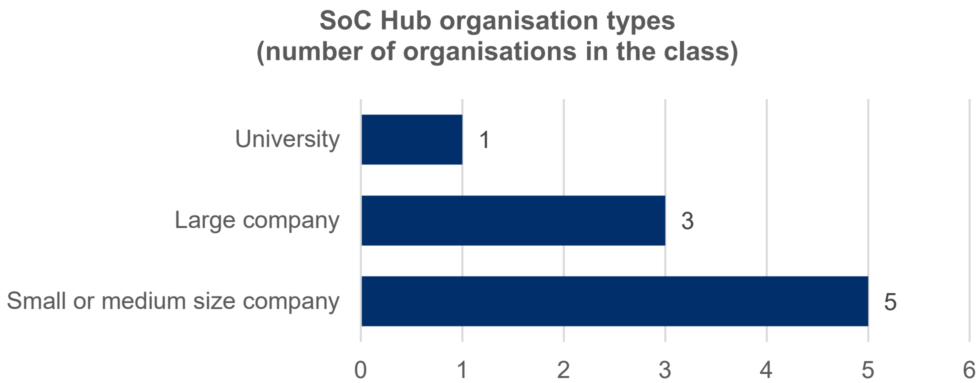


*Figure 21. System on a Chip Hub (case study), number of employees in the organisations involved in the ecosystem.*

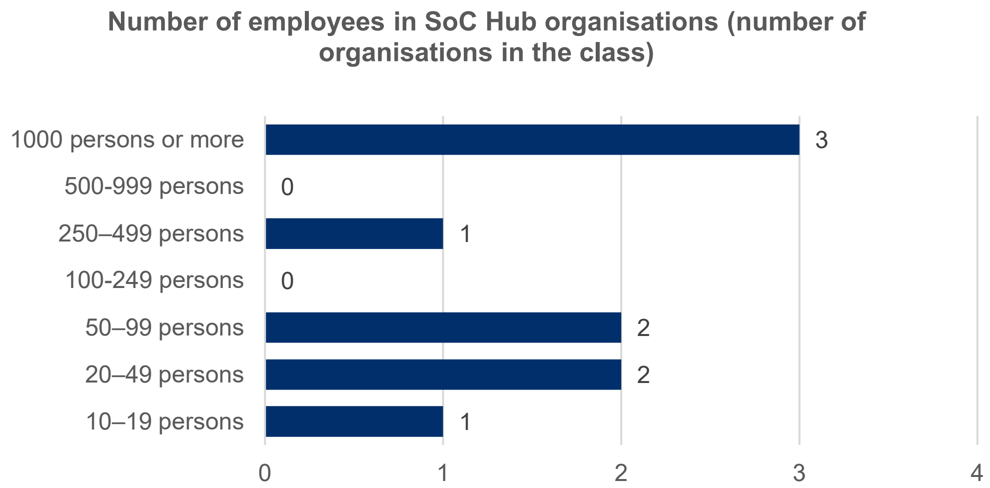
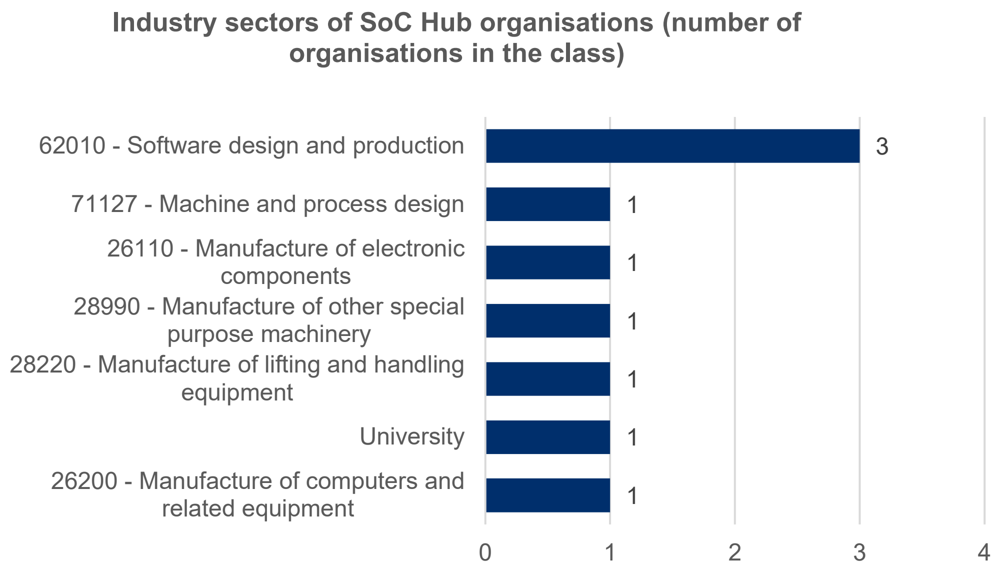



*Figure 22. System on a Chip Hub (case study), industry sector of organisations involved in the ecosystem*




.

# 4. EnergyVaasa

**EnergyVaasa** cooperation represents a broad umbrella for cooperation in the energy sector, within which one can identify strong, more targeted innovation ecosystems formed around leading companies. The object of a more detailed analysis in the case study was those organisations committed to EnergyVaasa cooperation. The following is a short summary of EnergVaasa partners, that were the subject of this case study.

