Project EASME/COSME/2014/014

An analysis of drivers, barriers and readiness factors of EU companies for adopting advanced manufacturing products and technologies

Deliverable 3 (based on Work Package 2):

Drivers and Barriers of EU Companies for adopting Advanced Manufacturing Technologies

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Main acronyms used in the report

3D	Three Dimensional
ACTPHAST	Access Centre for Photonics Innovation Solutions and Technology Support
AMT	Advanced Manufacturing Technologies
B2B	Business-To-Business
CAD	Computer-Aided Design
CAM	Computer-Aided Manufacturing
CECIMO	European Association of the Machine Tool Industries
CEO	Chief Executive Officer
CNC	Computer Numeric Control
COSME	Competitiveness of Small and Medium-sized Enterprises
DIY	Do It Yourself
EEN	Enterprise Europe Network
EFFRA	European Factories of the Future Research Association
EU	European Union
Fab Lab	Fabrication Laboratory
GPRS	General Packet Radio Service
HR	Human Resources
ICT	Information and Communication Technology
IP	Intellectual Property
KET	Key Enabling Technology
LED	Light-Emitting Diode
NACE	Nomenclature statistique des Activités économiques dans la Communauté Européenne
OEM	Original Equipment Manufacturer
PBS	Progression-Based System
PCB	Printed Circuit Board
PLC	Product Life Cycle
PLM	Product Life Cycle Management
R&D	Research and Development
RoHS	Restriction of Hazardous Substances Directive
SAP	Systemanalyse und Programmentwicklung
SBIR	Small Business Innovation Research Programme (US)
SBRI	Small Business Research Initiative (UK)
Sirris	Collective centre for innovation in the technological industry
SME	Small and Medium-sized Enterprise
TRL	Technology Readiness Level
VAT	Value Added Tax
VR	Virtual Reality

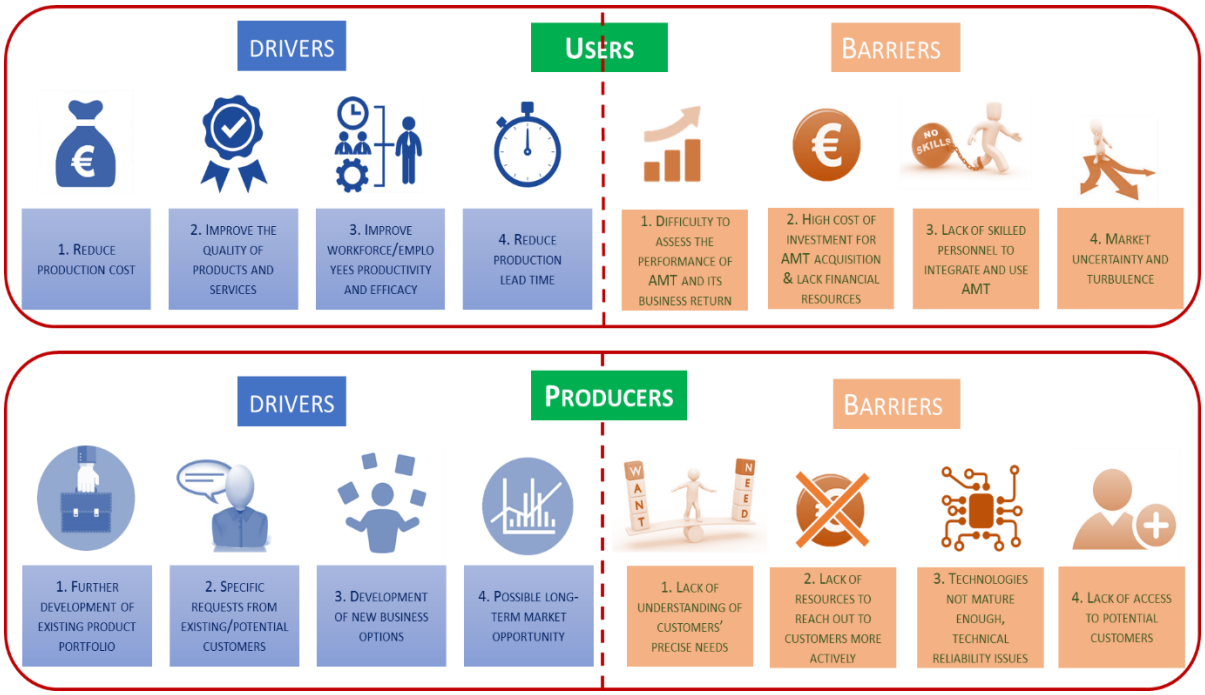
Executive summary

The adoption of advanced manufacturing technologies (AMT) by companies is seen as a prerequisite for the modernisation of the European industry. The adoption of AMT allows for an increase in energy efficiency as well as productivity. Both are pivotal factors in achieving long-term competitiveness in the market and preserving the natural environment for subsequent generations. Although the European economy benefits from having world-class manufacturing and research capacities, it struggles to bridge the gap between technological innovation and market commercialisation – a phenomenon which is often referred to as the valley of death. Moreover, low demand on the European market hinders the deployment of AMT by the European industry. In order to understand the factors affecting the uptake of advanced manufacturing by the European industry, representative case studies were explored and an online questionnaire was launched.

Several insights emerged from the qualitative analysis. Firstly, several drivers and barriers that emerged from the literature study, such as general arguments on the investment climate for AMT in Europe, were confirmed. Secondly, the analysis provided detailed information on how drivers and barriers relate to the demand situation, the financial situation, know-how, and competence and skills affect decision-making in various situations. Thirdly, additional drivers and barriers with regard to specific technologies, company size, geographic area and value chain position were identified. Hence, the qualitative analysis provided important information on what was new compared to state of the art and as such provided input for the quantitative analysis.

Additional insights emerged from the quantitative analysis. Hereby the most important drivers for users to invest in AMT were financially driven and human capital related. Additionally, the main barriers for users to adopt AMT were the high cost of investment in AMT and the lack of financial resources, while the main barriers for producers were related to marketing difficulties. Users did not master the capacity to overcome various barriers to the adoption of AMT, whereas producers felt well prepared to overcome them. Internal drivers to invest in AMT were more frequently mentioned than external drivers, indicating that there was a positive motivation through observed benefits of advanced manufacturing as a business model, rather than a passive adaptation to external market developments. Considering the three types of AMT, it seemed that investment in ICT-enabled and sustainable manufacturing technologies faced more barriers than investment in high performance manufacturing technologies. Within the three types, no single technology was considered as very important, but rather a group of technologies was perceived as such. This points towards the multidisciplinary character of industrial applications and hence the need for the integration of various KETs. The analysis also reflected the various stages of market development among Member States. For example, while Western European companies saw AMT as a suitable means to access new markets and differentiate themselves from competitors, this effect was less pronounced in Central, Northern and Eastern Europe.

The main drivers and barriers to invest in AMT are:



By distinguishing between three main types of AMT (high performance manufacturing technologies, ICT-enabled technologies and sustainable manufacturing technologies), few differences in drivers for users to invest in AMT were identified. The drivers "reduce the consumption of energy and materials" and "tackle environmental requirements/certification" were significantly more important for users active in ICT-enabled technologies and sustainable manufacturing technologies. With regard to barriers, respondents active in ICT-enabled technologies and sustainable manufacturing technologies faced more barriers as compared to respondents active in high performance manufacturing technologies.

Certain regions showed a difference in the main objectives to invest in AMT. For example, for 90% of respondents located in Western Europe, the ability to approach new markets by investing in AMT was an important driver. By contrast, only 46% of respondents located in Central Europe identified this as an important driver. In Western and Southern Europe, being able to stand out from competitors was an important driver for investment in AMT, while in Central, Northern and Eastern Europe, this was only the case for about 60% of the respondents. Regions also tended to differ in the barriers they face to adopting AMT. For example, the impossibility of integrating AMT into customers' current processes (i.e. due to standard/process incompatibility) was judged to be an important barrier in Southern Europe while it was of less importance in Central and Northern Europe. Market uncertainty and turbulence was of high importance fin Western Europe while it was of medium importance to Northern European respondents.

The means to overcome barriers to the adoption of AMT from a user perspective are:

Producers felt well prepared for overcoming the challenges related to understanding the technological opportunities resulting from the application of AMT and generally understanding the technological dynamics in the field. They were less well prepared for accessing relevant intermediary organisations of users like associations and for accessing additional markets. SMEs were less ready to overcome barriers to the adoption of AMT. Especially with regard to the access to pilot facilities and demonstrators to test the potential of AMT, SMEs evaluated their capacity for overcoming this barrier as being significantly lower than that of large companies.

The readiness to overcome certain barriers differed slightly amongst the three main types of AMT (high performance manufacturing technologies, ICT-enabled technologies and sustainable manufacturing technologies). In particular, for respondents active in ICT-enabled technologies and sustainable manufacturing technologies, overcoming the barrier to cooperation with users and developers/providers of AMT seemed more difficult.

Northern European respondents seemed to be better at overcoming the barrier to accessing pilot facilities/demonstrators for testing the potential of AMT. In contrast, Western and Northern European respondents struggled most to gain access to financial resources. Southern European respondents excelled in overcoming the barrier to cooperation with other AMT developers/producers.

