

3. Advanced production

Out of the 15 sector strongholds and emerging industries, the advanced production sector has the largest economic footprint. It is notable for its high level of exporting, with nearly half of firms exporting in 2019. Its central strategic position in the Danish economy is also reflected in the Danish Growth Fund's funding priorities. However, evidence from the stakeholder interviews conducted for this report suggests that there are a number of challenges facing start-ups and scale-ups that need to be addressed. This chapter develops policy recommendations for Denmark's advanced production sector. This is informed by an analysis of the key opportunities and barriers for start-ups and scale-ups in the sector, followed by an examination of specific policy initiatives in Austria, Sweden and Canada.

Policy recommendations for Denmark's advanced production sector

- **Develop funding models** that address the long timeframe needed for deep-tech and hardware start-ups and scale-ups to become sustainable businesses.
- **Encourage closer collaboration between advanced production companies and universities.** This should cover inter alia: joint applied research, joint development of products, joint exploitation of intellectual property (IP), students involved with the company, and syllabus development and planning.
- **Increase the representation of start-ups and scale-ups** in the membership, committees and strategy making processes of the Manufacturing Academy of Denmark (MADE) national cluster organisation in order to secure more start-up and scale-up focused projects and initiatives and their inclusion in broader cluster projects.
- **Broker effective relationships between larger firms and start-ups and scale-ups.** The brokerage should focus on matchmaking between large firms and start-ups and scale-ups with complementary competences. The aims should include encouraging large firms to take roles in acting as first customers for start-ups and scale-ups, acting as open innovation partners, offering technology support to reinforce supply chain resilience, and participation in incubator and accelerator activities.
- **Promote a closer and more systematic co-operation between MADE and regional entrepreneurial ecosystem actors,** since spatial proximity better supports start-ups and scale-ups.
- **Provide MADE with longer-term and freer funding on a competitive bidding basis,** accompanied by regular evaluations, to enable it to take more strategic actions for start-ups and scale-ups.
- **Alleviate talent shortages** by working with other clusters and universities, as well as by addressing the lack of diversity in the sector.
- **Strengthen the visibility and branding of entrepreneurial successes** in the sector.

Introduction

The advanced production sector stronghold covers activities in the areas of manufacturing and automation technology. In Denmark, a significant portion of this sector is engaged in the manufacture of machinery. In 2019, 5.6% of businesses in the advanced production sector were scale-ups, making this the sector stronghold with the highest concentration of scale-ups. Despite this relatively strong performance, there exist numerous barriers to the formation and subsequent growth of businesses, which are partially reflected in the low density of start-ups that exist in Denmark's advanced production sector. This section describes the following obstacles that start-ups and scale-ups face in the advanced production sector:

1. Difficulties entering the supply chain
2. The structure of the Manufacturing Academy of Denmark (MADE)
3. The role of large firms
4. The role of regional clusters and ecosystems
5. Long development timescales

6. Access to finance
7. Branding, incubation and acceleration
8. Talent shortages
9. The role of universities
10. Public procurement
11. Testing facilities
12. Lack of diversity

This is followed by an in-depth review of relevant international policy experiences to address such barriers in Austria, Sweden and Canada.

Box 3.1. A promising advanced manufacturing start-up in Denmark – Technicon

A company that has gained a lot from joining MADE is Technicon, which grew from a two-man start-up 7 years ago to having more than 60 employees in 2022. Technicon joined MADE as it could provide very innovative machine solutions but needed a machine builder willing to take some risks and work on things coming out of the research. MADE enabled it to develop such a relationship and build numerous sales in parallel with developing the new product.

Barriers to start-ups and scale-ups

Difficulties in entering the supply chain

In 2019, the advanced production sector had less than a third the number of start-ups as the food and bio resources sector. A particular challenge identified by MADE is that some global manufacturing companies are hesitant about embedding start-ups' technologies into their global production lines. This is due to uncertainty surrounding whether the start-ups are robust enough to reliably deliver products over the longer term. Large firms in the industry should offer technology support to start-ups in an effort to support the integration of start-ups into their supply chains.

The nature of the advanced production sector in Denmark further limits the number of new firms entering the industry. Denmark specialises in machine building. As a consequence, the enterprise base is dominated by established SMEs building machine assembly equipment for the manufacturing industry rather than new start-ups developing disruptive technologies that drive innovation, customised solutions built on standardised and modularised platforms, expanded after-sales/service offerings or circular products and business models. Moreover, without a dominant defence or automotive industry, much work is undertaken in niches.

The structure of MADE

MADE was established in 2014 by a group of advanced manufacturing businesses in conjunction with some eminent universities as a non-profit association in order to encourage major companies to manufacture in Denmark instead of offshoring. These original aims are reflected in the composition of MADE's board, which is weighted towards industry or representatives from large companies. The board has a very small proportion of start-up and SME representatives. This lack of representation inhibits an in-depth understanding within MADE of how the sector as a whole could benefit from the innovation and agility of new and growing firms. MADE intends to boost the representation of SMEs through an anticipated increase in membership numbers and changes to its management structures. These are positive first

steps. However, the fact remains that the purpose of MADE's creation was to support the competitiveness of its members rather than that of the Danish economy as a whole, so it has consequently not had entrepreneurship or start-ups woven into its vision and practices. The limited presence of SMEs, start-ups and scale-ups also limits the potential knowledge spillovers of the intra-cluster knowledge system.