**Public organisations**: Merinova Technology Centre, City of Vaasa, Vaasa Region Development Company VASEK, Vaasa Parks Ltd, Regional Council of Ostrobothnia and Ostrobothnia ELY Centre, Municipality of Mustasaari.

**Higher education institutions** (these institutions have also emphasised to some extent the energy sector in education and research and in development environments)**:** the University of Vaasa (and Vaasa Energy Business Innovation Centre, VEBIC, which is a multidisciplinary research and innovation platform at the University of Vaasa), Vaasa University of Applied Sciences, University of Applied Sciences Novia, Åbo Akademi University (Vaasa campus) and Technobothnia (which is a wide ranging laboratory unit co-owned by three universities, the University of Vaasa, Vaasa University of Applied Sciences and Novia University of Applied Sciences), Hanken School of Economics.

**Companies**: Large international export companies such as Wärtsilä, ABB, the Switch, Vacon, Hitachi Energy and Danfoss. Energy companies: Vaasan Sähkö Ltd, EPV Energy Ltd and Westenergy Ltd. Companies providing system delivery, design and project management services such as VEO, Citec, Schneider Electric/Vamp and Wapice. In addition, EnergyVaasa cooperation also includes several companies producing specialised production services and start-up companies.

*Figure 23. EnergyVaasa (case study), Turnover of companies*

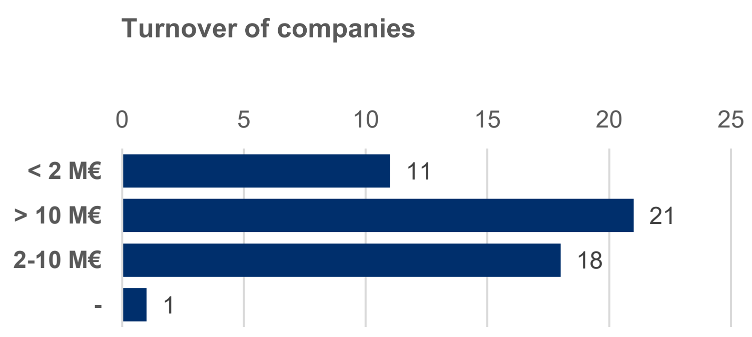
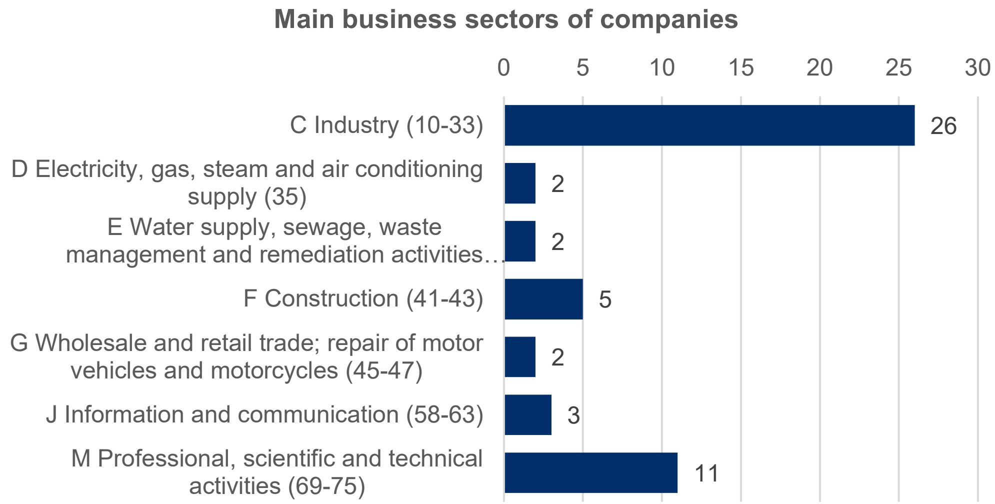