Initial insights from the quantitative and qualitative analyses indicated that policy support appears to be welcome in four main areas:

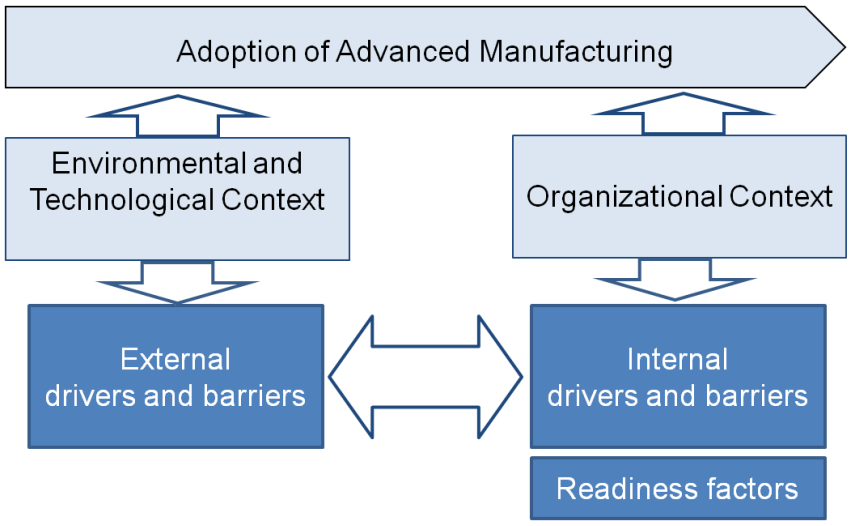
These insights will lead to further specified and targeted policy measures and practical recommendations regarding the adoption of AMT in the next deliverable of the study.

1 Introduction

1.1 Analysis of main drivers and barriers for the uptake of advanced manufacturing by EU industry (WP2)

Starting with the results of WP1 in terms of diffusion and impacts of AMT, this work package aimed at collecting and analysing information on factors affecting the uptake of advanced manufacturing by the EU industry. The focus was on understanding how internal and external drivers and barriers have affected decisions to implement AMT and determined the readiness factors affecting decisions. This information was transformed into guidelines in WP3 for further policy-making.

Figure 1: Framework for WP2

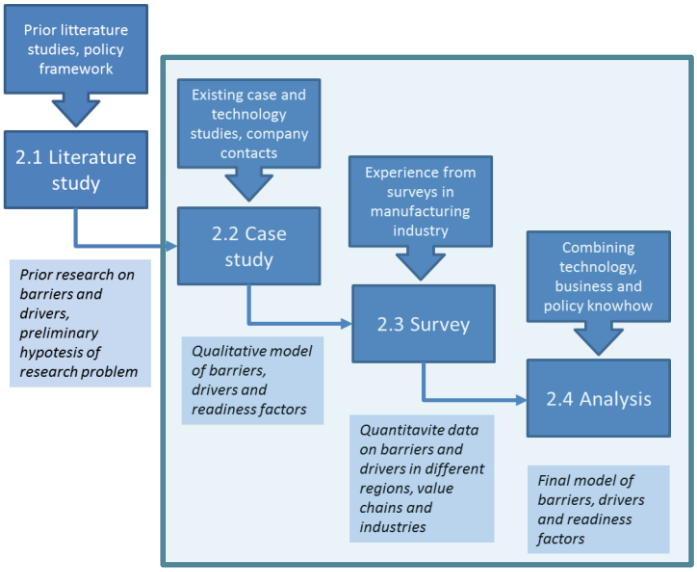


Source: Project Proposal

The analysis in Work Package 2 was undertaken in four main phases (see Figure 2). Where Deliverable 2 focused on the first two phases, the present deliverable focuses on the last three[1]. The case studies are now finalised, which allows for a full analysis of the qualitative data obtained during the interviews. An online questionnaire was sent to European companies (SMEs or large companies with less than 2 000 employees) in order to find out how they have used AMT or how they plan to use them. A questionnaire covering topics such as main drivers, barriers and SME readiness for advanced manufacturing products and technologies was developed. The questionnaire was translated into French, German and Italian in order to ensure that a large proportion of SMEs and large companies with less than 2 000 employees could answer in their mother tongue or in a language that they could understand, in addition to avoiding biases due to language confusion. An analysis of the barriers, drivers and readiness of SMEs and large companies with less than 2 000 employees was undertaken in order to identify differences and similarities in adopting AMT among regions and industries, in addition to explaining these differences through evidence-based findings.

[1] In Deliverable 2, initial findings from the case studies are reported (covering seven case studies). The final results of all case studies are reported in Deliverable 3.

Figure 2: Focus of the report as part of WP2



Source: Project Proposal

1.2 Methodology

The case studies aimed to identify and analyse the internal and external drivers that enabled companies to invest in AMT and pin-point which barriers have slowed down further diffusion of the technology. In this work package, 17 case studies were undertaken, covering 13 SMEs (<250 employees) and four large companies located in various European regions. A questionnaire consisting of four parts was developed:

1. Potential of AMT;
2. Business of the company (general);
3. How the company utilises AMT;
4. Input for policy makers.

The insights obtained from the case studies were used to fine-tune the firm-level questionnaire. The aim of the firm-level questionnaire was to find out how companies (SMEs or large companies with less than 2 000 employees) use AMT and why they use or plan to use them. The questionnaire was structured into five main parts:

1. Company profile (size, sector, location, etc.);
2. Relevance of AMT as user and/or producer;
3. Main objectives of using AMT;
4. Main hindering factors to using AMT;
5. Firm-level readiness for AMT use.

Section 2 provides more detail on the case studies-based qualitative analyses while section 3 offers insights into the quantitative analyses of the questionnaire. The latter section also describes the process adopted to reach the required response rate of 500 companies, equating to 20% of (at least) 2 500 European companies (SMEs or large companies with less than 2 000 employees). In this report, answers from 605 respondents were analysed.

2 Qualitative analysis

In order to understand the specific situation in Europe concerning investment in AMT, case studies were carried out on several European companies. In this study, the focus was on factors affecting the ability of the companies to invest in, and implement, existing new technologies. In the case studies, a semi-structured interview approach was used in order to broaden our understanding of AMT and the drivers and barriers to invest in these technologies. Through open-ended questions, the aim was to identify drivers and barriers that had not been identified in previous studies and to learn more about the underlying factors.

In the case studies, the interviewees were initially asked to determine the most important drivers and barriers to investing in AMT from their perspective. Next, their answers were cross-checked with more detailed discussions on investment decisions. In this chapter, the setup of the case study is described and then the results of all case studies are presented. The main objective of the qualitative analysis was to identify various, potentially relevant drivers and barriers to be studied in greater depth in the quantitative analysis. Hence, it should be regarded as a preliminary phase, providing input for the quantitative analysis.

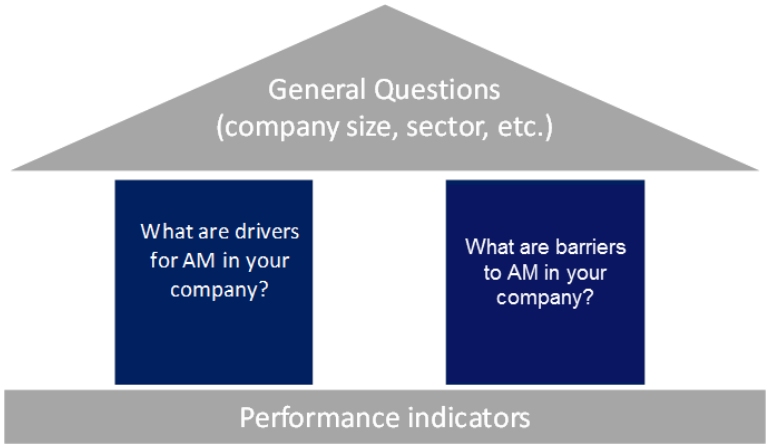
2.1 Methodology

The main steps of our case study approach were to:

- Set up a case study template based on a literature review;
- Choose case studies in each region;
- Carry out case study interviews;
- Complete the case study documentation for analysis.

Each company interview was expected to take two to three hours. The company interviews were mainly carried out by two researchers from the research organisation responsible for the interviews in that area. Each interview was documented, based on an interview template, in order to enable analysis and comparison of cases. The main questions focused on various categorical barriers and drivers, accompanied by general questions (see also Figure 3 below and Annex D for the interview questionnaire).

Figure 3: Main pillars of the semi-structured interview guidelines



Source: Project Proposal

The main steps of the analysis were:

- For each case, identification of barriers, drivers and readiness factors;
- Comparison of cases in a region in order to identify differences between companies in various positions along the value chain;
- Comparison of cases to identify potential differences between industries and regions.

The interviews were carried out and documented in English. The initial analysis of barriers, drivers and readiness factors in each company was carried out by the responsible organisation and was documented, case by case, in a national language and in English. This information was used for further analysis.

The aim of the case studies was to identify and analyse the internal and external drivers that have enabled companies to invest in AMT as well as which barriers have slowed down their further diffusion. The choice of leading adopters of advanced technology provided a good understanding of drivers, but it provided less information on barriers. Nevertheless, a good understanding of the causality behind the drivers explained what can slow down diffusion of new technologies and what can become a barrier, if not properly addressed. Since there had to be homogenous coverage of the various regions of Europe, with a clear focus on SMEs, the distribution of the case studies among the partners and regions was planned as follows. For each region, two SMEs and one large company were initially chosen for the case study interview. The final setup of the cases in the various regions is shown in Table 1.