Another issue for MADE is its lack of long-term guaranteed government funding. Currently, only four years government funding is provided for running core cluster activities (promoting stronger cooperation within the cluster and between cluster firms and external organisations, e.g. universities), whereas EU state aid rules permit the basic funding of innovation clusters for up to 10 years. Other activities must be based on project funding as well as membership fees and private finance. These activities include research and development to increase the innovation activities of the cluster's firms and the development and implementation of special programmes to support start-ups and scale-ups. This cluster funding model contrasts to that found in other countries. For example, in Norway and Sweden, cluster organisations can in normal cases be funded for at least ten years. The relatively high reliance on short-term project funding for cluster organisations in Denmark leads to insufficient funding remaining for long-term strategic tasks.

The role of large firms

The importance of large firms in the advanced production sector can create a barrier to the progress of start-ups and, in particular, scale-ups, if large firms prioritise supply chain resilience and determine that innovative collaborations are too risky. MADE is working with other organisations, including universities, through conferences, workshops and mini-projects in order to help start-ups and scale-ups implement new technologies in their own companies. This helps ameliorate some of the risks for both scale-ups and large firms and their supply chains. The collaborations supported by MADE will create bigger and more internationally competitive companies by facilitating technological advancement within established companies and by helping new companies to better integrate into the market.

Culture is another barrier to start-ups and scale-ups in the advanced production sector in Denmark. Most large companies in the sector do not have an investment arm that works to generate spin-off companies or support start-ups. There is therefore a need for a partner organisation to support large firms in their interactions with start-ups and potential spin-outs. MADE is clearly an actor that can do this, although other start-up community actors could also undertake this sort of activity. Whichever organisation is involved they must be one that has a start-up culture of their own.

An issue that has been identified for the sector as a whole is that manufacturers need to adopt a customer-centric mindset and evolve business models to connect products using digitisation (EY, 2022^[1]). As newcomers to the market, start-ups and scale-ups could play a key role in changing the culture within the advanced production sector.

The importance of large firms in the advanced production sector means that collaboration between established firms and recent entrants is key to supporting start-ups and scale-ups. Brokering such collaborations should be an activity that MADE engages in more. Positioning start-ups and scale-ups within the manufacturing value chain is also important. A further issue is sustainability. Large companies will not invest in a new company with an exit strategy in place. Instead, they want long-term commitment to ensure a reliable production line.

The role of regional clusters and regional entrepreneurial ecosystems

Several interviewees emphasised that geographical proximity between stakeholders is especially important in supporting the development of start-ups and scale-ups. A frequently cited example is Odense Robotics, where a close spatial, organisational, and social proximity between industry, universities, municipalities, entrepreneurs and investors has facilitated successful outcomes. There is a role for MADE

in establishing co-operation channels between itself and regional entrepreneurial ecosystems in order to promote innovation, start-ups and scale-ups.

Long development timescales

In the advanced production sector, start-ups and scale-ups typically need 5-7 years before they are able to start to market new products. This is unlike the situation in software, for example. However, those start-ups and scale-ups that do make it to market with the necessary investment potentially represent the future in a rapidly changing sector. Denmark has the ambition of creating more scale-ups in advanced manufacturing and other sectors. However, in the case of advanced manufacturing this requires patient support involving a strong long-term investment capital strategy that fits with the time to market for new products in the sector.

Access to finance

A major barrier to start-ups and scale-ups in the advanced production sector is insufficient access to the large-scale capital resources needed, especially in the deep tech and hardware areas. Indeed, MADE has already identified more stable long term financing as the most pressing need for the sector. Other sources also suggest that both early-stage and later-stage companies in many sectors have trouble accessing loans (TechBBQ and Vaekstfonden, 2019^[2]). The result is that promising and dynamic new firms may cease trading within a relatively short period of time after having failed to attract capital.

A sustainable financial ecosystem is dependent upon collaboration between the ecosystem stakeholders (TechBBQ and Vaekstfonden, 2019^[2]). This is particularly true in the advanced production sector. Collaborations should involve philanthropic funds, such as the Novo Nordisk and Carlsberg Foundations, as well as private investors and larger companies. An example of a funding initiative within the hard tech ecosystem is TechStation Invest, which invests in innovative hard-tech companies with products that are still at the development stage. TechStation Invest expects market launch to be a maximum of 24 months away from the time of investment, with typical investment sizes ranging from DKK 500 000 to DKK 5 million.

Branding, incubation and acceleration

Start-ups and scale-ups need help with branding to give them international visibility. An example of this assistance is the support provided to Technicon by the Foreign Ministry to help the company to export.

Incubation and acceleration support is also typically a key element of start-up and scale-up support. They help address key challenges for start-ups and scale-ups include in the areas of having minimum viable product thinking and discriminating successfully between what is needed and not needed. There are a number of initiatives in place, including the collaboration between MADE and Accelerace on the Beyond Beta programme, which also involves the 13 other national cluster organisations. Another relevant programme is the Technical University of Denmark's Danish Tech Challenge, which supports 20 hardware start-ups each year by providing mentoring, workshops and access to investors. In addition, TechStation is a key technology incubator in Denmark with an associated investment arm, TechStation Invest. Following incubation, TechStation incubatees leave to go to their own premises or to accelerators. However, more incubation and acceleration activity is needed for the advanced production sector, such as guidance, demonstration projects, and development projects, which focus specifically on start-ups and scale-ups through successful incubation and acceleration.

Talent shortages

One of the main challenges for start-ups and scale-ups in the advanced production sector is finding employees, in particular engineers and talented researchers. Denmark has a shortage of the engineers

and other skilled personnel needed to drive growth and innovation within industrial companies (Sorivelle, 2018^[3]). MADE reports that the greatest challenge in this area is finding candidates with technical knowledge of computer science that can then be integrated into manufacturing. Moreover, knowledge and skills in the field of robotics are needed to take on evolving technologies. These skills are also in high demand internationally.

The role of universities

Linking to the skills shortages identified above, some of the stakeholders interviewed have suggested that there is scope for universities and university colleges to create further programmes that develop skills that are more aligned with the needs of the advanced production sector.