*Figure 24. EnergyVaasa (case study), Main business sectors of companies*



# Appendix 3. Measuring the impacts of innovation ecosystems – possible indicators

*Table 23. Common measurement perspectives identified for ecosystems.*

| | INPUTS | ACTIVITIES | OUTPUTS AND RESULTS | OUTCOMES AND EFFECTS | IMPACTS |
|---|---|---|---|---|---|
| **What should be measured?** | Extensive utilisation of resources:<br>• Financial and personnel<br>• Available networks of expertise and competences (extensive collaboration, diversity)<br>• Collaborative platforms and other support structures<br>• Competences | Bringing together, developing and fostering a network of actors, designing a distribution of labour and clarifying roles (formulating and clarifying a shared vision)<br><br>Opening up of innovation activities (including changing modes of operating, co-creating and innovating) | Enhancing internal and external co-operation and the use of information in the ecosystem<br><br>Enhancing the movement of intangible and tangible capital within the ecosystem<br><br>Increasing the attractiveness and importance of the ecosystem | Strengthening of capacities benefits innovation outcomes in business<br><br>Scaling up and expanding the utilisation of innovation | Strengthening competitiveness<br><br>The importance of ecosystems in social and societal transitions, such as improving sustainability and wellbeing (contribution made to national or international objectives, policy goals and missions) |
| **Examples of indicators** | Participants and their diversity (as to industry, size, sectors, international partners etc.)<br><br>New resources / investments to development<br><br>The utilisation of diverse funding instruments and sources for ecosystem development | Shared strategies (the identification of common themes in organisation strategies), roadmaps and connections to societal changes (recognised areas for RDI-cooperation)<br><br>Performance indicators (new actors involved in RDI cooperation, projects, facilitated opportunities and participation and commitment to co-development, etc.)<br><br>Expectations of RDI cooperation vs. experimental value, participation<br><br>Activity and reporting on ecosystem cooperation within one's own organisation | Sharing and disseminating knowledge in ecosystems<br><br>The increase in RDI-collaboration and its qualitative changes (diversification and deepening)<br><br>The recognised improvement of relevance and visibility of the ecosystem<br><br>Change / growth of ecosystem: the supply of value, internationalisation of networks, international recruitments<br><br>Increase in RDI inputs and intensity (funding, personnel)<br><br>Repatriation of RDI funding from international and national sources<br><br>New joint investments, demonstrations, pilots, innovation outputs etc.<br><br>Value added to diverse stakeholders (learning), direction of RDI and prioritisation (clarification of strategy and recognition of business potential<br><br>Reduction of risk | Improved innovation capacity<br><br>Acceleration of development cycles<br><br>New innovations<br><br>Increase in the taking into use of innovations<br><br>Expansion to new reference markets (indicators including procurement volumes) | The share of RDI inputs of GDP, Economic and productivity growth, Diversity of economic structure<br><br>(When assessing the impact, continuous monitoring, qualitative review and assessment of the role of the ecosystem in question to international competitiveness is very important) |

*Table 24. Measurement perspectives identified for science / research-driven innovation ecosystems.*

| | INPUTS | ACTIVITIES | OUTPUTS AND RESULTS | OUTCOMES AND EFFECTS | IMPACTS |
|---|---|---|---|---|---|
| **What should be meas-ured?** | • see above | Development of competence and capabilities (combining basic and applied research and users of research results; cooperation between research groups)<br><br>Social and international influence (decision-making, legislation, education)<br><br>Linking ecosystem RDI activities to regulatory preparation and standardisation work (highlighting ecosystem RDI themes in decision-making, legislative preparation, education) Increasing research activity in the field | Growth in the multidisciplinary nature of research<br><br>The emergence of new teaching and training content<br><br>Sharing and disseminating information through international networks<br><br>Increase in RDI intensity and activity in the participating companies. | Emergence of new promising commercialisable research results that will lead to the emergence of new products and business concepts<br><br>More efficient utilisation of the researched information e.g., in the development of companies' businesses, piloting and commercialisation | Strengthening Finland's position and attractiveness research areas;<br><br>Wide dissemination and scaling of research results internationally |
| **Examples of indicators** | International research partners and companies utilising the results | Research-business collaboration<br><br>Shared RDI-projects and forms of business collaboration<br><br>New openings between research groups and new combinations or competence areas | Repatriation of RDI funding, contractual research collaboration<br><br>Ability to attract and recruit new expertise and talent (researchers)<br><br>Publications<br><br>Testbed-supply and public-private infrastructure and funding to co-use of research infrastructure | New internationally important research areas<br><br>New IPR, patents<br><br>International scientific breakthroughs<br><br>Start-ups | International benchmarks and rankings<br><br>More broadly also the share of research work as measured in person years undertaken by PhDs of all work measured in person years<br><br>Residence permits issued by the Finnish Immigration Service for experts and researchers<br><br>Number of foreign students and researchers in universities |

*Table 25. Measurement perspectives identified for business-driven innovation ecosystems.*

| | INPUTS | ACTIVITIES | OUTPUTS AND RESULTS | OUTCOMES AND EFFECTS | IMPACTS |
|---|---|---|---|---|---|
| **What should be measured?** | See above | Compilation of a network of ecosystem actors and development of division of labour (clarification of a common goal space and a common vision)<br><br>Opening up innovation activities (changes in the organisation of RDI activities) | Decreasing risks, savings and effectivisation of resource use, better targeting RDI inputs<br><br>Finding new application areas and business opportunities<br><br>Strengthening capabilities and capabilities for launching new business areas and cooperating<br><br>Increased RDI intensity of SMEs | Renewal of business and business models<br><br>Acceleration of the innovation cycle and accelerating the diffusion and scaling of innovation in innovation ecosystems | Business renewal and international competitiveness; scaling of results and broader effects on business growth and development |
| **Examples of indicators** | Partners from universities and different sized companies from different sectors | Collaborative RDI contracts<br><br>New models of RDI partnerships<br><br>Number of shared RDI projects (aiming at commercialisation)<br><br>Substantive direction of RDI projects (including social / societal responsibility)<br><br>National and international visibility (communications) | Increase in RDI inputs (funding, personnel)<br><br>Utilisation of new (research) knowledge and expertise in companies<br><br>Repatriation of national and international RDI funding, foreign investment in the ecosystem, international risk financing | New business activities and expanding to new markets / creation of demand in new markets and for new products<br><br>New IPR, patents<br>Start-ups<br><br>Strengthening the position of companies in international markets | Improved competitiveness and productivity, increased turnover and export of companies involved in the ecosystem |