Table 1: Distribution of the case studies

	Central Europe (ISI, IDEA)	Northern Europe (VTT)	Southern Europe (ITIA, IDEA)	Eastern Europe (ISI)	Sum
SME (<250 employees)	4	2	3	4	13
Large compa-nies	1	1	2	-	4

Source: Own analysis

In order to obtain geographical spread across the case studies, the EU was divided into four geographical regions as follows:

- Central Europe: Germany, Austria, Poland, Czech Republic, Slovakia, Hungary;
- Western Europe: France, Belgium, the Netherlands, Luxemburg, United Kingdom, Ireland;
- Northern Europe: Denmark, Sweden, Finland, Latvia, Lithuania, Estonia;
- Southern Europe: Spain, Portugal, Italy, Greece, Malta, Cyprus;
- Eastern Europe: Romania, Bulgaria, Slovenia, Croatia, Serbia.

By choosing leading companies in main industry sectors in each region, drivers affecting existing investments were more easily identified. This was the reason why leading SMEs in each region were identified. In addition, attention was devoted to their positions in the value chains: OEM (large/SME), component manufacturer (large/SME) and subcontractor (SME). To sum up, criteria for choosing a company for our set of case studies were:

- Company region (to cover all parts of Europe);
- Company size (clear focus on SMEs, supplemented by large companies);
- Value chain position (to cover various positions).

In order to gain an in-depth insight into the particularities of companies and the challenges they have to deal with, when adopting (or not adopting) AMT, it was of great importance to find not only the right companies, but also the correct expert to undertake interviews within the company. For this project it was of the utmost importance that interviews were undertaken with the owner of the company (especially for SMEs), the head of production or the CEO (especially for large companies). Companies were contacted by members of each regional partner, relying on their direct company contacts and also on their network of intermediates, such as clusters and industry-related associations.

Organisations chosen for case studies in each geographical region were:

- Central Europe: Fraunhofer ISI;
- Western Europe: IDEA Consult, ITIA;
- Northern Europe: VTT;
- Southern Europe: ITIA, IDEA Consult;
- Eastern Europe: Fraunhofer ISI.

A predefined list of drivers/barriers was used to facilitate the discussion, building upon the framework used to analyse drivers and barriers in the literature review (see Figure 3 of Deliverable 2). The technological, organisational and environmental contexts were translated as follows:

- Technological context: technological maturity, specific regulation/legislation/policies regarding a technology;
- Organisational: know-how/skills, process requirements, customer service level, availability of internal finance, productivity, costs;
- Environmental: demand, competition, availability of external finance, sustainability.

This was translated into the following groups of drivers and barriers (see Table 2):

Table 2: Predefined groups of drivers/barriers

Type of drivers/barriers
• Financial situation
• Demand situation
• Competitive situation
• Know-how, competence and skills
• Process performance
• Customer requirements
• Legislative, regulation, and political situations
• Sustainability
• Other external drivers/barriers

Source: Own analysis

2.2 Analysis of the case studies

Four large companies in Europe were involved in the case study interviews. Three of these companies were users of AMT and the fourth was a producer of AMT. All three user companies are producers of consumer goods in a global market and are struggling with losses or barely breaking even. To these companies, economies of scale and cost-cutting are central drivers. AMT such as industrial robots, automatic handling systems and automated warehouse systems are in use in all of these companies. One of the companies also reported using additive manufacturing. The fourth large company in the case study operates in a business-to-business environment. Here, the market is growing, but competition is tough. Moreover, this company is familiar with industrial robots and 3D printing. It also develops control and sensing technologies and manufactures micro-mechanical components. All four companies reported having experience with ICT-enabled manufacturing technologies and sustainable manufacturing technologies.

Thirteen of the case study companies are SMEs. The majority of these companies are high performing family-owned companies. They reported moderate to fast growth over the last three to five years. Most companies have a fairly traditional level of automation in their manufacturing department. Eight of the SMEs are AMT producers and although these companies design and produce highly automated machines and equipment, several of them scarcely use automation in their own production processes. One of the AMT producers reported having an automated line for electrical board production. Some use digital means such as CNC machines and robots for welding or material handling. Five companies in this group use AMT. Two of the user companies only reported one single investment in production robots.

AMT producers are experts in the engineering and design of their own products. This can, to some extent, be seen in how they invest in ICT-enabled manufacturing technology. This technology is used in their own processes and is delivered to customers as part of their machine and equipment service. Some of the companies have also invested in sustainable manufacturing technology, such as energy saving technology or life cycle management technology.

Eight SMEs reported investments in high performance manufacturing technologies, six reported investments in ICT-enabled manufacturing technologies and six reported investments in sustainable manufacturing technologies. Companies also indicated investments they had not yet implemented. Nine of these were in high performance manufacturing technology, one in ICT-enabled manufacturing technologies and one in sustainable manufacturing technology.

A summary of AMT use and considered use by SMEs and large companies is shown in Table 3. Only three SMEs have experience with robots and none reports experience with automated materials handling or automated warehouse systems. Many of the companies use CNC machines and CAD/CAM links in production. On the ICT side, the most common tools are CAD systems and simulation tools for construction and production reconfiguring. Data transfer from machine tools is mentioned by one company. Energy-saving technologies are also used in some companies.

Table 3: AMT use and interests in case study companies

	Invested in AMT	Interested in AMT
	SMEs	
North 1 **(user/producer)**	- Robot for customer demonstrations (sales) - CAD, simulation - Clean air and floor in factory facility	
North 3 **(user)**	- Robots for welding and edging - CAD	- Energy saving from warm air
East 1 **(user/producer)**	- Automated manufacturing of PCB, automated quality control - Automation of PCB development and manufacturing, calibration lab, simulation, GPRS and Bluetooth - Long-life meter devices	- Additive manufacturing
East 2 **(user/producer)**	- Data transfer from welding machines	- PCB manufacturing automation
East 3 **(user/producer)**	- Product life cycle management system	- Additive manufacturing
East 4 **(user/producer)**	- CNC technology - Computer based development and programming of CNC machines	- Automation of production processes
South 2 **(user/producer)**	- Factory facilities	-
South 3 **(user/producer)**	- New facilities, heat treatment furnace - Sustainable manufacturing technology and logistics	-
South 5 **(user)**	- Robot island - 3D simulation technologies	- Product life cycle management systems
Central 1 **(user/producer)**	- Dry processing/minimum lubrication - VR/simulation in production reconfiguration, VR/simulation in product design - Enterprise resource planning - Product life cycle management systems	-
Central 2 **(user)**	-	- Additive manufacturing - VR/simulation in production reconfiguration
Central 4 **(user)**	- Press machine automation - Simulation in construction - Smart technology for linking energy positions with the aim of reducing energy costs	-
Central 5 **(user)**	- CNC cylindrical grinding machine - 3D modelling CAD/CAM - LED lighting	-
	Large companies	
North 2 **(user)**	- Robots for welding - Robots for quality control - Automated material handling	- Simulation - Virtual reality technology

	Invested in AMT	Interested in AMT
South 1 **(user)**	- Industrial robots - Handling systems - Automated warehouse management - ICT applied to machinery/production control through computers and mobile devices - Control system for shut down of machines	-
South 4 **(user)**	- Industrial robots/ handling systems - Automated warehouse management systems - Additive manufacturing - Supply chain management with suppliers/customers - Enterprise resource planning - Dry processing/minimum lubrication - Combined cold, heat and power	- Technologies for safe human-machine cooperation - VR/simulation in production reconfiguration
Central 3 **(user/producer)**	- Industrial robots/handling systems - Manufacturing micro-mechanical components - Additive manufacturing - Control and sensing technologies - Product life cycle management systems - Energy efficient technologies	-

Source: Own analysis

2.2.1 Description of case companies

North 1 is a family-owned SME from Finland. The company focuses on the design and production of highly customised automated manufacturing systems for the heavy manufacturing industry. Company employees are highly skilled, with roughly half of them having a degree in engineering. About 90% of production is exported, with roughly 60% travelling outside Europe. Major investments in a plant and product development were made in 2003 and 2004, with an enlargement in 2009.

North 2 is a leading service provider in consumer goods. Today, the company employs over 2 000 professionals in Finland and abroad. North 2 is known for its high quality and the ability to scale up production very quickly, using its own engineering resources and know-how. Managing investment in production technology and product line implementation enables the company to keep investment costs down and speed up implementation. North 2 has grown and made significant investments in recent years - plans for expansion already exist.

North 3 is a subcontractor for sheet metal machining and assembly. The main customer segment served is the heavy lorry industry. The company is situated in the middle of Sweden and has about 50 employees. The company is especially good at understanding the needs of the customers, producing prototypes quickly and producing cost efficient mid-sized batches. The main market is Sweden. Roughly 15% of production is exported. The market has grown slightly and recovered somewhat since 2009. Economically, the company is doing reasonably well. It has invested in several robots for welding and edging pressing. The main investments were made 10-15 years ago, but the company has updated the equipment annually, with small investments in new or replacement technology.

East 1 is a Hungarian SME designing and manufacturing customised measuring equipment for the industry. It is a privately owned limited company with solid finances. It grew rapidly between 2008 and 2014 following heavy investment in production facilities and product development in 2006 and 2007, respectively. In 2013–2014 the company invested in enlarging its plant facilities.

