Making invisible visible: systemic impacts of Business Finland

Research questions in brief

A specific aim of this brief is to illustrate the process of systemic impacts of Business Finland in the context of Artificial Intelligence (AI), and to update the traditional logical impact model to make Business Finland's systemic impacts visible. We address this aim with the help of multi-criteria evaluation integrated with a system dynamic (SD) model. This research is part of Innopact study that explores impacts and the evaluation practices of technological and business experimentation.

Main result

Today's global trend in innovation policy is the integration of sustainability goals (Sepponen et al., 2021). It is unquestionable that sustainability mission is wide and complex, therefore demands sound understanding of how sustainable development and growth can be reached. However, traditional evaluations are driven by techno-economic indicators of productivity and efficiency. These indicators are not aligned with sustainability targets and tell little about the technological and business experimentation in tackling the societal challenges. In this context, systemic impact analysis becomes even more important, and yet more complex. This requirement is operationalized through new kinds of methods and indicators, which strengthen horizontal and systemic approaches and put emphasis on sustainability in evaluation. Making impacts visible and supporting decision making in order to accelerate significant drivers of sustainable growth and renewal is essential.

In order to make sense of invisible impact, we have organized two multi-stakeholder virtual workshops which hosted participants from different spheres of the Finnish innovation system related to AI, namely research, policy, funding and industry.

The main findings of the study relate to the observation that the current (AI) innovation system lacks a robust and extensive integration of societal needs and sustainability targets. In order to address this discontinuity in reaching systemic impacts, we propose the following points for the innovation policy-makers:

- Introduce combined multi-criteria and system dynamic approaches in innovation evaluation;
- Include sustainability and systemic nature of innovations and industrial renewal in policy target setting comprehensively; and
- Increase multi-stakeholder approaches in innovation evaluation to create common understanding of impactful intervention points and to make visible the value from different perspectives (actors and sustainability dimensions).

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The aim of Innovation and Growth Research funded by Business Finland is to find solutions to the global challenges of the Finnish economy and society.

Introduction

The traditional logical impact model does not make Business Finland systemic impacts visible.

VTT and Gofore's approach in the study is multi-criteria evaluation integrated withthe system dynamics (SD) modeling. By multi-criteria evaluation, we mean analysis of multifaceted dimensions of performance resulting from innovations (Gallouj & Djellal, 2010; 2013). We argue that its adoption is an important extension to the current evaluation practices (Hyytinen, 2017), as the integrated societal spheres broaden the traditional evaluation criteria from the techno-economic aspect to "immaterial", systemic and societal values of impacts.

System dynamic modelling reveals the interrelationships and multiple feedbacks between the different elements in an innovation system (Ruutu, 2018). It helps to understand the behavior of complex, time variant and nonlinear systems over time. In a SD model the relations between actions and actors in the system are formulated into a mathematical form in a way that dynamics of any variables in the system can be computationally simulated.

The multi-criteria impact evaluation model generates in depth understanding of different impact targets and mechanisms.

Integration of the approaches of multi-criteria evaluation and SD modeling makes visible the way that Business Finland's short and long perspective impacts emerge as a result of multiple interconnected elements in the innovation system, which create complex behavior and dynamics over time. Understanding and making visible the systemic nature and hidden performance of research and innovation activity is essential for achieving Business Finland's strategic goals that highlight the importance of sustainable development. This is because sustainable development encompasses systemic phenomena that cannot be tackled and evaluated using conventional evaluation criteria that focus predominantly on economic growth.

Data/materials

Our methodological target is to integrate multi-criteria evaluation framework to system dynamic modeling and involve key stakeholders (research, policy, funding and companies) in the model building.

Group model building engages key stakeholders in modelling and generates understanding of Business Finland's systemic and dynamic impacts.

We selected artificial intelligence (AI) as a case area. AI is a cross-cutting technology area which can be widely applied in healthcare, finance, energy and manufacturing, for example. AI can be employed in various public sector services as well. Finland is of one the first nations to produce a national AI strategy in 2017[1] to enhance research and education in AI areas, which has augmented AI-education programs and AI-research funding. Increase is also observed in key scientific indicators. For instance, the number of publications and amount of Academy of Finland funding show deep growth trends within the last years (Figures 1 and 2).