*Table 26. Measurement perspectives identified for regionally rooted innovation ecosystems.*

| | INPUTS | ACTIVITIES | OUTPUTS AND RESULTS | OUTCOMES AND EFFECTS | IMPACTS |
|---|---|---|---|---|---|
| **What should be measured?** | Long-term commitment to using regional development funding instruments for ecosystem development<br><br>RDI infrastructure of universities and educational institutions<br><br>Investments by the cities in strengthening RDI cooperation through urban development instruments and measures and, for example, through public procurement | Large-scale pooling of resources, development and continuous renewal of the division of labour to promote the development of ecosystems = regional organisation of ecosystem cooperation<br><br>Strengthening trust and cooperation between different regional and local stakeholders | Strengthening regional and international cooperation<br><br>The emergence of new system-level collaboration<br><br>The emergence of new development and testing environments<br><br>Companies’ activity in RDI in Finland | Increase in investments made in the region and its organisations<br><br>Removal of barriers and bottlenecks to development (strengthening demand, opening up new markets) | Strengthening the innovation conglomeration and increasing international attractiveness<br><br>Locally born and tested solutions to societal challenges. |
| **Examples of indicators** | | Regional strategy work, opportunities, cooperation agreements<br><br>Joint RDI projects financed through different national and international funding channels (project portfolio thinking)<br><br>Strong investment in RDI collaboration and activities by the leading companies | Strengthening the interconnections of different industries and stakeholders in the region<br><br>The increased awareness and recognition of the region as an innovation environment<br><br>New experiments and RDI infrastructure in higher education institutions and companies. | Increase in investments made in the region<br><br>Domestic and foreign investments in companies and risk financing<br><br>New research areas supporting the ecosystem, placement of experts in regional organisations, new directions in educational content | Increase in the intensity of RDI activities in the region<br><br>Job growth<br><br>Business productivity growth<br><br>Diversification of the economic structure<br><br>Achievement of societal goals set in the region (e.g., carbon neutrality; energy savings) |

# Appendix 4. Literature review

In this appendix, we present a more detailed, albeit incomplete, survey of previous works in economics and management science regarding innovation, business and entrepreneurial ecosystems, as well as related concepts (such as industrial clusters and networks).

## Economics

The economics literature has not really addressed the ecosystem phenomenon explicitly, while it has covered extensively similar concepts such as innovation clusters and knowledge spillovers. Some previous works, such as Peltoniemi (2004), make clear distinctions between the concepts of ecosystems, clusters and networks. For example, the cluster concept is usually associated with geographical concentration, while ecosystems do not necessarily display a clear geographical localisation (even though in many cases they do). Despite the differences, ecosystems, clusters and networks do share a number of features, such as the importance of cooperation between different entities. In other cases, concepts like clustering are identified as being a key characteristic of innovation ecosystems (see Laasonen et al, 2019, or Scaringella and Radziwon, 2018).

In the light of these considerations, we believe that publications in literatures such as those on clusters or knowledge spillovers can provide interesting insights on the impacts of collaborations and the sharing of knowledge (in a broad sense) on economic outcomes. As we do for the management literature, we do not review extensively the existing literatures, but instead consider a small number of exemplary works which we think establish a convincing causal relation or provide generalisable approaches to measure clusters or networks (and therefore signal the presence of ecosystems).

*Measuring Clusters*

The identification of the presence of local clusters of industries (including firms and related institutions) has been widely explored in the literature, without, as yet, coming to a definitive consensus. Some of the important differences in the methods proposed by the literature lie in whether we should focus on individual industries and how they are overrepresented in certain locations, or whether inter-industry linkages should be taken into account in the measurement process.

Among the works which take the latter approach we find Feser and Bergman (2000). In particular, their methodology relies on national-level input-output tables to measure purchasing and selling patterns between industries. The importance for firms to be spatially close to their suppliers has been identified as an agglomerating force since Marshall (1920), hence the input-output linkages between firms are important in order to better understand clustering patterns. The methodology adopted by Feser and Bergman (2000) consists of computing a large correlation matrix between industries, based on sales/purchase patterns, while in a second step a factor analysis (using the principal components technique) is used to extract the latent clusters driving the correlations found. Industries are then assigned to a specific, non-mutually exclusive, cluster based on factor loadings (the strength of the relationship between the industry and the factors). Finally, the authors identify the presence of clusters at the local level, by looking at the presence (in terms of employment or value added) of industries, and their associated latent clusters, in a given region.

A more refined measure of inter-industry linkages is presented in Ellison et al. (2010). In this study, the authors do not limit linkages to purchase and selling patterns but also consider sharing of occupations (proxying the reliance on a similar labour pool) and sharing of knowledge, approximated by patent citations across industries. To identify local clusters, they rely on the conglomeration index proposed in Ellison and Glaeser (1997), which accounts for geographical concentration patterns, as well as for the different plant-level size distribution across various industries.

Delgado et al. (2014) formulate another clustering algorithm to define the U.S. Benchmark Cluster Definitions. They rely on measures of inter-industry relations regarding input-output, occupations which are measured at the national level, as well as location-based correlation measures which look at the geographic correlation of establishments and employment among industries. They combine the various similarity matrices and then use clustering techniques, such as *kmean* clustering, to make a first estimate of the clusters which are mutually exclusives. Subsequently, they score the resulting clusters using the principle that industries inside the clusters should be relatively similar to each other and dissimilar from those in other clusters. These clusters can then be applied to the desired geographical scale, e.g., regions, to measure local clusters.