East 2 is a Serbian SME specialising in the development and production of industrial welding equipment and tools. In addition to R&D and production, the company repairs and maintains all types of welding units and offers training for professional users. It employs mechanical, electronic and IT engineers for the development of customer-specialised technology. The company has a huge co-operation network, which enables it to develop and produce customer-specialised systems of highly automated mechanical and electronic parts for welding and cutting tools.

East 3 is a Croatian SME that focuses on the development, design and production of high speed precision motorised spindles, direct drives and other high speed technology. It also focuses on engineering, design and automation of special machine tools and systems. East 3 is a medium-sized enterprise with 70 employees and an annual turnover of €5.5 million. Its products are customised to the specific needs of individual customers. The company has a modern, technically advanced factory in Croatia and sales are located in Croatia as well as in other EU countries. The company is mostly export-oriented: 90% of the company's products and services are exported, 75% of which go to the Western European market and 15% to the US. The company is a privately owned, limited company with solid finances. It grew rapidly from 2010 to 2014, investing heavily in 2013.

East 4 is an SME located in Serbia. The company has been developing and manufacturing agricultural machines and components since 1987. In the last five years, the company has invested in a new unit which specialises in the production of machine components using CNC-controlled precision machine tools. This unit only develops and produces products for foreign customers. The unit employs highly specialised workers - not only in development, but also in manufacturing. The company has invested in new CNC machine tools and ICT-enabled technology, such as software for design, development, digital process control and simulation. The company employs 24 people in the new CNC unit, roughly half of whom are engineers. The unit grew rapidly between 2014 and 2016. In 2015 and 2016 the company invested about 30% of its turnover in new production facilities and product development.

South 1 is a large company located in Spain. It develops, produces and supplies household furniture in the Iberian Peninsula. The company has a strong focus on technologies and services. It strives to improve its competitive position through technological innovation and design, the quality of its products and its customer service.

South 2 is a family-owned machine tool company in Spain, specialising in building and selling high added value machining centres throughout the world. It is an SME and its competitiveness is based on high quality products, flexibility and customisation. The company is constantly improving its designs, product range and services related to machinery. This is how it can offer exactly what customers need and not just a standard machine.

South 3 is a social economy company offering precision cutting tools and solutions for various industrial uses in the building sector. Its design and advanced geometry ensures the best finish and performance for all designed materials. The use of modern coating increases cutting speed. The company exports more than 80% of its production.

South 4 is one of the major household appliance manufacturers in the world, with approximately $20 billion in annual sales, and manufacturing and technology research units in about 70 countries. In a mature and concentrated market, led by a few big competitive players, the company leverages a broad global scale relying on regional divisions to meet local consumers' preferences. With two recent acquisitions, the company has become more geographically diverse and has realised market share growth. Its main competitive advantages are based on high economies of scale and reduction in labour costs in particular in assembly operations.

South 5 is a family-owned business which, since the 1960s, has produced laminated fiberglass reinforced polyester for various uses in the industrial sector, such as agriculture, residential construction and DIY. The company covers the Italian market and exports to various European and African countries. In the last few years, the Italian market has declined while exports have reached 50% of sales. Each regional market typically requires various product characteristics in terms of preferred colour ranges, roll lengths, packaging and batch sizes. South 5 bases its strength on its capacity to fulfil various customers' requirements (in terms of colour, characteristics, delivery, etc.) as well as being able to satisfy the smallest orders. This small-lot strategy has allowed the company to survive the 2009 crisis when order volumes drastically reduced. The company's financial situation has been in a constantly improving trend since 2012.

Central 1 is an SME producing AMT. It designs and builds unique, high quality and ultra-precise fully hydrostatic machine tools. The market for its products is quite small. Therefore, it targets high quality niche products and focuses on flexibility and customisation. The company currently has 70 employees. Central 1 exports 95% of its products, of which 30 to 40% travel are exported outside of Europe. The company mainly invests in its own technology as it has a policy to outsource much activity to other players. A limited part of its activity is concentrated on services and maintenance, although it is paying increasingly more attention to helping customers work with machines.

Central 2 is a small French manufacturing enterprise founded in 1946, currently employing 60 people. It has been active in general mechanical processing, acquiring expertise and enlarging its activities in industrial maintenance and consultancy. The company has developed close relationships with its customers, relying on quality and responsiveness, in order to satisfy customers' needs. The company often struggles to remain profitable; the resources it needs to explore innovation opportunities and the risk of adopting new technologies are often very high barriers to significant innovation for the company. Currently the company competes in the market by means of its productivity, cost reduction and agility to adapt to customers' requirements.

Central 3's core expertise is measurement across machine tools and technologies. The company applies tools and techniques to measure and support feedback loops. It is also active in the fields of metrology and post-process measurement. In that context, the company deals with motion-

measuring technologies and sensors for high precision manufacturing. One of the key areas is metrology and this is where the business has initially experienced substantial growth, as Central 3 is a main provider of solutions and programmes for high precision manufacturing. Over 300 software engineers are currently working on and building software and tools to support hardware products. The primary market focuses on manufacturing in relatively low volumes for sectors such as aerospace, power generation and health care. Future markets include industrial machines, the automotive industry and components for consumer technology products. The company invests heavily in R&D and is constantly pushing the boundaries of technology. Central 3 has grown over the last five years. A lot of this growth has been driven by requirements for increased efficiency and waste reduction. Most of its revenues are export-based, as it exports over 95% of its production.

Central 4 is an innovative company in the aluminium processing industry, which deals with the production of technical extruded parts and assemblies. Its expertise is cold-forming by impact extrusion, combined with innovative processing techniques which emphasise the use of aluminium. Each solution is completely and entirely tailored to the needs of its customer. The company employs about 230 people, of which roughly 10% are engineers. It was founded in 1988 as a family business. Today the company is a privately owned limited company with solid finances. In the years 2012 to 2015, the company enjoyed moderate growth. The company invested heavily during those years. Currently, the company invests an amount of money comparable to six months turnover.

Central 5 is a company in the metal and synthetic special processing industry which produces technical parts for the mechanical engineering, automotive and aircraft industries. Its expertise is both machining metal using CNC machinery and producing thermoplastic parts by injection moulding. Moreover, it offers its customers several manufacturing services, project management and a quality centre. The company employs about 100 people, of which roughly 10% are engineers. The products are customised to the specific needs of individual customers. The company has a modern and technically advanced factory in Germany. The company was founded in 1991 as a family business. Today the company is a privately owned limited company with solid finances. In 2014 and 2015, the company enjoyed a moderate growth rate of 8% and invested heavily. In 2014, the company also established a new CNC cylindrical grinding machine.

The cases, their AMT investments and arguments for investing or not investing are described in more detail in Annex A.

2.2.2 Case material for analysis

In the interviews, the interviewees were first presented with a list of predefined AMT. This was meant to act as an introduction to the topic of the interview and a means of checking which technologies the companies are already familiar with. The result of this initial topic was summarised in Table 3, earlier in this chapter.

The second set of questions concerned the case companies, their line of business and their economic performance. Short descriptions of the companies are provided in Section 3.2.1 to give the reader an understanding of what kind of companies are involved.

In the third part of the interview, the interviewees were asked to describe their views on drivers and barriers to AMT investments in Europe and how national and European policies support or prevent AMT investments in their country. The open questions in this part of the interviews gave the respondents space to define their own points of view. The comprehensive information compiled by the researchers then compared the companies and a list of twenty central topics on drivers, barriers and the readiness of the industry to invest in AMT. The results of this analysis are presented in Chapter 3.3 and organised according to the predefined groups of drivers and barriers (see Table 2).

The fourth part of the interview focused on the drivers of AMT investments already made by the companies and on the barriers affecting negative investment decisions or decisions awaiting a final conclusion. The list of predefined groups of drivers and barriers was used to guide the interview. The interviewees were asked to give a quantitative estimate of the importance of the groups of drivers and barriers and qualitative arguments as to why they were rating the driver or barrier as they were. This line of questioning gave a total of 28 descriptions of AMT investments made by the case companies and 18 cases of negative or pending investment decisions. The number of AMT investment cases was higher than the number of case companies, since some companies described several investments in various types of AMT. Some of the case companies preferred to give more general views on drivers and barriers to AMT investment.

The information on AMT investment decisions formed the basis for the main analysis of drivers and barriers. It contained 151 ratings of the importance of specific drivers and barriers and 302 qualitative arguments or short quotes as to why a driver or barrier was important to the company. This material was structured and analysed from two points of view. Firstly, the predefined groups of drivers and barriers in Table 2 were used. Secondly, the material was structured based on:

- The size of the case company (SME, large company);
- The region (Central, Eastern, Northern and Southern Europe);
- Position in value chain (AMT user, AMT producer);
- AMT (high performance manufacturing technologies, ICT-enabled manufacturing technologies and sustainable manufacturing technologies).

The analysis was systematically carried out, grouping the quantitative and the qualitative material into a matrix of eight by four. Due to the fairly low volume of quantitative data it was mainly used to support the qualitative analysis. The specific character of each unit was concluded by inductive reasoning. For AMT investment decisions made or to be made, a comprehensive list of drivers of and barriers was formed and presented in Annex B.