Some larger companies engage with universities over PhD students, but this practice is limited among SMEs. MADE's educational track is currently working with universities, university colleges and vocational training schools to develop more technicians and graduates. This programme could be expanded to involve SMEs, creating groups of players that work on a topic and develop solutions. This would enable the businesses to become more embedded within the ecosystem.

Danish universities also provide more direct assistance to start-ups and scale-ups. For example, the Technical University of Denmark (DTU) supports start-ups and scale-ups in advanced manufacturing. During the product development phase, DTU helps with approvals, and after businesses have made it to market, it provides assistance in creating after sales service and well-functioning logistics chains. TechStation Invest has a close collaboration with DTU on start-up projects.

In several stakeholder interviews, it was suggested that universities need to be more flexible on intellectual property issues and should provide reasonable access to research for firms of all sizes.

Public procurement and testing and regulation

The European Commission has identified Denmark as a good performer with respect to its public procurement for innovation (PPI) system (European Commission and PWC, 2021^[4]). Denmark's PPI system dates back to 2011, when grants were introduced to public procurers in the municipalities and regions to cover expenses associated with PPI, including market analysis, legal advice and the development of tender materials (Danish Business Authority, 2019^[5]). Between 2011 and 2015, 23 projects were funded under this grant scheme (the initiative ended in 2015). Between 2014 and 2019, Denmark operated a pre-commercial procurement of innovation scheme, which funded feasibility studies and prototype development. Meanwhile, the Innovation Partnerships scheme between 2017 and 2019, which was made possible by the Danish Public Procurement Act in 2016, involved the incorporation of development and procurement into a single contract.

Since 2015, a platform for ideas competition (challenges.dk) has been in place, which has raised awareness of better procurement practices and solutions and has stimulated new markets. However, a number of weaknesses were consistently identified in the stakeholder interviews regarding public procurement. Among these were the difficulty for new and small firms to get onto the approved list of suppliers to government agencies. At least one business has consciously avoided becoming a supplier to government because they feel that the process is too slow and too difficult. These difficulties are partly inherited from EU procedures, although some are also local to Denmark. The interviews suggested that new and small firms are not getting sufficiently involved because procurements are often large and complex for them, leading to work and risks not worth taking. Suggestions for responding to these problems include (not mutually exclusive):

- Effective brokerage to enable SMEs to become involved in a consortium to have access to smaller and more manageable contracts.

- Separately identified procurement of innovative components / finer granularity in general.
- Pre-tender expressions of interest.
- Support through the process for SMEs.
- Improved overview and information on the procurement processes.

Start-ups and scale-ups do not always have good knowledge of the testing facilities available to them. A mapping exercise has therefore been launched to show where piloting and testing facilities are available for start-ups and scale-ups in the advanced production sector. A digital tool provides an overview of the test facilities.¹

Lack of diversity

The advanced production sector has a very low representation of female university graduates and of women in general within the workforce. This lack of diversity contributes to talent shortages and also narrows the range of different perspectives on innovation and entrepreneurship in the sector.

International policy experiences

Austria – Plattform Industrie 4.0²

Overview

Austria has a strong focus on advanced production. In 2020, Austria's manufacturing industry accounted for 18% of GDP (International Trade Administration, 2021^[6]). The industry includes a number of multinational manufacturing firms, although the majority of Austrian firms are small to medium sized businesses with an average of 100 employees. In order for Austrian industry to become more internationally competitive and develop a brand, many companies need to increase their productivity by adopting cutting-edge innovative technologies. Industry 4.0 advanced manufacturing solutions are critically important to this effort.³

This section will examine the actions taken by Plattform Industrie 4.0 to help start-ups and scale-ups to adopt Industry 4.0 manufacturing solutions. It is particularly interesting as an example of support to start-ups and scale-ups in the hardware sector and is of relevance to the advanced production sector in Denmark.

Plattform Industrie 4.0 was established in 2015 as a membership-based non-profit organisation by the Federal Ministry for Transport, Innovation and Technology, the Association for the Electrical and Electronics Industries, the Association of Metaltechnology Industries, the Austrian Federal Chamber of Labour, the Austrian Trade Union for Production Workers and the Federation of Austrian Industries. Membership is open to companies, academic institutions, research organisations, NGOs and other institutions that are Industry 4.0 leaders in Austria. The core mandate of the platform is to facilitate the implementation of Industry 4.0 and to foster collaboration among relevant stakeholders with the aim of creating an innovative industrial production sector and boosting high-quality employment. The organisation considers technological innovation, new business models, knowledge transfer and the widespread deployment and implementation of digital technologies to be the key drivers of Industry 4.0.

The approach of the platform is to bring all stakeholders together to jointly address the challenges and opportunities of Industry 4.0 in an inclusive manner, in order to realise benefits for all parts of the industrial value chain. To do this, it connects relevant suppliers, research institutions, networks, social partners and interest groups from different policy areas and industrial sectors. Plattform Industrie 4.0 has nine thematic expert groups, which work in defined subject areas and consist of experts from their respective fields. The

groups aim for a balance between experts with scientific experience and those with practical and operational experience. Around 500 experts are involved in the work, with the outputs including roadmaps, guidelines, strategies, analytical documents, workshops and events.

Issue 1: Working groups with a focus on support for start-ups and scale-ups

Plattform Industrie 4.0's expert group on security and safety focuses on IT and data security and aims to provide hands-on expertise and best practice use cases for SMEs, including start-ups and scale-ups. Meanwhile, the expert group on pilot factories seeks to create a real and neutral testing and research environment in which development and testing can take place without disrupting ongoing production. This environment is open to both partner and non-partner companies. Research infrastructure, smart production labs and pilot factories are regarded as an important means of addressing challenges faced by SMEs in relation to the digital transformation. For instance, pilot factories facilitate the joint development of new products and processes and act as a test facility for complex and modern manufacturing systems. They are also a focal point for interdisciplinary research (e.g. mechanical engineering, mechatronics, electrical engineering, computer science, ergonomics) and provide an environment for training, further education and industry-related learning.