A quite different perspective is offered by techniques that abstract from inter-industry linkages and rely solely on individual industries’ overrepresentation in a given location. A good example is offered by the location quotient which is a ratio between the employment (other measures can be used) share of a given industry in a given location and the share of employment for the same industry at the national level. One of the most problematic aspects of the location quotient however is that the cut-off value used to determine an industry as concentrated in a given location is not fixed. O'Donoghue and Gleave (2003) correct this problem by using statistical significance criteria to determine the importance of a local cluster. Another and probably more pressing problem with location quotients is that they disregard links between industries, thus the identification of clusters is dependent on expert decisions.

Additional recent works on measuring clusters include Egeraat et al. (2018), Brenner (2017) and Manzini and Luiz (2019). The first study adjusts the location quotient by taking into account the number of firms, as well as employment, the uneven spatial dimension of given locations, as well as the uneven size distributions of concentrations. Brenner (2018) which is an extension of Scholl and Brenner (2016), also considers physical distances when measuring clusters, while Manzini and Luiz (2019) combines location quotient with exploratory spatial data analysis, to determine local concentrations and links between different geographic units. Finally, we refer the reader to Bergman and Feser (2020) for an overview of cluster identification techniques.

*Mechanisms and impacts of clusters*

While in the previous sub-section we have described a few examples of works dealing with cluster measurement, here we look at a number of significant works which study the mechanisms of cluster formation and their impacts.

Since Marshall (1920), it has been argued that the main reason for the existence of clusters is the reduction in transfer costs. These costs can be of inputs (firms have an advantage in locating near their suppliers), labour-related (having a large labour pool to find employees with the required skills is beneficial to a firm in a cluster) and knowledge transfer costs (in particular regarding the transfer of informal knowledge). The latter aspect is particularly important in our cases, because it is one of the pivotal characteristics of innovation ecosystems.

Ellison et al. (2010) offers one of the most interesting analyses regarding the drivers of industry conglomeration. In particular, they test whether having similar input-output relationships (goods transfer), common occupational/skill requirements (skill transfer) or technology (knowledge) lead to higher conglomeration. Using data from the US and an instrumental variable technique to alleviate the endogeneity issue, the authors find that all three channels are important, with the input-output relationship and sharing of workers skills being the quantitatively most significant factors. Intellectual spillovers, measured by patent citations, remains a significant driver, but less so than the other two.

One particularly important study for our setting is Whittington et al. (2009). The study focuses on the US biotech sector and it investigates contemporaneously the impact of belonging to a geographically defined cluster and being in a geographically dispersed (even international) network on firm-level innovation, measured by patent applications. They find that firms which are geographically close to other biotech companies tend to innovate more and the same goes firms which are in a central position in a global network. Interestingly, the interaction of the two terms is negative, pointing to the diminishing efficacy of local clusters for firms which are in strong network positions.

Regarding the impacts of clusters on the local economy, Delgado et al. (2010) provides an interesting example regarding the effect of clusters on entrepreneurship. The empirical analysis is based on US economic areas from 1990 to 2005 and defines clusters using the US Cluster Mapping Project (Porter, 2003). Together with individual clusters, the authors also consider linked clusters and the similarity of clusters in neighbouring regions. Moreover, the authors are interested in measuring convergence effects, distinguishing this from clustering effects. The main dependent variables of interest in the study are the number of new establishments created by new firms and their employment. They find that while there is a negative convergence effect (i.e., higher levels of a start-up employment are associated negatively with its growth), the presence of clusters is positively associated with start-up creation and employment.

A particularly interesting work on the impact of clusters is Greenstone et al. (2010). To avoid endogeneity issues, namely that clusters do not start in a given location randomly but rather due to potentially unobserved local characteristics, they identify US counties which were chosen narrowly by large firms to set up a new plant. They find that plants which belong to a “winning” county experience a statistically and economically higher productivity growth, compared to plants located in counties which barely lost the possibility of getting a new large plant on their territory. Moreover, they find a positive effect of a new large plant opening on local wages, indicating that the productivity growth experienced by incumbent plants is not reflected in more profits. Greenstone et al. (2010) also considers the interaction between a plant opening in a winning county and the degree of closeness between the new plant and the incumbent plants. Using the same measures as in Ellison et al. (2010), the authors find a positive, statistically significant, interaction between technology and knowledge sharing, as well as sharing of similar occupation requirements and the effect of a new plant opening. However, they do not find a meaningful interaction with input-output linkages. These results are particularly importance for us, because they indicate again how knowledge spillovers which are key factors in ecosystems are important drivers of agglomeration and cluster effects. We discuss some interesting studies on knowledge spillovers in the next sub-section.

*Knowledge spillovers*

In a similar fashion to the literature on clusters and agglomeration economies, the academic discussion on knowledge spillovers is enormous and, as such, it is not possible to cover it comprehensively here. However, given the centrality of these concepts to the ecosystem discussion, we will discuss a limited number of papers which bring to bear solid evidence regarding the existence of knowledge spillovers.

One relatively early work on the study of knowledge spillovers, in a geographical context, is Anselin et al. (1997). In this empirical analysis, the authors consider US state-level and metropolitan area-level data to estimate the impact of both public and private R&D activity on the local stock of knowledge (measured using innovations count). One of the most interesting results of the analysis is that the presence of university research activity in a metropolitan area does not only impact positively local knowledge, but it has a positive impact on innovation conducted in nearby areas, providing evidence for the existence of knowledge spillovers. On the other hand, no geographical spillovers effects are found for private R&D activity.