In the last part of the interview, the interviewees were asked how their company is affected by regulations and how national or EU policy could be changed to better support AMT investments. These insights have served as input for Work Package 3. Annex C contains a list of the main arguments made by the interviewees.

2.3 Results of the qualitative analysis

2.3.1 Main drivers and barriers to AMT in Europe

The case studies on drivers and barriers to invest in AMT were undertaken in 14 companies in four regions of Europe covering 11 countries. In the interviews, the representatives of the case companies were asked to describe their views on drivers and barriers for European companies to invest in AMT and what the EU could do to improve the situation in Europe. A set of factors affecting AMT market conditions in Europe was identified. The factors were grouped based on the predefined groups of drivers and barriers that are presented in Table 2. In this chapter, summaries of the case study results are presented.

2.3.1.1 Financial situation

A central challenge was that few companies are prepared to make productivity leaps through investments in new advanced technologies. Users are more willing to continue to work with already installed technologies. The primary criterion for selection of a supplier is usually the price and not the novelty of the technical solution. In publicly listed companies and companies operating in low-margin markets and relying on economies of scale in particular, management is strongly risk-adverse when considering new investments for innovation. Innovation projects are launched when the return on investment is significant and no high risks are present. In particular, it is important not to invest in technologies where the advantage and robustness are not clearly proven, so as not to damage the quality and reliability of the company's image. Management is particularly cautious about putting new technologies into production if they have not been exhaustively tested and previously engineered.

AMT are very expensive and the companies in developing countries cannot invest in them. Hence, they are willing to invest if their customers are willing to co-operate in that investment. EU subsidies could be another solution. Unfortunately, such possibilities are not known to small companies.

2.3.1.2 Demand situation

The European AMT market is seen as very passive at the moment. The European AMT market is not one unified market as there are differences between countries and regions. Some leading areas like Germany seem to be slowing down, while others like Italy and France are showing some signs of awakening. Local or national activities and support also affect the way industry is investing. For instance, the Basque country has successfully supported AMT investments. There are good examples of companies which dare to invest in other countries with high labour costs. For instance, Danish and Norwegian companies are mentioned in the interviews.

The readiness to invest in AMT is negatively influenced particularly by the financial situation and uncertainty of the demand. The lack of knowledge and competencies with regard to new technologies as well as the various cultural barriers impede the adoption readiness of companies. The main challenge of AMT suppliers is to change the mind of managers, helping them with knowledge development as well as with finding the right partners for co-development and co-financing of AMT adoption projects.

Many companies are unfamiliar with the technologies offered by small AMT producers. As the technology is unknown, they often do not dare to take the step to transition to these technologies, as they perceive the risk as too high.

2.3.1.3 Competitive situation

Some AMT user industries are facing market concentration and intensification of competition from Asia. This is the case in the mass production of consumer goods where the entry into the European market by Asian producers has destabilised competition and led to several complaints with regard to dumping practices. In the AMT market, Chinese competition has not yet been successful in Europe due to high quality requirements.

As mass production is increasingly offshored to countries in Asia, Africa or Latin America, European companies have to compete with local suppliers in these countries. The prices of these suppliers are significantly lower than the prices of European companies. One way to deal with this problem is to adopt new technologies such as robots or digital systems to develop and construct better quality products and competitive prices. This is the main reason why European mass-producing companies are willing to invest in AMT.

European companies also invest in AMT in order to remain open to future development possibilities. The business life cycle has shortened in recent years as it is necessary to remain flexible and responsive to new market opportunities. This is especially the case for SMEs that focus on specific niches and risk being left out if technologies change and new competitors enter the market. Well-established companies have more references and resources for R&D, enabling them to attract more subsidies from the EU. This affects the competition and puts SMEs as suppliers of AMT in a less favourable position.

2.3.1.4 Know-how, competence and skills

Lack of competence and know-how in adopting and using new technologies is also seen as a barrier to implementing AMT in Europe. This specifically concerns the use of complex ICT-enabled systems with a high level of digitalisation combining electronic and software elements, especially when implementation of the system requires input from several suppliers. In the case of high performance manufacturing systems, the situation can be reversed due to new and user-friendly technology.

Organisational culture can also significantly affect AMT investment decisions. In a company with a deep lean manufacturing culture and tradition, employees at all levels are involved in development work. They use a wide set of management and organisational instruments that are supported by paper documents as a tool to enable information on sharing and intra-organisational dialogue. In the perception of company culture, digital tools are often not suited to lean manufacturing practices as not all employees have the required competencies using digital tools.

The diffusion of AMT is also slowed down by complex structures in large globally operating companies. In multinational companies, important decisions must not only meet the approval of top management, but also of the management of the various business units that are involved as future users

of the innovation. Sometimes it might be the case that various units have different priorities or different understandings if new technologies. Finding a common agreement may require a time-consuming process.

In order to manage innovation risk, user companies often cooperate with innovation partners that develop, customise and industrialise the technology. User companies do not have infrastructure capable of developing and introducing technology innovations, so they need to collaborate with innovation partners to develop the technology to TRL 9 as buyers are only interested in introducing it into their production lines once the technology reaches this stage.

Also the availability of reliable suppliers for the new technologies is important. Users have to rely on solid suppliers, able to guarantee the supply of novel technologies, serve various production sites and assist in case of problems. This is a problem for SMEs whose products are not well known or are very innovative. Hence, there is a need for brokerage events.

Potential AMT users are often not willing to invest in consultancy or training to become acquainted with new technologies. It would, however, be helpful in case user companies could invest in trainings for their employees organised at the supplier's facilities. This would imply that employees can follow training to become acquainted with the new technology in the supplier's factory.

2.3.1.5 Process performance

The introduction of AMT has consequences in several areas. It may require re-engineering of processes, training of personnel, changes in infrastructure or changes in product design. The introduction of AMT often requires significant additional investments.

2.3.1.6 Legislative, regulation and political situations

Low competitiveness of the labour force and high cost of labour is affecting the entrepreneurial climate in some European countries. This also affects how entrepreneurs and managers view investment in AMT and investment in general.

Also CE Marking Directives can affect AMT investments. They can put SMEs in a situation where they do not have the know-how to plan and implement the investment, but are forced to buy this from external experts, adding extra cost to the investment.

2.3.2 Evaluating the importance of drivers and barriers

The interviewees were asked to identify and describe AMT investments and rate the importance of drivers or barriers in the specific investment decision (scale from 1 to 5[2]). The scores of all investment decisions are shown in Table 4 and Table 5. Some companies described more than one AMT investment, resulting in 27 investments being described.

[2] 1 =low importance and 5 =high importance

Although the statistical significance of the answers could not be properly tested due to the small sample size, some remarks can be made on how important the interviewees consider the various drivers to be. Firstly, the driver "*customer requirements*" was evaluated by almost all respondents. It had a rather high average value, indicating that this was an important driver. Secondly, the "*process performance"* driver had the highest average value and a low standard deviation. Thirdly, the driver "*financial situation"* clearly divided the group of respondents. Two respondents considered it not important, two respondents reported it to be of medium importance and two considered it very important. Fourthly, the driver "*Know-how, competence and skills*" *wa*s rated as not important by one interviewee although the other interviewees gave it at least a number three or higher.

The interviewees were also asked to identify AMT in which the company had not yet invested and to describe how the predefined set of barriers affected their decision not to invest. The interviewees were asked to give a number on a scale from 1 to 5 on the importance of the barrier (see Table 5). There were major differences in how respondents answered the questions on barriers. For instance, the average values vary from 1.9 and 4.2.

In general, barriers were rated to be of lower importance than drivers. Among the groups of barriers, the barrier *"Know-how, competence and skills"* was rated as the most significant barrier to invest in AMT. The barrier "*Financial situation"* received a similar score. Other important barriers included "P*rocess performance"* and "*Demand situation".* The least important barrier was "*Sustainability"*.

Table 4: Importance of drivers

Positive decision	N1	N2	N3	E1	E2	E3	E4	S1	S2	S3	S4	S5	C1	C2	C3	C4	C5	Average	Devi-ation
Size	sme	large	sme	sme	sme	sme	sme	large	sme	sme	large	sme	sme	sme	large	sme	sme		
User / provider	up	u	u	up	up	up	up	u	up	up	u	u	up	u	up	u	u		
AMT	smt	hpmt	hpmt	hpmt	hpmt	ictmt	hpmt	multi	infra	smt	multi	hpmt	smt	hpmt/ict	hpmt	hpmt	hpmt		
Financial situation	1	-	5	5	3	1		5	3	3	1	1	2	-	4	3.7	2.5	2.9	1.8
Demand situation		-	5	4.7	5	5	5	5	4	4	2	3	2	-	4	3.5	3	4.0	1.6
Competitive situation	3	-	3	3.7	4	4	3.5	4	5	5	5	5	2	-	5	4.5	3	4.1	1.4
Know-how, competence and skills	1	-	4	3	3			5	4	3	4	4	2	-	5	4	5	3.5	1.5
Process performance	5	-	3	5	4	5	5	5	4	4	5	1	5	-	3	5	5	4.2	1.7
Customer requirements	4	-	1	4.6	5	2	4	4	3	4	1	5	2	-	4	4.5	4.7	3.4	1.7
Legislative, regulation, political situation	3	-	1	5				4	2	5	3	3	2	-	3	1	1.5	2.9	1.6
Sustainability	3	-	1	5		3	4	3	4	3	3	5	2	-	3	3.7	3	3.3	1.5
Other external drivers?		-								5				-				5.0	-
Average	2.9	-	2.9	4.5	4.0	3.3	4.3	4.4	3.6	4.0	3.0	3.4	2.4	-	3.9	3.7	3.5		
Deviation	1.5	0.0	1.7	0.8	0.9	1.6	0.7	0.7	0.9	0.9	1.6	1.7	1.1	0.0	0.8	1.2	1.3		