Issue 2: Qualifications and competences for Industry 4.0

Plattform Industrie 4.0's expert group on qualifications and competencies involves representatives of all founding members, as well as educational institutions, research institutions, policy makers, administrators, companies and interest groups. It acts as a central steering committee to focus on the content alignment of the activities of Plattform Industrie 4.0. The objective of the expert group is to support young people, companies and education and training providers in developing their skills and qualification programmes in a way that proactively exploits the opportunities offered by Industry 4.0 and digitalisation. The focus is:

- Qualification and competence requirements for Industry 4.0;
- Digital infrastructure in education and training and the digital skills of teachers;
- Recognition of non-formally and informally acquired competences.

Issue 3: Co-operation between Plattform Industrie 4.0 and the mechatronics cluster to roll-out the Austrian Industry Maturity Model

The Austrian Industry Maturity Model, developed by the Mechatronics Cluster of Upper Austria and the University of Applied Sciences Upper Austria, evaluates the readiness of firms for digitisation. In order to support businesses of all sizes and to promote Industry 4.0, Plattform Industrie 4.0 has launched a joint initiative with the Mechatronics Cluster of Upper Austria and the University of Applied Sciences Upper Austria. The initiative aims to promote the nationwide roll-out of the Industry Maturity Model. At the regional level, the Plattform Industrie 4.0 has sought to involve all of the regional business agencies.

Issue 4: Sources of funding

Plattform Industrie 4.0 is funded through a combination of membership fees and basic seed funding provided by the six founding members. Membership fees are charged annually with a three-tier subscription model. Large companies located in Austria with more than 1 000 employees contribute an annual fee of EUR 7 500. Smaller companies, research institutions and trade unions pay EUR 5 000. Businesses that fall under the start-up scheme make an annual contribution of just EUR 750.

Plattform Industrie 4.0's annual budget amounts to approximately EUR 600 000. These funds are used to cover the operational costs of the activities of the platform itself. Other sources of funding are used for any Industry 4.0 related activities. These could include, for instance, setting up a training scheme in a region, funding a relevant R&D activity or commissioning a study.

Issue 5: Added value of the platform

Having an organisation that oversees major developments in Austria at both a national and regional level and combines this knowledge with international trends delivers significant additional value to members and stakeholders. This is especially the case for SMEs, which may not have the capacity to conduct these activities independently. This information is developed in the expert groups. Several research collaborations have been started between companies and research organisations as a result of the platform.

Lessons for Denmark

A national organisation that oversees major developments in Industry 4.0 technologies, with good connections to regional innovation and entrepreneurial ecosystems and a special focus on the needs of SMEs, start-ups and scale-ups in the advanced production sector, is of great importance in promoting and accelerating innovation and technological development. This is necessary to maintain and increase international competitiveness. The national cluster for advanced production, MADE, could take on a similar co-ordinating and monitoring role in Denmark.

Of special importance to start-ups and scale-ups is the establishment of a pilot factory to create a real and neutral testing and research environment for the development and testing of new products and processes. This is because access to such facilities appears to be a limited resource for small firms.

SMEs, including start-ups and scale-ups, in the advanced production sector can face considerable obstacles to digitisation. The launch of the Austrian Industry Maturity Model to evaluate the digitisation readiness of firms is therefore of particular relevance to these businesses.

Recommendations for Denmark based on the Austrian case

- MADE could take on a co-ordinating and monitoring role in the area of Industry 4.0, overseeing major developments with a focus on the needs of start-ups, scale-ups and SMEs.
- Evaluate the need for establishing thematic groups within MADE that bring together experts with a combination of research knowledge and practical and operational experience.
- Establish a pilot factory to create testing facilities and for the development of new products and processes. This is especially important for start-ups and scale-ups. This could be carried out as a co-operative initiative between MADE and DTU.
- Launch a Danish Industry Maturity Model to evaluate the digitisation readiness of firms. This could be organised by MADE in co-operation with one of the technical universities.

Sweden – Robotdalen (Robot Valley) and Automation Region

Overview

Sweden is one of the most innovative countries in Europe, ranking second in the World Intellectual Property Organization's 2021 edition of the Global Innovation Index. The advanced production sector is one of Sweden's strongest sectors, with world leading companies such as ABB, Atlas Copco, Volvo and Scania. All of these companies are either mainly located or have a strong presence in the East Central Sweden region, which is composed of five counties around Stockholm. The region is classified as an innovation leader in the EU's Regional Innovation Scoreboard. Several of the region's universities have science parks, incubators and test beds. Examples include the Linköping Science Park, which runs the largest incubator in Sweden, and the Ängen test bed in Örebro Science Park. Other science parks exist in cities closely connected to local industry, such as the Robot Application Center (RAC) in Munktell Science Park in

Eskilstuna and the Automation Center in Västerås. These areas are associated with very vibrant start-up and scale-up ecosystems.

The “Vinnväxt – Regional Growth through Dynamic Innovation Systems” programme aims to contribute to Swedish innovation capacity by supporting the emergence of internationally competitive research and innovation environments in specific high value creation growth areas within regions. Robotdalen and Automation Region are two Vinnväxt clusters funded by Vinnova, the Swedish National Innovation Agency. Vinnova provided the two clusters with funds of up to EUR 1 million per year for 10 years, extendable to 16 years with tapered annual funding. Regional partners are required to provide matching funding. Thus the funding for each cluster amounts to EUR 1 million from Vinnova and 1 million from regional triple helix stakeholders. Long-term funding from Vinnova facilitates strategic and long-term planning for the cluster and its participating firms’ innovative development. It also supports closer co-operation between the cluster firms and regional universities and helps with securing a strong national and international branding and presence. The funding is accompanied by regular evaluations to verify that the clusters fulfil the goals set out in their funding bids. If not the funding for the cluster from Vinnova is terminated.