Additional evidence of the existence of knowledge spillover, this time at the individual-level, is provided in the fascinating study of Azoulay et al. (2010). The analysis focused on knowledge spillover among academics, in particular university staff in US medical schools. To gauge causality, the authors rely on the exogenous variation provided by the death of very influential academics (referred to as superstars) and examine how their passing affected the academic output, measured in terms of quality-adjusted publications, of their co-authors. The findings of the paper point toward meaningful, both statistically and quantitatively, negative effects on the output of superstars' co-authors, after the death of the superstar. The analysis conducted in the paper is also able to highlight which possible mechanisms drive the spillovers. While the authors do not find a complete explanation in terms of skill substitutability or diminishing resources (for example, lower access to funding), they find that co-authors closer to the departed superstar in terms of academic interest (idea space) suffered more in terms of publication output. At the same time, the results do not point to meaningful geographic effects.

A final recent work we want to discuss here is Buzard et al. (2020). An interesting novelty provided by the paper is that it does not rely on administrative geographical location, rather it presents clusters of research activity which are based on effective local proximity. Using R&D labs locations for the north-east coast of the US, as well as for California, Buzard et al. (2020) study the relationship between cluster sharing and the likelihood to cite patents generated in the same R&D labs cluster. In the absence of knowledge spillovers, we would expect the geographical distribution of patents' citations to be independent of the R&D lab location. Instead, the results of the paper show that patents generated in a given R&D cluster are two to six times more likely to cite patents produced in the same cluster.

## Management Science

The management science literature has dealt with the concepts of innovation, entrepreneurial and business ecosystems much more extensively than its economics counterpart. However, very few management studies have produced quantitative measurements of ecosystem participation, or of general impacts stemming from ecosystems. Moreover, previous works have not formulated a generalisable method to measure ecosystems but have rather concentrated on networks starting from specific focal firms or industries. Instead of providing a long list of case studies and qualitative assessments, we focus on discussing a (very) limited number of works that we deem to be close to the main research questions at the base of this report (ecosystems' impacts and measurements).

A more general introduction to the topic, which also includes a survey of early works, is provided in Autio and Thomas (2014). There, the authors provide a definition of innovation ecosystems and how they have been addressed, theoretically and empirically, in the literature. Other literature surveys which encompass the theoretical and conceptual aspects of ecosystems, as well as broader empirical applications, are Stam and Spiegel (2016), Järvi and Kortelainen (2017) and Suominen et al. (2019), among others. For a review on works on networks, a related but distinct concept compared to ecosystems, we direct the reader to Phelps et al. (2012).

Below, we structure our (succinct) survey of selected works based on the main purpose of the study considered, i.e., whether it deals with the measurement of ecosystems, or whether it looks at their impacts.

*Studies on ecosystems measurement*

A relatively early example of ecosystem mapping is provided in Basole (2009). In that work, the global mobile ecosystem is measured and connections between firms are established, resulting in a network encompassing more than 7000 companies and 18 000 relationships, covering multiple industries. In addition to the mapping of the network, the authors calculate a set of measures such as density (the degree of interaction in the ecosystem) and centralisation (the compactness of the network). While observing that during the period of the analysis, covering the years 2002-2006, there were no identifiable central hub segments, the author already observed the potential for Google and Apple to become focal firms in the mobile ecosystem.  A similar work regarding the visualisation of the mobile ecosystem is Basole et al. (2015). Despite the tight focus, the analysis is exemplary due to the use of rich data sources on firm-level connections, as well as data on R&D and strategic alliances, to define the boundaries and structure of the ecosystem of interest, on a global scale.

Mercan and Göktas (2011) propose, in a cross-country analysis, a measurement of innovation ecosystems based on the use of data on clusters development, industry-university collaborations and perception about the culture to innovate, all of which are collected in the Global Innovation Index reports. The authors then proceed to quantify the relation between innovation propensity and these factors, finding that only the industry-university collaboration index has a significant positive relationship with innovation. Although the analysis is quite simple, the attempt to quantify the presence of innovation ecosystems in a generalisable way makes it an important contribution.

Turning to entrepreneurial ecosystems, Acs et al. (2014) represents an important work regarding measurement. They quantify the presence of entrepreneurial ecosystems by formulating the Global Entrepreneurship Development Index (GEDI), which is based on three main components. First, the authors use measures of individuals’ attitudes to entrepreneurship (e.g., the percentage of the population who believe that they have the right skills to start a business) obtained by the Global Entrepreneurship Monitor (GEM). In a second step, these individual-based measures are weighted by contextual variables (e.g., urbanisation or internet usage). Finally, the country-level index is penalised for the presence of bottlenecks, meaning that the index is corrected by the lowest scoring component. This implies that a country which improves their lowest component (removes the bottleneck) will boost its entrepreneurial ecosystem more than by improving aspects where it already performs well. The GEDI has been applied in multiple works (e.g., Acs et al., 2018) and it has been expanded to regional settings in Szerb et al. (2019), with the formulation of the Regional Entrepreneurial Development Index (REDI).