Source: Own analysis

Table 5: Importance of barriers

Negative decision	N1	N2	N3	E1	E2	E3	E4	S1	S2	S3	S4	S5	C1	C2	C3	C4	C5	Average	Devi-ation
Size	sme	large	sme	sme	sme	sme	sme	large	sme	sme	large	sme	sme	sme	large	sme	sme		
User / producer	up	u	u	up	up	up	up	u	up	up	u	u	up	u	up	u	u		
AMT	hpmt	-	smt	hpmt	hpmt	hpmt	hpmt	?	hpmt	?	multi	ictmt		multi	hpmt	hpmt	hpmt		
Financial situation		-	5	5	4.5	4	5	5	3	3	2	3	-	5		5	3	4.0	1.7
Demand situation		-	3			5	5	5	2	4	1	5	-	2		5	5	3.8	2.0
Competitive situation		-	3				5	5	3	5	1	1	-	4			3	3.3	2.0
Know-how, competence and skills		-	3		4	4	4	5	3	3	4	5	-	5	5		4	4.1	1,7
Process performance	5	-	3		4	4		5	2	4	2	1	-	5		5	5	3.8	1.9
Customer requirements		-	1					4	3	4	1	1	-	5				2.7	1.9
Legislative, regulation, political situation		-	1			3		5	3	5	3	5	-	3			1	3.2	1.9
Sustainability		-	1			2		4	3	3	1	1	-	1			1	1.9	1.3
Other external barriers?		-			4					5	4		-	4				4.3	2.2
Average	5.0	-	2.5	5.0	4.1	3.7	4.8	4.8	2.8	4.0	2.1	2.8	-	3.8	5.0	5.0	3.1		
Deviation	-	0.0	1.4	-	0.3	1.0	0.5	0.5	0.5	0.9	1.3	2.0	0.0	1.5	-	0.0	1.7		

Source: Own analysis

2.3.3 Summary of qualitative analysis of AMT investment decisions

This chapter summarises the conclusions of the quantitative analysis of drivers and barriers to invest in AMT in order to provide an understanding of the readiness of European companies to invest in AMT. The results are presented from the point of view of the predefined groups of drivers and barriers.

2.3.3.1 Financial situation

The financial situation was rated as one of the most important barriers to investing in AMT, while it was rated lower as a driver for investment in AMT. This is a strong indication of the importance of the financial situation of European companies as the group of companies chosen for the case studies is performing well. A high return on investment is a prerequisite for investing in AMT, but not sufficient if funding cannot be found. For SMEs this can become a barrier when internal resources are scarce and there are insufficient skills and resources to obtain public financing. Co-financing with customers is an important source of funding for both large and small companies. All but one of the companies indicated that their financial situation allows them to invest in manufacturing technology, but external support would enable them to invest in more sophisticated technology.

In all regions, the financial situation was more important as a barrier to investing in AMT than as a driver. Some differences of focus could be inferred from the interviews. For example, not all European countries provide financial support to invest in AMT. This is specifically the case for countries in Eastern Europe.

The financial situation is especially important when considering investments in high performance manufacturing technology. This could be due to high investment costs of technology, but from the comments of the interviewees, it appears that implementing this type of technology is often connected with product development and process re-engineering, which both contribute to the cost of implementing this technology. The comments on subsidies for ICT-enabled technologies raise the question of whether there are differences in opportunities among the various kinds of AMT.

Solving the financial situation can be considered a prerequisite for investment in AMT, both for AMT users and AMT producers. The users in the case studies focused on the necessity to possess the best manufacturing technology, while the AMT producers seemed to be more inclined to consider AMT too expensive for their production.

2.3.3.2 Demand Situation

The demand situation was clearly an important driver and barrier for SMEs and large companies. Although there were some differences in how the demand situation was rated in the two groups, it was difficult to see clear differences in how the demand situation affected investment decisions in the two groups of companies.

The companies in Central Europe discussed demand of large batch production, while the companies in Eastern Europe debated the demand of customised production. Due to the limitations of the research material, this cannot be considered a systematic difference. The choice of case companies with only SMEs in Eastern Europe is a crucial factor affecting this topic.

What is interesting is that there are companies in Central and Eastern Europe which talked about huge demand. This somewhat contradicts the general picture of markets in Europe described by the other case companies. The European AMT market was seen as particularly passive, yet an Eastern European AMT producer mentioned a huge demand for customised products. Perhaps this is an indication of change happening in Europe.

It appears that investment in high performance manufacturing technology is sensitive to changes in demand. One hypothesis could be that such an investment concerns a major process in the company. ICT-enabled technologies enable customisation and support the company in coping with specific customer needs. This can be a means to improve competitiveness in a poorer market situation. There were few comments on sustainable manufacturing technology. It appears the companies are not familiar with this technology and there seems to be limited demand from customers for sustainability.

2.3.3.3 Competitive Situation

The competitive situation was clearly seen as a major driver for investment by large companies. Economies of scale push for high volumes, high efficiency and low costs. For SMEs, AMT provide an opportunity to stand out through improved products and services and avoid competing on costs. High performance manufacturing technology does not benefit SMEs in the same way it does the high-volume production in larger companies.

Only minor differences between the answers from various regions were identified. In Central Europe the focus of the comments was on speed and quality to compete on price. In Eastern Europe the small and medium-sized AMT producers focused their comments on flexibility and speed to serve their customers. Flexibility was also a competitive edge for the companies in Northern Europe. One company also considered sustainable manufacturing technology a competitive edge. In Southern Europe, process efficiency and low costs were considered important.

In the group of 17 companies, only two companies (one in Central Europe and one in Southern Europe) commented on heavy competition from companies in favourable conditions. Based on the small number of cases, it was difficult to see any systematic differences between regions regarding their attitude towards the competitive situation.

The results of the case studies reflected the fact that the three groups of technology are implemented for various reasons. High performance manufacturing technologies are mainly implemented in the process of transforming physical raw material and components into final products. ICT-enabled technologies can also partly be used to manage this process, but in most cases these technologies are used to manage other processes related to physical manufacturing or other services in the company.

Managing information helps to cut cost and time in production, but it can also be a means to supervise operations like logistics, machine condition monitoring, product data management, etc. Sustainable manufacturing technology can to some extent cut costs or improve working conditions, but it is also seen as a means to improve the company's image.

Many technologies in the high performance manufacturing technology group focus on improving efficiency of the manufacturing process via automation. This improves the user's ability to compete on cost and production speed. Flexibility in technology also enables variation of products through modulus and predefined designs. ICT-enabled technologies can be used to support high performance manufacturing technology, but they also open up possibilities for competing with flexibility and providing rapid reaction to specific customer needs.

To some extent, the differences in the comments on drivers and barriers between the AMT users and the AMT producers could be explained by the fact that all but one are SMEs producing highly customised products that avoid direct competition with low price mass production. The group of AMT users was more diverse and operated in the mass-production or mass-customisation paradigm. While the large companies in this group all produce consumer goods in large quantities, the SMEs are suppliers of parts in a business-to-business environment where repetition is central but production happens in small batches.

2.3.3.4 Know-how, competence and skills

Lack of know-how, competence and skills constitutes an important barrier for both SMEs and large companies. Together with the financial situation, this was rated as the most important barrier to the implementation of AMT. Know-how, competence and skills are important drivers of investment in AMT in large companies, where in-house training of employees enables companies to improve competitiveness. Engineering skills were not seen as a driver of investment in AMT by SMEs. Lack of know-how, competence and skills is an important barrier to small, medium-sized and large companies. The lack of skills or competencies may concern employees on the shop floor, engineers and managers. A major difference between large companies and SMEs is that the former group has more in-house resources for training its own employees.

Some regional differences could be outlined. In Central Europe, the focus on know-how, competence and skills was on machine operators and factory personnel. In Eastern and Northern Europe, the focus was more on skills and engineering know-how. In Eastern Europe, there seemed to be a lack of engineers knowledgeable on the most modern types of AMT. In Northern Europe, there was no general lack of skilled engineers, but there seemed, more specifically, to be a lack of engineers in the domain of mass-production or mass-customisation. The companies in Central and Northern Europe also emphasised the need for in-house employee training and tools and methods for performing the training.

How know-how, competence and skills are perceived in the various regions contradicts to some extent the real educational level in these areas. In Central Europe, where the level of general education

is good, the comments indicated a lack of skills and competences among factory personnel. In Eastern Europe, there seemed to be a lack of engineers. The case study material did not show whether this is due to a gap between the educational system and industrial needs, a high demand for engineers, or a brain drain to Western countries with higher salaries.

There were slight differences in the need for know-how, competence and skills between the three technology groups. Implementing high performance manufacturing technology puts pressure on engineers to develop and implement technologies. In ICT-enabled technologies, there is a specific need for engineering skilled in integrating new technology with old technology. In addition, there is a need to develop the skills of users of the new technology. In sustainable technology, the lack of know-how is rather at the level of company management, as managers are not sufficiently aware of how this technology can benefit their company.