Robotdalen

Robotdalen belongs to the first generation of Vinnväxt cluster. It was established in 2003 and was funded up until 2016. Since the termination of national funding, Robotdalen has continued its activities through two different organisations. One belongs to Mälardalen University (MDH) and the other is owned by the four regional co-funders all located in the East Central Sweden Region. The overall strategy for the ‘new’ Robotdalen is to exploit the resources, networks and competencies that have been created to strengthen support for the commercialisation of new products through start-ups and scale-ups. By bringing together industry, academia and the public sector, the organisation has developed, implemented and commercialised robotics solutions for an array of applications. It has also built a strong network of key players that has an active role in realising Robotdalen’s vision of becoming an internationally acclaimed innovation environment that enables the commercial success of new robot solutions.

Issue 1: Longstanding commitment to start-ups and scale-ups

Since its inception, Robotdalen has placed an emphasis on new enterprise creation and has supported innovators, start-ups and scale-ups in bringing ideas to market through prototyping and product development processes. This is carried out in co-operation with incubators that target start-ups and scale-ups seeking to transition from an idea to commercialisation. Robotdalen estimates that 20 new products and 19 new companies were created during its first ten years.

Issue 2: Role of large firms

Large firms have been fundamentally important for Robotdalen for a number of reasons. Firstly, they connect the region to the global market. Secondly, they can provide markets for start-ups and scale-ups. Finally, collaborations between small and large firms promoted by Robotdalen strengthens the innovative capacity of large firms and provides small firms, start-ups and scale-ups with crucial market channels.

Issue 3: Funding and infrastructure

Robotdalen supports SMEs, start-ups and scale-ups in finding relevant sources of funding, including for the fast commercialisation of innovations. Through its network and partners, businesses can also access support in developing prototypes and accessing universities, customers and incubators. The approach includes joint pilot and test environments, facilities and infrastructure, where partners can produce and test their first prototypes. Robotdalen has two test centres for the development of robot applications.

Automation Region

Automation Region is an innovation platform where SMEs, large corporations, academia and the public sector collaborate on interdisciplinary projects. It seeks to market Swedish automation expertise, stimulate innovations and secure the industry's long-term skills provision by facilitating collaboration, networking, inspiration and skills development. It was established in 2016 and is one of the latest Vinnväxt clusters. It is financed by funds from the EU, the Swedish Agency for Economic and Regional Growth, Vinnova and various regional actors. Mälardalen University (MDH), with leading research in areas such as embedded systems and future energy systems, is the host organisation for Automation Region.

Automation Region has 150 member organisations, including both small firms and large firms, which are the cornerstone of its business engagement. However, activities and events are open and inclusive and provide a means of expanding the membership base further. The presence of world leading firms such as ABB and Siemens is equally important as the involvement of smaller innovative firms. MDH's role as the host organisation means that academia has been closely engaged. Automation Region has also taken the strategically important and successful decision to actively tap into the broad academic knowledge base outside the immediate region by involving Chalmers University of Technology in Gothenburg, Luleå University of Technology, Umeå University and Linköping University. This enables academic collaboration between the institutions, prevents unnecessary duplication and utilises available expertise.

The Automation Region Research Academy (ARRAY) is a recent initiative that enjoys the active support of the Swedish Knowledge Foundation (KK), MDH and several industrial partners (ABB, Volvo CE, Skanska, Sandvik and First Control Systems). Regional stakeholders have shown themselves to be engaged with the Automation Region and its vision. This is demonstrated by the variety of partners that support the accelerator Synerleap, which brings start-ups and ABB together for access to ABB's network, clients and technology. The aim is to help start-ups accelerate and expand into global markets, with support from ABB. Other important elements of the regional ecosystem include:

- CREATE, a business incubator in Mälardalen. CREATE is associated with Expectrum, which is a hub for the diffusion of knowledge of technology to a broad group of stakeholders ranging from secondary school pupils and teachers to firms and organisations.
- SICS/RISE, a large national applied research organisation in Sweden.

Automation Region intends to develop its role as a system integrator. This entails having a good understanding of how the regional innovation system works and where the bottlenecks and drivers exist. It also involves expanding the network of large firms and connecting these world-class players, as well as research institutions, with start-ups, scale-ups and SMEs.

Issue 1: Practical support for start-ups and scale-ups

Activities organised by Automation Region include breakfast meetings and seminars to increase knowledge of technology and market trends, as well as workshops for advanced learning in selected areas. There are also opportunities for businesses to find new collaborations with the private, academic and public sectors. Through the Automation Expo – a miniature trade fair hosted by one of the members or another relevant company – businesses have the chance to present their products and services in a time and cost-efficient way.

Issue 2: Support from national government for infrastructure

Vinnova encourages and supports small companies by providing infrastructure such as incubation offices, test centres and verification resources. It finances structures that make it easier for start-ups to execute their ideas, test their products, identify and connect with potential customers, join networks and form relationships. Generally, all innovative start-ups can get support from Vinnova either directly or via the

excellent incubator programme, which will support 20 incubators in Sweden with a total of SEK 350 million during the four-year period between 2021 and 2025. In addition to financial support, the incubators receive a special quality stamp from Vinnova, which is important in helping them to obtain funding from other sources. Gender equality and sustainability have become priority development areas for the incubators.