Stangler and Bell-Masterson (2015) provide a simpler approach to the measurement of entrepreneurial ecosystems which relies on using a multiplicity of indicators regarding aspects such as density (the share of new firms), fluidity (the population and labour market inflows at outflows in a given area), connectivity and diversity (for example by looking at the share of immigrant workers in a location). While the study does not provide a single index, it offers a broad view and provides suggestions on how best to obtain the required data.

A significantly different approach is provided in Bruns et al. (2017), who do not attempt to measure regional entrepreneurial ecosystems based on a set of indicators, but rather seek their existence by examining the interaction between the presence of entrepreneurs and GDP growth. The main idea is that healthy entrepreneurial ecosystems would boost the effect of the presence of entrepreneurs on economic activity, which is then revealed in a latent class analysis. In other words, regressing regional GDP growth on entrepreneurial activity should reveal heterogeneity in slope coefficients, depending on the different state of the entrepreneurial ecosystem. A somewhat related approach which measures the existence of entrepreneurial ecosystems is Lafuente et al. (2016).

Other works on entrepreneurial ecosystems have relied on simpler measures such as the number of new tech firms (Lai and Vonortas, 2019) or the total early-stage entrepreneurial activity of the GEM (Bosma et al., 2017). Other recent works providing their own measures of enterprise ecosystems' strength include, among others, Vedula and Kim (2019), and Stam and van de Ven (2019).

An attentive reader will notice that a large part of this section concentrates on measuring entrepreneurial ecosystems. This is because the literature on this topic has underlined the importance of the geographical dimension, be it at the regional, municipal or national level. Starting from a given location renders the measurement of the ecosystem easier than in the case where we would be interested in a global network. As we will see in the next section, most of the empirical studies on innovation and business ecosystems have instead started from a selected group of so-called focal firms, and then expanded the data to encompass competitors, suppliers, customers and other institutions belong to the ecosystem surrounding those firms. The implication of this approach, is that there are very few examples (cited above) of generalisable ways to measure innovation ecosystems and that the empirical analyses have usually focused on specific cases.

An interesting exception is offered in Clarysse et al. (2014). In their study, they define the sample by selecting a region (Flanders) and then by identifying the innovative start-ups belonging to the region. From this basis, the authors proceed to map the knowledge ecosystem by looking at the partners of these start-ups in various innovation projects, as well as the business ecosystem by using information on business partners, commercial alliances and the financial support network. The peculiarity of this work is that the authors manage to define both a knowledge/innovation and business ecosystem for the region (even though they find that the latter does not exist). It is however important to note here that this is another example of geographical focus, even though the defined ecosystems also include international partners which does not fit completely with the idea of global ecosystems.

*Studies on the impacts of ecosystems*

The management literature on innovation ecosystems has mostly produced empirical works on the effects and dynamics of ecosystem on their members, either focal firms or more peripheral actors.

One seminal work on the dynamics of innovation in a business ecosystem is Adner and Kapoor (2010). The authors consider the semi-conductor lithography equipment industry and examine how innovation challenges impact the focal firm (in this case the lithography tool producers), depending on which part of the ecosystem experiences the shock. In particular, the study finds that innovations stemming from the components part of the ecosystem (in this case the lens and the energy source producers) positively affect the performance of the focal firm, while technological challenges in complementary firms (in this case mask and resist producers) have a negative effect on the performance of the focal firm. Finally, they find that the benefit of vertical integration increases during the technology life cycle. The argument here goes that component challenges lead to learning opportunities for the focal firm, as well as generating barriers to imitation. The contrary happens for complement challenges which create opportunities for rivals to catch up and slow down the learning curve for the focal firm because complementor challenges reduce the value of the final product for the focal firm, lower demand and slow adoption.

Taking the opposite view as compared to Adner and Kapoor (2010), Ceccagnoli et al. (2012), examine the effect of joining a platform ecosystem on the performance of small firms (in this study, referred to as small independent software vendors, ISVs). The study is interesting because it includes a large sample of ISVs, 1210 over the period 1996-2004 which enter the SAP (a large enterprise software developer company) ecosystem. The authors are able to measure partnerships between the focal firm and ISVs over time, as well as the degree of downstream capabilities (how much the ISVs can sell their products for on their own) and copyright protections. The main findings of the analysis are that ISVs entering the SAP ecosystem experience an increase in sales and are more likely to issue an initial public offering and that the effects are amplified when the ISVs have greater intellectual property rights and downstream capabilities.

The empirical analysis in Clarysse et al. (2014) seeks to answer two main questions: do innovation ecosystems lead to business ecosystems? And does participation in an innovation ecosystem affect firm-level innovation capabilities? Based on the sample we described at the end of the previous sub-section, the authors find that the region of Flanders is characterised by a strong innovation ecosystem, with multiple large universities and research institutes acting as central players. On the other hand, they do not find the presence of a significant business ecosystem. Regarding the second question, Clarysse et al. (2014) find an interesting heterogeneous effect of collaboration on innovation, namely they observe a positive relation between collaboration with a central organisation and innovation, while collaborating with a peripheral actor has a negative effect on innovation. Finally, they find that financial support does not correlate start-up innovation.