Comparing the comments of AMT users and AMT producers, few differences were noted. The main topic identified was access to engineering skills. Having good engineers can be a driver of investment, while a lack of engineers was identified as a barrier for both AMT users and producers. Although AMT producers have in-house engineering resources to develop their products and services, they seem to face the same challenge as AMT users in finding engineers and integrating and operating AMT into their production processes.

2.3.3.5 Process performance

A clear difference between SMEs and large companies was identified in the area of process performance. For large companies, where operations are based on economies of scale, automation of production and improvement of productivity are central objectives. Their production processes are tuned towards high capacity and continuous production. Each task is repeated multiple times and suitable for automation, implying that high performance manufacturing technologies can be very efficient. For SMEs focusing on customised or small batch production, the opportunity for repetition is less significant and automation plays a smaller role. In this case, management of processes and controlling of diverse information is more important.

From the point of view of process performance, the case study material did not show differences in drivers and barriers based on the geographical location of a company. The differences were more related to the type of production. Companies producing customised products have a hard time automating their processes, while companies producing larger volumes of products find this technology very useful for optimising process performance.

The interviews revealed differences among the three groups of technologies. High performance manufacturing technologies tend to focus on physical production processes. The volume of production can be either a barrier or a driver to invest in AMT, depending on its level. A higher volume and repeated procedures allow steps in production to be automated. Implementing high performance manufacturing technologies can disturb the continuous operating process and is considered a potential barrier to investment in AMT. ICT-enabled technologies enable collection of information, com-

munication and information-sharing in new ways and can be used to manage, support or develop main processes in a wide variety of companies. A main driver for the use of sustainable manufacturing technologies appears to be the possibility of saving costs through reducing energy use and scrap and using raw materials.

The situation of AMT users and producers with regard to process performance is similar as AMT is used to improve the efficiency and productivity of production, cut costs and speed up processes. AMT producers mentioned flexibility, integration between design and production, and improved maintenance of equipment. AMT can help companies to improve processes in many ways, but a misfit between the potential of AMT and the need for process improvement is a barrier to investing in AMT.

2.3.3.6 Customer requirements

Customer requirements play a very important role for SMEs. In sales and design departments, a central objective for using ICT-enabled manufacturing tools is to document customer requirements and turn them into a product or service. In production, the commitment to provide customised solutions implies little repetition and limited opportunity for automation. In larger companies, products are rather produced in large numbers without changing the designs.

Although there were some differences in how companies from various regions regard customer requirements as a driver or barrier, no real evidence of systematic differences between the regions could be found. High quality was mentioned in most regions, while speed of production was cited by companies located in Central and Eastern Europe. Innovation, new functionality and new products were mentioned by companies from Central, Eastern and Southern Europe, while sustainability was only mentioned as a customer requirement in the Northern regions.

The comments on high performance manufacturing technologies create a picture of simultaneous holistic innovation or development of products, services and manufacturing processes. In the case of ICT-enabled manufacturing technology, the comments stress single improvements such as improved quality, better planning, minimum disturbance and compatibility. This could indicate that AMT implementation differs amongst these two groups in scope, which probably affects costs and the time span for implementation. This implies that ICT-enabled manufacturing technologies are a faster and more efficient means of reacting to customer requirements than high performance manufacturing technologies are.

Customer requirements are important for AMT users and producers. The arguments for high quality, speed of production, compatibility of technology and processes and lower prices are the same for both groups. Customer requirements do not differ for the AMT users focused on customised, flexible production versus AMT producers focused on batch production.

2.3.3.7 Legislative, regulation and political situations

Although the interviewees were able to identify situations where the business of their company or customers was affected by legislation, directives and regulation, these factors were not considered to be an important driver of AMT investment. Large companies rated legislation, directives and regulations as major barriers to investing in AMT, while SMEs did not consider these barriers to be important. SMEs tend to have fewer resources and less know-how to cope with changes and new regulations.

One company in Eastern Europe considered legislation, regulation and the political situation to be important drivers to invest in AMT. This finding was to some extent supported by the qualitative findings from the Eastern European companies which showed that these topics are important in shaping the market. Only Southern Europe rated legislation, regulation and the political situation as important barriers. Legislation, regulation and the political system were seen as potential drivers for investment in AMT in three regions while all regions expressed their concerns regarding the freedom to make business decisions. Eastern Europe considered difficulties applying for subsidies to be a barrier.

The impact of legislation, directives and regulation is often not so visible and this might be a reason why this group of drivers and barriers was not seen as important for AMT investments. Due to the low number of comments, no clear difference between the technology groups could be identified and no systematic difference between AMT users and producers could be found.

2.3.3.8 Sustainability

Sustainability was not highly rated as a driver or barrier although most companies reported some kind of activities in this area. The main driver seemed to be cost savings through reduced use of energy or reduced scrap and waste. There were, however, some comments about strategically more advanced ways to utilise sustainability and sustainable manufacturing technology. This indicates that some European companies see new possibilities in this area. For example, one company from Northern Europe identified sustainability as a strategic issue affecting its business activities, not only through cost reduction but also through customer value and company image.

Sustainability was a driver in all three groups of AMT. Although circular economy has been raised as a hot topic for the industry, few commented on sustainability concerned aspects other than saving scrap and waste. One exception is a Swedish SME's representative who is also interested in energy recovery from the air in their plant. In Sweden, the municipality is supplying companies with information on sustainable technology, because it is in the interest of the municipality to achieve sustainability targets. One of the Central European companies is a producer of sustainable manufacturing technology.

AMT users and producers view sustainability in a similar way. As one of the interviewees said: "Productivity and quality of performance come first, but after this, sustainability is also important to the customer". This indicates that the companies are aware of requirements for sustainability, but that it is not yet the main driver.

2.3.4 Size, region, value chain position and technology

The size of the company had a clear impact in some areas on how the companies perceive drivers and barriers to invest in AMT. The main differences are based on differences in business logics. The competitive edge of SMEs is based on fulfilling customer requirements better than the competition. This has a direct effect on their process performance. Large companies use AMT to improve efficiency and productivity through a high level of repetition and automation in their production, while SMEs focus on efficient management of processes and information management to produce a wide variety of customised products. Another difference between SMEs and large companies can be derived from the fact that smaller companies have fewer financial and in-house resources. They have a need for outside support, but often lack the resources (time and know-how) to apply for public support.

The differences between the four regions in Europe were smaller than expected. There seemed to be some difference in availability of public financial support between the countries, but little difference with respect to know-how, competence and skills. Lack of skills was identified as a common challenge, but there were differences in the deficiencies the companies experience. In Central Europe, the focus was on the skills and know-how of machine operators and factory personnel while in Eastern and northern Europe, the focus was rather on resources and engineering skills. Developing competence for in-house training was mainly mentioned by companies from Central and northern Europe.

The three groups of AMT were different in some ways. Several of the high performance manufacturing technologies studied in this project have been around for a long time, as it often concern household technologies in mass-production or mass-customisation processes. ICT-enabled technologies and sustainable technologies are often new or emerging technologies. High performance manufacturing technologies focus on the core of the production processes at manufacturing companies. They not only affect production technology, but also products and production processes. Implementing new high performance manufacturing technologies involves, in many cases, profound changes in the entire production system. As a result, investments in these technologies are high and a rapid payback is critical for the companies. Risk of poor demand or poor performance by the technology has to be avoided. ICT-enabled manufacturing technologies are often used to improve the information flow in existing processes. More efficient means of information management are used to create new service business models, altering the roles of actors in a value network. Better information management enables efficient operations in areas previously performed as low-technology manual support services. This implies that investments are often not high and the benefits can be significant.

The implementation of AMT also requires special skills and competencies. In the case of high performance manufacturing technologies, highly-specialised skills are needed especially on the engineering side. When new technology is implemented, skills and competencies have to be renewed in the design of products and production. For ICT-enabled manufacturing technologies, engineering skills are also needed but the implementation of this type of technology also puts pressure on the skills and know-how of users.

Some small differences between AMT users and producers could be outlined but the reason is likely to be connected to the companies' operating model. Most AMT producers are SMEs that are producing highly customised products while many of the user companies are large companies that are producing large volumes of standardised products. This might explain why users seemed more likely to invest in high performance manufacturing technology compared to AMT producers.

2.4 Conclusion from the qualitative analysis

The qualitative analysis led to many interesting insights. Firstly, several drivers and barriers that emerged from the literature analysis were confirmed. Secondly, additional drivers and barriers were identified in relation to specific technologies, company size, geographic area and value chain position (e.g. sufficient demand is a prerequisite for investment in AMT, some companies lack the skills and resources to apply for public funding). Thirdly, some relevant, strong and unequivocal phenomena could be identified, based on the fact that the majority of companies participating in the case studies outlined the same issues. Hence, the qualitative analysis should be seen as a preliminary phase, providing important input on what is new compared to state-of-the-art and as such provides input for the quantitative analysis.

In particular, the analysis of comments from the interviewees on the AMT investment decisions confirmed that **the investment climate for AMT in Europe is indeed an important driver**. The analysis also gave more detailed information on how drivers and barriers affect decision making in different situations.