Issue 3: The role of Ignite Sweden

Ignite Sweden works as a national network for local and regional ecosystems, comprising incubators, science parks, Vinnväxt clusters and other initiatives funded by Vinnova such as its strategic innovation programmes. It is co-ordinated by Swedish Incubators and Science Parks (SISP) and was developed and established by a number of incubators (Minc, Malmö, LEAD, Linköping, Sting, Stockholm, Things, Stockholm and Uminova Innovation, Umeå). Kista Science City and Sahlgrenska Science Park have also recently joined as lead incubators. It also collaborates closely with Automation Region. Ignite Sweden is co-funded by Vinnova and the Swedish Energy Agency.

The aim of Ignite Sweden is to connect large companies with start-ups and scale-ups as first customers. Since 2017, Ignite Sweden has connected 761 start-ups with 243 corporates, resulting in 4 087 meetings and, most importantly, more than 230 commercial collaborations. The funding from Vinnova means that Ignite Sweden's services can be free to use for start-ups, while large companies and the public sector must pay. Ignite Sweden focuses especially on the automation, automotive and energy sectors. Generally, it is very important to engage deep tech start-ups with customers from as early a point as possible. This is because of the large amount of time (10 years or more) needed to develop new products and processes, with this process involving both engineering and manufacturing. Thus, it is important to find as many commercial collaborations as possible. The aim is to find 1-5 customers for each start-up. It is an important signal for a start-up is obtaining a well-known company such as Volvo or ABB as a first customer, as this makes it easier for the start-up to find funding and new customers, both domestically and internationally.

Start-ups within the energy sector focusing on the green transition and sustainability enjoy extra funding opportunities from the Swedish Energy Agency, which invests in early phase start-ups, and from ALMA, Sweden's most active early stage investor, whose green tech investment fund is backing Swedish early stage start-ups that significantly reduce greenhouse gas emissions. ALMA has EUR 65 million under management.

Ignite Sweden has started using functional public procurement for innovation (PPI) in its collaboration with the public sector. Both Ignite Sweden and public sector agencies are still involved in a learning process, but Ignite Sweden sees great opportunities to develop functional PPI into an important policy measure for finding first customers in the public sector for start-ups coming up with innovative and sustainable solutions to solving societal challenges.

Lessons for Denmark

The long-term and generous funding from Vinnova to clusters such as Robotdalen and Automation Region pays dividends. Regular evaluations by international researchers are taking place, to identify whether the clusters fulfil and live up to their development plans. The professor's privilege and absence of intellectual property rights for the universities make the co-operation between universities and industry easy and smooth, and also leads to more academics initiating start-ups, often in incubators run by universities.

Long-term funding gives the clusters the opportunity to carry out strategic planning on how to promote the innovativeness and competitiveness of the clusters and their participating firms. This is significant in enabling strong engagement with start-ups and scale-ups, especially in deep tech sectors, which have a longer time horizon for their innovation journey than software sectors.

As part of supporting start-ups and scale-ups, the cluster organisations systematically work to connect start-ups and scale-ups with large companies as first customers and channels to international markets.

This focused and systematic work is in addition to that which large companies themselves are doing. It offers a key rationale for why the Swedish start-up scene has become one of the strongest in Europe.

The experience of Ignite Sweden also provides some important potential lessons for Denmark. It is an example of a very successful national network initiative, co-ordinated by Swedish incubators and science parks, to connect large companies and the public sector with start-ups and scale-ups as first customers. It is noteworthy that the focus of Ignite Sweden is on deep tech sectors such as advanced production and energy, where patient, knowledgeable and internationally-oriented companies often play an important role as first customers for start-ups and scale-ups.

Recommendations for Denmark based on the Swedish case

- MADE should focus more on new firm formation and supporting innovators. Of vital importance is taking ideas to market via prototyping and product development processes. This includes working with regional incubators and accelerators that help start-ups and scale-ups through the commercialisation process. Longer-term funding of the cluster could be instrumental in achieving these goals. An incentive to the cluster organisations to work with start-ups could be provided by making start-up support a criteria for evaluation of cluster organisation success in delivering on their public funded mandate.
- Evaluate the idea of establishing a Danish Ignite to encourage large firms to work with start-ups and scale-ups. This would strengthen the capacity of both large and small firms to innovate. In particular the organisation could broker connections leading to large firms acting as first customers and channels to international markets for start-ups and scale-ups. Such an organisation could be established by a collaboration between MADE and regional clusters.
- Provide cluster organisations with long-term funding, which enables them to take on strategic actions and contribute more to building national and regional entrepreneurial ecosystems. Long-term funding must be accompanied by regular evaluations to see whether the cluster is fulfilling the goals that were set out when the original competitive funding was awarded, using performance indicators supplied by government.
- Infrastructure and funding are essential for the scaling up process, particularly for joint large and small firms' test and pilot environments and facilities.
- Host networking events, for example breakfast meetings, to encourage interactions within and between national and regional entrepreneurial ecosystems.

Advanced Manufacturing Supercluster, Canada

Overview

The Innovation Superclusters Initiative (ISI) programme, launched in 2018 as part of the Innovation and Skills Plan from 2015, is a policy initiative introduced by the Canadian federal government. It has been designed and implemented as a policy to support innovation and growth among promising clusters and industries. The ISI has a budget of CAD 950 million from the government and matching funding from the private sector, universities and other levels of government (the triple helix partners) in the regions. The aims are to bridge the gaps between science and commercialisation and provide support for start-ups and scale-ups. By fostering partnerships between businesses and research, educational and financial institutions, the ISI seeks to encourage the development of skills needed by industry and create opportunities for growth and innovation. These partnerships are also designed to facilitate technology transfer and the application of new ideas in the marketplace. The heart of the approach is building the right kind of partnerships across supply chains that lead to new efficiencies and mutual economic benefits for both large and small firms.