Deschryvere and Kim (2016) represents a nice comparative study on the impact of ecosystem participation and young innovative companies' performance, for Finnish and Korean firms. The authors not only consider the potential different impact of ecosystems on young firms' performance, but also investigate in which phase of the enterprise's does life belonging to an ecosystem matter most. The main data sources for the analysis are firm-level surveys regarding the awareness and the impact of ecosystems for start-ups. For the Finnish case, the survey considers all applicants to TEKES (the Finnish Funding Agency for Innovation) for the years 2009-2013, while in the Korean case small and innovative firms are sampled at random in the machinery and software industry (between the two countries 424 firms are sampled). The ecosystem awareness, participation and impacts are self-reported by the interviewed CEOs. This approach offers an opportunity to measure ecosystems (both innovation and business) participation at the firm-level, even though it does not allow for a quantitative measurement of the strength of participation or a way to generalise ecosystem measurements. In terms of ecosystems' impact, the surveyed firms report positive effects, while actual performance metrics (such as employment, turnover and profits) do not show significant differences between participant and non-participant firms. The authors do however urge readers to interpret the results with care, due to missing information.

Another work which attempts to link knowledge and business (entrepreneurial) ecosystem with regional performance is Tsevtkova (2015). The study focused on U.S. metropolitan areas, and it is interested in the channels of how knowledge and entrepreneurship that lead to economic growth. The two alternative hypotheses considered are the missing link hypothesis (MLH) and the knowledge spillover theory of entrepreneurship (KSTE). While related, the two theories present significant differences. In the MLH, both healthy knowledge and entrepreneurial ecosystems need to be present to stimulate regional growth, while in the KSTE it is postulated that the presence of a knowledge ecosystem will generate spillovers and residual knowledge which will attract businesses automatically and thus generate growth. The results found in Tsvetkova (2015) support, although weakly, the MLH while she finds no evidence of the KSTE.

Stronger support for the KSTE hypothesis is found in Lafuente et al. (2016). Using a cross-country dataset including 63 countries for 2012, the authors find that including information on entrepreneurial ecosystem (measured by the GEDI), helps explain performance differences between countries. They also find that knowledge investments and favourable business conditions improve efficiency, with innovation-driven economies performing best.

Another paper linking entrepreneurial ecosystems with growth is Bosma et al. (2017). The interesting contribution of this work lies in its attempt to link explicitly and empirically, institutional quality, entrepreneurship and growth, using a panel of EU countries. While they do not find a large correlation between GDP growth and entrepreneurial activity, the size of the relation becomes much larger when institutions are included in the model as determinant of entrepreneurship, indicating the importance of high-quality entrepreneurial ecosystems.

Additional interesting works including local economic growth and entrepreneurial ecosystems are, among others, Lai and Vonortas (2019) and Szerb et al. (2019). The first work considers Chinese prefecture-level data from 2008 and 2015 and determines that factors such as knowledge creation, the presence of large universities and access to finance promote innovative entrepreneurial activity. Another interesting study on entrepreneurial ecosystems in China is provided in Yuan et al. (2021). Szerb et al. (2019) consider instead EU regions between 2012 and 2014 and study the differential impact of quantity and quality entrepreneurship on growth, while interacting with the surrounding entrepreneurial ecosystem. Using the REDI to measure the ecosystem, they find that the quantity of entrepreneurship does not enhance productivity, while quality entrepreneurship does. Interestingly, these effects are moderated by the presence of a good ecosystem (the effect of quantity entrepreneurship is positive and it becomes smaller for quality entrepreneurship). A work that also considers the interaction between the entrepreneurial ecosystem, firm characteristics and their resulting output is Vedula and Kim (2019). Their main finding is that a healthy entrepreneurial ecosystem leads to a higher chance of survival for new firms, but the effect is moderated depending on the experience of the founders of the enterprises considered.

Shifting the focus slightly, Nepelski et al. (2019) deal with how the type of partnership stemming from EU-funded research networks impacts the commercial potential of the innovation output. Using a sample of 603 research projects, they find that partnerships showing strong organisational diversity impact positively the commercial potential of innovation, pointing to the importance of establishing innovation and entrepreneurial ecosystems with varied types of participants. On the other hand, they find that geographically fragmented networks, especially with internationally dispersed partners, have less innovation potential, highlighting the importance of locational proximity in knowledge transfers.

**Conclusions**

With this literature review, we have tried to summarise the main findings surrounding the measurement of ecosystems and their impacts, gathered from the economics and management science literatures. While the economic literature does not explicitly deal with the ecosystem concept, it offers causal and generalisable evidence regarding similar phenomena, such as clusters and knowledge spillovers. On the other hand, while providing mostly correlational findings and less generalisable results, the management literature proposes careful conceptual analyses of ecosystems and offers interesting empirical exercises which overcome geographical contexts.

While the vastness of the literature does not allow us to draw any clear-cut conclusions, we can attempt to recover some broad messages. First of all, ecosystems are not easy to measure, especially if we want to consider the global scale. On the other hand, if the focus is at the geographical level, multiple techniques can be used to measure the presence of clusters and networks. While multiple works coming from both economics and management science point to the positive effect (or at least a correlation) of ecosystems on their participants, the evidence regarding aggregate impacts is weaker. There are however multiple findings pointing to the beneficial impact of clusters and knowledge networks on the overall economic performance of their area.

tietokayttoon.fi/en

ISBN PDF 978-952-383-480-4
ISSN PDF 2342-6799