In addition, Finland hosts some 50 AI technology developing companies, and a significantly higher number of companies that apply AI solutions. Since 2017,

[1] https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/160391/TEMrap_47_2017_verkkojulkaisu.pdf (accessed 10.6.2021)

Business Finland has supported over 300 AI companies, and the amount of funding has rapidly increased from 2018 onwards. The AI field is growing rapidly in Finland and globally. In this study, we address the AI-related innovation system from Business Finland's point of view.

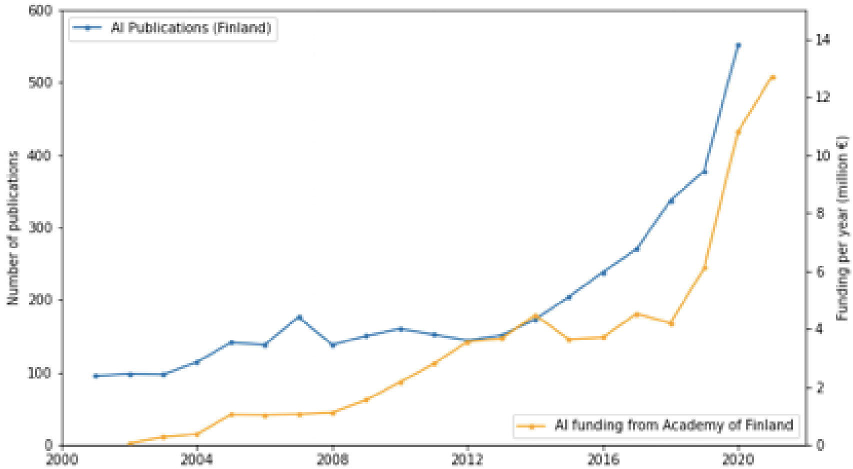

Figure 1: Number of AI publications and amount of Academy of Finland funding

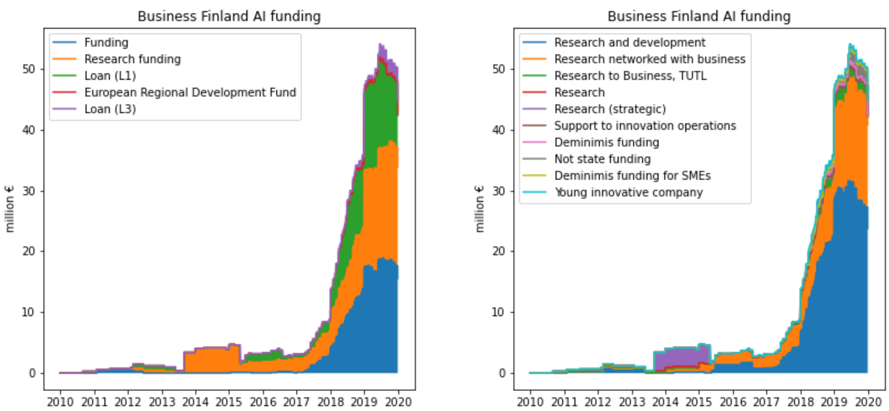

Figure 2: Business Finland funding related to Artificial Intelligence

We have explored the Finnish AI innovation system in two half-day multi-stakeholder virtual workshops. Participants were from different spheres of the innovation system, namely research, policy, funding and industry. In the first workshop, we identified impact mechanisms and actual impacts and obstacles, whereas a second workshop concentrated on discontinuities of the AI innovation system and policy and societal impacts of AI. The model was co-developed internally by the research team based on the qualitative data collected in Howspace tool, and discussions during the workshop.

Results

Within the Technological Innovation System (TIS) approach, multiple reinforcing feedback loops have been identified that are needed for the successful development of new innovations and their uptake in markets and in society. These reinforcing feedback loops are called "motors of innovation" (Suurs, 2009). Activating these motors of innovation requires countering policy resistance and achieving a critical mass of innovation activities of multiple actors. If the innovation system has severe discontinuities, there is a great risk that innovation policy measures never reach their intended potential.

A key finding is that integration of societal needs throughout the R&D&I is critical to direct the targets and outcomes.

Within the Finnish innovation system, there are currently different measures targeting different points in the innovation system. On the one hand, there are instruments for creating required scientific competencies in a specific field, such as AI. On the other hand, there are measures for supporting companies in go-to-market activities. However, between these two types of activities there is a need for innovation system activities that link basic science and the commercial activities of firms. Based on our study, there are currently discontinuities around this area.