A central challenge is that relatively few companies scale into globally-competitive companies operating at the cutting edge of innovation. Helping researchers to commercialise their discoveries and supporting entrepreneurs, in particular women and indigenous people, in attracting investment are key in enabling businesses to start up, scale up and become globally competitive. Certain sectors, such as clean technology and other hardware or deep tech sectors, face particular difficulties in finding sufficient late-stage and patient capital. Canada needs a clear path to growing more companies by focusing on capital markets, participating in emerging markets, and providing incentives for Canadian companies to expand and have a long-term presence in Canada.

The activities of the superclusters are centred around four key strategic priorities:

- Attracting cutting-edge research, investment, and talent;
- Increasing R&D and technological activities;
- Supporting entrepreneurship and commercialisation of new products, processes, and services with the objective of scaling up existing firms, and;
- Fostering a critical mass of firms and strengthening collaboration between private, academic, and public sector organisations.

One such supercluster is the Ontario-based Advanced Manufacturing Supercluster (AMS), which seeks to build up next-generation manufacturing capabilities, incorporating technologies such as advanced robotics, additive manufacturing, the internet of things, machine learning and cybersecurity. AMS promotes the adoption and integration of all aspects of advanced manufacturing. In 2018, the not-for-profit organisation Next Generation Manufacturing Canada (NGen) was awarded CAD 230 million from the federal government to manage the AMS. It received an additional CAD 20 million in federal funding in 2021. At the end of December 2021, NGen had 4 500 members including 1 000 researchers and other industry experts. A third of its members are based outside Ontario. NGen has approved CAD 234 million of funding for 167 projects that are worth a total of CAD 605 million, leveraging CAD 317 million in additional industry investments. Its 167 projects involve 579 project partners, which include 207 research teams from colleges, universities and other research centres, and 372 companies, of which 328 are small companies. 40% of project partners funded by NGen come from outside Ontario, and one quarter of the projects are interregional.

The supercluster works with innovation centres and industry organisations across Canada's manufacturing industry. To develop the ecosystem, NGEN has recently recruited members (no fee) and provided funding for developing advanced manufacturing regional and technological clusters across the country. There are now 17 advanced manufacturing clusters in Canada. There are quarterly meetings between the supercluster and the regional and technological clusters it supports. The supercluster uses a syndicated leverage approach, acting with other funders.

All projects need to integrate technology into manufacturing, which implies that all technology firms involved in cluster projects need to have a manufacturing partner and projects need to have an approval from a manufacturing expert.

Issue 1: Gaps in the ecosystem

The AMS has a high proportion of tech start-ups and a strong ecosystem but there remain important tasks that are needed to fill gaps in the ecosystem. There is a funding gap, especially for scale-ups, since developing devices for manufacturing takes a longer time than, for example, software solutions. This means that funding from NGen must address gaps in innovation financing. This includes providing later stage funding for pilot development and feasibility evaluation and the testing of new manufacturing applications.

Issue 2: Building consortiums involving large and small firms

A focus of NGen is involving small firms in the development of manufacturing applications. For companies to receive financial support from the supercluster, their projects have to be collaborative and involve at least one small company and potentially also educational institutions. Research, technological development and manufacturing are required to be brought together and integrated into a manufacturing solution. Part of the challenge has been finding out how to integrate the start-ups into applications that deliver broader economic value. The rationale for the strategy of embedding start-ups into collaborations on manufacturing applications is the potential for SMEs to be part of an integrated approach to delivering unique solutions for manufacturing.

In practice, this means that collaborations require bringing together firms with expertise in different technologies. AMS actively seeks out SMEs with the potential to develop applications and manages their development through its small business management project. A lot of work is conducted up front in matchmaking and identifying and assessing the capabilities of the partners in the project itself. During this process, it is important to take on board the expectations of the manufacturing firms. A unique aspect of the initiative is the independent project selection process, which involves an assessment by a panel of experts. This ensures that the projects are industry driven and approved by industry experts. NGen also works with the project team to help them to commercialise the technology.

All of the projects involve a variety of technologies. A criticism has been made about a lack of targeting of one area of technology or one area of manufacturing. The strategy is, however, that in order to develop a solution for manufacturing, a number of different technologies need to be involved, with tech companies working together to develop a unique solution that may then be commercialised in a variety of manufacturing applications.

To make consortiums involving large and small firms work effectively, upfront collaboration agreements between partners are important. These collaboration agreements have to specify the project team, which ensures that the people on the project can deliver the intended outcomes, as well as IP sharing arrangements. The project consortium receives funding from NGen when collaboration agreements are concluded. The participating companies take joint responsibility for carrying out the project. If there is a major change in the team, then the contract is renegotiated. All projects are evaluated by independent industry and technical experts.

Small firms are generally happy with the model but receiving buy-in from large firms, which is a necessary pre-requisite for project approval, can be more challenging. An important guiding principle for creating a consortium is not to involve competing businesses. Another is to bring in small companies and start-ups that provide unique competencies and/or technologies. The large manufacturing company in the collaboration does not usually want to buy the small firms, but may wish to license the technology. NGen supports projects that attempt to develop integrated solutions on the basis of a meaningful collaboration between project partners. This provides the smaller firms with an opportunity that they would not otherwise have had on their own as well as a chance to involve partners in developing IP arising from their project further down the line. Each company can develop its own IP, alongside owning the IP of the project.

Collaboration with the universities is problematic because each has its own strategy for IP ownership. For this reason, collaborations work better between the companies. NGen has an IP manager who works with all teams to help them understand the value of the IP and how to manage its commercialisation. The main types of IP involved are industry secrets, trade secrets, knowledge, skill sets and patents.