Specifically, a key neglected area is the identification of societal needs for AI. A finding from our system dynamics model, which is based on earlier computational modelling studies of the technological innovation system approach (Walrave & Raven, 2016; Raven & Walrave, 2018), is that the level of identified societal needs (for AI) is involved within several key feedback loops in the innovation system that establish the link from basic science to market offerings (Figure 3**Error! Reference source not found.**).

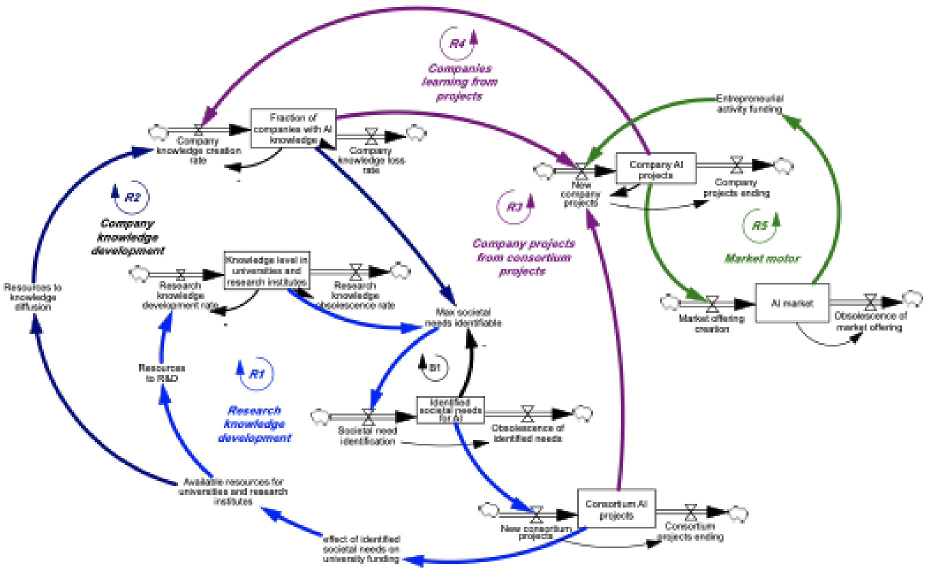

Figure 3: System dynamics model showing key feedback loops in the innovation system

The main feedback loops of the model are the following:

- *Research knowledge development (R1):* Identified societal needs form the basis for consortium projects within a specific area of research. Consortium projects bring funding to research, based on which the knowledge level can increase. This cycle also makes it possible to identify new societal needs.
- *Company knowledge development (R2):* Funding from consortium projects can also be applied for disseminating knowledge to companies and public sector organisations. A better knowledge base in companies provides better opportunities for identifying further societal needs for AI.
- *Company projects from consortium projects (R3):* Consortium projects that involve research organisations and companies can lead to follow-up company projects in which companies develop their offerings further and test them in pilots. These enhance companies' learning, which provides a better basis for identifying more societal needs and opportunities for AI, which can then lead to more consortium projects as well.
- *Companies' learning from projects (R4):* Increased knowledge from company projects can directly lead to new ideas for company pilots and proof of concept (PoC) projects in companies that increase companies' understanding of AI even more.
- *Market motor (R5):* Finally, based on company pilot projects firms are able to create new markets for AI solutions. A clear market demand for AI solutions provides firms more financial resources to launch new development and pilot projects.

Challenges for innovation policy

One of the general challenges to create and show impact is that traditional impact models tend to be overly simplistic and omit important aspects of innovative activities. In reality, successfully reaching impacts requires systemic and complex processes, which can be depicted in the system model approach. The following challenges are seen via a lens of emerging field, here AI, which struggles with enormous knowledge capacity and capabilities' needs as well as need to verify systematic impacts.

1) Challenge in funding instruments to create systemic impact

One of the major discontinuities highlighted by the system dynamics model is a gap in transforming research knowledge, combined with identified social needs for AI-related solutions, to pilots and testing. A reason why this discontinuity exists and hinders optimal innovation development is that current funding instrument(s) are not effective in (a) fostering collaboration between academic and applied research, and (b) between research and AI-companies. In addition, they do not put emphasis on societal targets, like sustainability; instead, the focus in funding instruments and related projects is too directly on business objectives.

The first of these obstacles relates to the challenge typical for an emerging cross-cutting field where the need for knowledge creation and capacity is enormous. The AI-innovation system has research funding, but as the field has urgent basic and applied research needs, both fields tend to focus on their own area because of scarcity in human resources. As a result, true co-creation among research partners does not optimally happen.

The second obstacle strongly relates to a collaboration challenge also, but from a slightly different angle. It was observed that dissemination of know-how from academia to industry, and vice versa, is rigid which shows in identification of societal needs for AI-solutions in academic research, and also in fluent translation of these need-based innovations to piloting and finally to market. Here a lack of fluent dissemination of know-how and tacit knowledge, instead of codified research results, seems to create the most substantial discontinuity.

For example, the identification of societal needs (in R2) helps private enterprise to identify commercial opportunities which then serve as innovation demand pull-factor (in R5). However, a lack of alignment of societal and business objectives creates an unnecessary policy gap.

2) Challenge for innovation indicators to make impact visible

A second challenge is that evaluation of innovations and their performance is dominated by traditional science and technology (S-T) indicators, highly oriented towards the technological aspects and visible to our traditional economic lens. Consequently, performance is usually analyzed in terms of productivity, i.e. as an input-output function. This means the neglect of the “hidden performance” that concerns the societal aspects of innovation impacts: equality, ecological sustainability, and societal well-being for example.

In practice, this bias is reflected in innovation indicators: available data emphasises technical and economic values and analyses the impacts based on the data of R&D intensity, patents, industry standards, number of start-ups, for instance whereas non-technological, societal and systemic values are invisible in the existing data. For example, data available of AI impacts tells about resources (= funding) or direct outputs. Instead, systematic data on AI impacts on broader society or sustainability is missing (to make R1 and R5 operate effectively).

3) Challenge of systemic view to ensure sustainable decision making

A third challenge reflects the challenge in traditional linear view on innovation and emphasises a systemic view which put focus on sustainable nature of innovation, uncertainty of the innovation process, and the close linkage of innovation to collaborative learning. These prevailing thoughts affect not only the theory of innovation but also the innovation related policy and practice: many policy instruments are still founded on the linear model. Recent studies have suggested that both research into innovation policy and the actual policy processes should acknowledge a systems approach. This requirement is operationalized through new kinds of methods and indicators, which strengthen horizontal and systemic approaches and put emphasis on sustainability and impacts in evaluation. Besides, novel approaches to strategic management and evaluation to support transformative change have become a necessity (Schot and Steinmueller, 2018).

In practice, this challenge necessitates new kinds of methods, which orients toward future, are able to capture the dynamic and sustainable nature of innovations, and considers the role of multiple actors in generation and implementation of innovations. Further, evaluation should be seen as supportive mechanism for innovation: evaluation provides an arena for multi-voiced and continuous reflection and increases the ability to respond to the complex societal situations. The system dynamics modelling is important in illustrating the multiple impacts of Business Finland's activities so that resources and policy actions can be targeted to the places in the innovation system with the most benefits.

Proposals for action

- ***Combine multi-criteria and system dynamic approaches in innovation evaluation***: Traditional evaluation methods and measures are not able to capture neither the diversity of innovations in a systemic context nor the multifaceted dimensions of performance resulting from these innovations. In order to contribute to a more purposeful evaluation practices and methods, a new combinatory approach is suggested based on multi-criteria and system dynamic perspectives.
- ***Include sustainability and systemic nature of innovations and industrial renewal in target setting***: As a practical implication in the decision making, the evaluation concepts and criteria should be tuned to perceive the systemic and sustainable nature of innovations and industrial renewal. Also, to understand and make visible the hidden performance of innovations novel indicator development is required. New types of dynamic and systemic indicators to describe complex and non-linear processes in the generation of impacts are required to support management, decision making and direct systemic change.
- ***Increase multi-stakeholder approaches in innovation evaluation to create common understanding of impactful intervention points***: Participatory modelling methods are useful to stimulate learning processes and promote mutual understanding in the context of governance processes (Halbe et al., 2020). In strategy development, long-term systemic effects of different actions need to be

anticipated. The system dynamics modelling should be more widely applied for identifying suitable intervention points as well as potential sources of policy resistance so that ways to overcome these can be designed effectively.

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