Issue 3: The role of Innovation Solutions Canada – public procurement of innovation and governmental challenges

NGen is mainly focused on commercial applications in manufacturing. There is a procurement challenge in Canada's public sector, which does not always see procurement priorities through the lens of

supporting Canadian innovation and scale-up. PPI to address governmental challenges such as climate change is an important instrument for supporting start-ups and scale-ups. To date, 3% of the government's budget for environmental technology is aimed at start-ups. The public sector is not yet consistently bringing together the right companies. The supercluster model may be a highly effective way of meeting these challenges.

Innovative Solutions Canada (ISC) is a procurement programme, which aims to direct government procurement towards innovators and entrepreneurs. It is modelled on the US Small Business Innovation Research (SBIR) programme. It positions the federal government as a first customer, issuing specific challenges and looking for proposed solutions. The programme supports the development of early-stage, pre-commercial innovations with the potential for global commercialisation. The challenges are designed around solutions and desired outcomes, rather than known products or process specifications. This is referred to as functional public procurement of innovation (PPI). ISC also helps Canadian firms generate and leverage new intellectual property. Another objective is to encourage procurement from companies led by people from underrepresented groups, such as women, Indigenous people, youth, disabled individuals, LGBTQ+ people etc.

Issue 4: Evaluation

Continuous evaluation is key to the success of the AMS. NGen monitors the projects it funds and contractually has quarterly meetings with the project teams where financial claims are reviewed and progress is discussed. These meetings with project teams allow NGen to evaluate how to further help the projects to commercialise, for instance by identifying whether there are other companies that can be brought in or whether there are other types of funding support that can be leveraged. When projects close within a 5 year timeframe, the project team is required to report their sales and employment data to NGen, as well as outcomes with respect to other economic, workforce, social, and environmental impacts.

At the end of December 2021, 39 of 167 projects were closed, involving NGen investments of approximately CAD 45 million. As a result of sales of products, IP and licensing, the projects had generated CAD 1.85 billion in sales, representing a forty-fold economic return on investment. NGen monitors many indicators including sales, IP, licensing, the number of jobs in projects and the number of students in projects.

Issue 5: Larger firms' concerns about working with small firms

One of the biggest challenges in working with the large companies is that they do not necessarily want to share their IP. This is addressed by undertaking financial due diligence of small firms, getting to know the firms and helping them develop stronger management capabilities. It also involves working with the large manufacturing companies to encourage them work with the small technology companies as meaningful partners in the development of solutions as part of an open innovation partnership. In many cases, this depends on re-engineering the product to simplify supply chains to reduce the risk. However, some large companies see the partnership as merely buying and selling technology and as a consequence fail to have their projects approved for supercluster funding.

Issue 6: Skills shortages

The skills required in the sector are evolving, including a growing need for more digital understanding. To learn more about this issue, AMS, in partnership with Statistics Canada, conducted a survey of 6 000 manufacturers. Most surveyed firms said that they did not achieve business objectives from their investments in technology because they lacked the skills required to run the technologies productively. To help deal with this management challenge, the cluster has a transformation leadership programme. This can provide a roadmap that advises companies on how they can ask the right questions, add value and find opportunities for improvements in their technology solutions and processes and skill sets. This is

important for smaller companies, which often have a limited idea of their skill requirements in 5 years' time and do not know how to find this out.

Issue 7: Supporting inclusive entrepreneurship objectives

Equality, diversity and inclusion are a major part of AMS' focus and a key part of the organisation's programming. The 16-person board has nine women and is chaired by a senior female manufacturing leader. The organisation is diverse at the top and is investing in a number of equality, diversity and inclusion initiatives, particularly on the workforce development side. For example, a number of initiatives support entrepreneurship education for black youth and for indigenous youth.

Lessons for Denmark

- The majority of NGEN's members are smaller firms. The cluster has a strong focus on supporting smaller firms, including start-ups and scale-ups. All projects must have smaller firms as partners.
- Identifying how start-ups and scale-ups can deliver unique solutions fosters engagement of these firms in working with manufacturing applications.
- Collaboration agreements must be signed upfront before they receive funding. This is important because the expectations and the whole nature of the partnership need to be made explicit, including IP sharing arrangements. It is also vital that the project teams have the right people to deliver the intended project outcomes. The supercluster has an IP manager working with the project teams.
- Adopting a hands-on approach by working with companies to help them identify what they need in projects, IP, or training is important. Also key is talking to tech and manufacturing companies on the topic of current and future challenges.
- The supercluster works in a systematic way to support regional and technological clusters across Canada.
- Adopting an organisation-wide ethic of equality, diversity and inclusion.

Recommendations for Denmark based on the Canadian case

- Ensure that all cluster projects have smaller firms as partners.
- Initiate a programme for qualifying smaller firms that helps them to adopt advanced technologies and develop managerial capabilities.
- Assist in providing funding for later-stage scale-ups engaged in building new manufacturing applications.
- Establish an IP manager in MADE that works with project teams.
- Establish a systematic strategy for organising collaboration between the national cluster and regional science parks, incubators and accelerators to develop the entrepreneurial ecosystem.
- Adopt a similar national public procurement programme to ISC, which in turn is based on the US's very successful SBIR programme. It has the advantage of supporting early-stage companies to meeting challenges around solutions and desired outcomes and encourage diverse and inclusive innovation and entrepreneurship.

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Notes

¹ See [Digitalt værktøj: Danske Testfaciliteter | Virksomhedsguiden](#) (in Danish).

² A key source for this section is Boog et al., 2019[18]

³ Industry 4.0 refers to the fourth revolution that has taken place in the manufacturing sector, characterised by automation and smart, autonomous systems and facilitated by data and machine learning.



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