The **demand situation stands out as crucial for both SMEs and large companies**. When the demand situation is favourable, AMT are used to increase capacity and/or improve process performance. In large companies, AMT are used to improve process efficiency and productivity in order to be competitive in mass-production or mass-customisation markets. Meanwhile SMEs use AMT to distinguish their products and services from those of competitors. **The fear of losing process performance due to immature AMT is a strong barrier to invest in emerging AMT. Finance can be a barrier**, especially for small companies if internal resources are lacking and if external support cannot be found. Competition can also be a powerful driver. Customer requirements were a driver rather than a barrier to AMT adoption as SMEs compete on the ability to provide customers with unique solutions.

Know-how is very frequently a barrier to investment. A lack of skilled engineers and factory personnel will stop a company from acquiring new technology, even though if properly operated it could improve their processes. The need for know-how depends on technology, but also on the size of the company.

Regulation and the political environment are important overall, both as drivers and barriers, but they seem less important for SMEs than for large companies. Sustainability is considered a chance for new business opportunities, particularly by some SMEs. Many companies invest in this technology, as they see an opportunity to save costs and to improve their brand image at the same time.

3 Quantitative analysis

3.1 Introduction

A questionnaire was launched to validate the insights obtained in the case studies and the work undertaken in WP1. The focus of the questionnaire was to find out how European companies (SMEs or large companies with less than 2 000 employees) use AMT, or why they plan to use AMT, what is hindering them to do so and how ready they are to implement them. The questionnaire strongly built upon the insights obtained through the literature review and qualitative analysis.

Closed-form questions were used in the questionnaire, which applies similar categorisation in order to maximise the comparability of the results. The main reasoning behind the predefined groups of drivers and barriers as identified through the qualitative analysis was used (see Section 3.1), but in order not to confuse the respondent, jargon associated with the particular framework (see Figure 3 of Deliverable 2) was avoided. It was decided not to include open-form questions with the aim of reducing the time needed to complete the questionnaire. Respondents were informed that filling in the questionnaire would only require about 10 minutes. In practice, the average response time was 12 minutes and 30 seconds.

As the questionnaire targets SMEs or large companies with less than 2 000 employees, it was provided in English, French, German and Italian in order to avoid self-selection due to any confusing language that might bias results. This also ensured that a large share of SMEs and large companies with less than 2 000 employees answered in their mother tongue or in a language that they could understand. When clicking on the link of the questionnaire, respondents could pick the language of their preference.

In this chapter, the selection procedures of the SMEs or large companies with less than 2 000 employees are described, following by the description of the dataset and the analyses of the data.

3.2 Methodology

The objective of the questionnaire was to have very broad coverage in terms of manufacturing sectors and COSME countries. Therefore, two approaches were followed to reach SMEs and large companies with less than 2 000 employees.

3.2.1 Direct approach

A direct approach was adopted, one that builds upon the Amadeus database in order to compile a list of companies that fitted our targeted sample of companies. From Amadeus, companies that employ between 30 and 2 000 employees active in the last available year were selected in the following sectors (excluding companies that had no recent financial data):

- Food, beverages, tobacco industry (NACE 10-12);
- Chemical industry (NACE 20-21);
- Rubber and plastic industry (NACE 22 23);
- Metal industry (NACE 24 25);
- Electronic and electrical equipment (NACE 26 27);
- Machinery (NACE 28);
- Transport equipment (NACE 29 30).

In order to select companies in these sectors, an "AMT keyword" driven search was performed, similar to the search strategy applied in the literature study (part of WP2 and reported in Deliverable 2).

Search term
"Advanced Manufacturing"
"Sustainable Manufacturing" OR ("Sustainability" AND "Manufacturing")
"Manufacturing" AND ("Digital Technologies" OR "Big Data" OR "Internet Of Things" OR "Industrial Internet" OR "Cyber-Physical Systems" OR "Product Life Cycle Management" OR "Supply Chain Management" OR "Enterprise Resource Planning" OR "Manufacturing Resource Planning")
"High Performance Manufacturing" OR "Additive Manufacturing" OR "Micro Manufacturing" OR ("Manufacturing" AND "Industrial Robot")

The questionnaire was directly circulated to 54 832 companies selected from the Amadeus firm database. This number was well above the request in the Terms of Reference to address the questionnaire to at least 2 500 European companies (SMEs or large companies with less than 2 000 employees). In addition, 1 879 companies were directly called based on a list of companies received from CECIMO as well as on the lists issued from Amadeus. In many cases, these companies were called twice: when they showed an interest in the questionnaire, they were followed up to see if they had actually completed the questionnaire.

When calling these companies, many expressed their frustration after repeated requests to answer questionnaires, which are now common in the sector. In their view, too many questionnaires are launched in their community, and this is compounded by the fact that the rationale for completing such questionnaires is often unclear. In addition, many respondents expressed their concern that the European Commission could not induce any change to improve their situation. Hence the response rate was extremely low, as it proved very difficult to convince respondents to complete the questionnaire.

3.2.2 Indirect approach

In addition, an indirect approach was taken when contacting the main intermediary organisations and industry associations associated with the use and uptake of advanced manufacturing products and technologies in a variety of manufacturing sectors. These organisations and associations were asked to circulate the questionnaire to their members and companies from their networks by adding the link to the questionnaire in their newsletters and on their website or by directly contacting the companies.

1 612 people at 1 042 intermediary organisations (clusters, chambers of commerce, professional associations, etc.) were called and asked to circulate the questionnaire among their members. Most organisations have more than ten members, and several organisations have over 100. For example, Sirris sent the questionnaire to its 2 500 members; EFFRA included an article on it in their members' newsletter; CECIMO disseminated the questionnaire to all associated organisations; and several clusters in France and the Netherlands accepted to forward the link to the questionnaire to their members. We received the email addresses of 961 people that agreed to distribute the questionnaire among their members or agreed to discuss the possibility of distributing the questionnaire among their board members. After three weeks, these people were contacted again.

In addition, the questionnaire was supported and distributed by following heads of sector groups of Enterprise Europe Network (EEN):

- Aeronautics and Space;
- Agrofood;
- Automotive, Transport and Logistics;
- Biochemtech;
- Environment;
- Healthcare;
- ICT Industry & Services;
- Intelligent Energy;
- Maritime Industry and Services;
- Materials;
- Nano and Micro-Technologies;
- Sustainable Construction;
- Textile & Fashion.

Several intermediary organisations and the contacted EEN chairs reacted very positively to our request and confirmed that they had mobilised their network. We contacted them regularly as the response rate remained low compared to our outreach efforts.

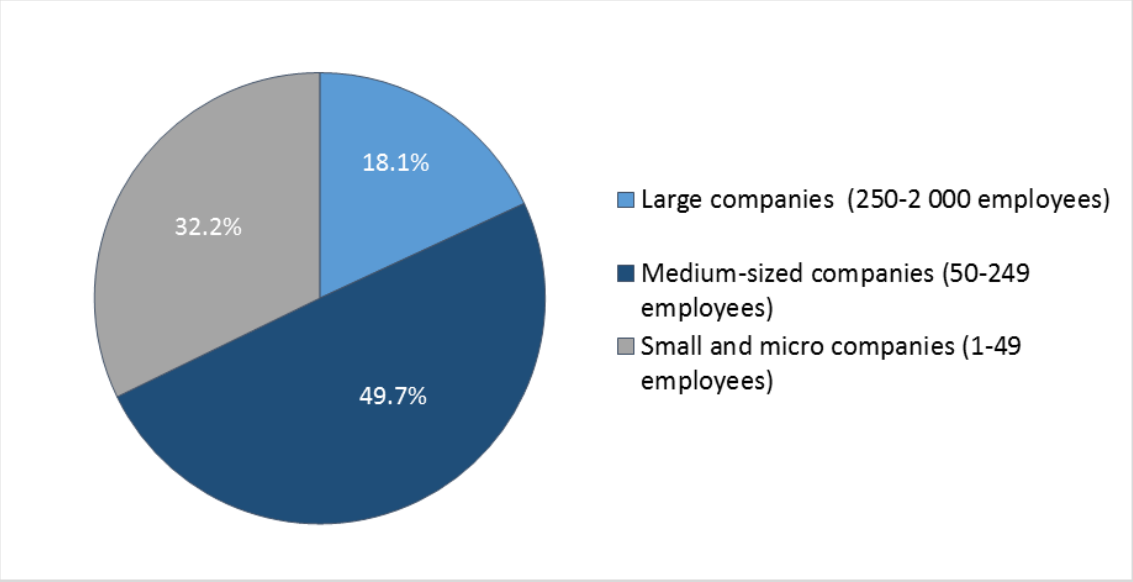
3.3 Basic description of dataset

In this section, an extensive descriptive analysis of the dataset by company size, sector, location and coverage of manufacturing activities is delivered. The answers from 605 respondents were analysed. Not all data could be used, however, as some respondents indicated that they are very large companies (>2 000 employees). Hence, 44 respondents were excluded from the analysis. In addition, 31 respondents were headquartered in non-COSME countries and were therefore excluded. As none of the questions was obligatory, the response rate per question varies.

3.3.1 Company profile

The analysis of the company size of the respondents of the questionnaire revealed that 49.7% of the respondents are medium-sized companies i.e. those that have between 50 and 249 employees. The other groups, namely large companies (250-2 000 employees) and small and micro companies (1-49 employees), represent respectively 18.1% and 32.2%.

Figure 4: Company size (n=525)[3]

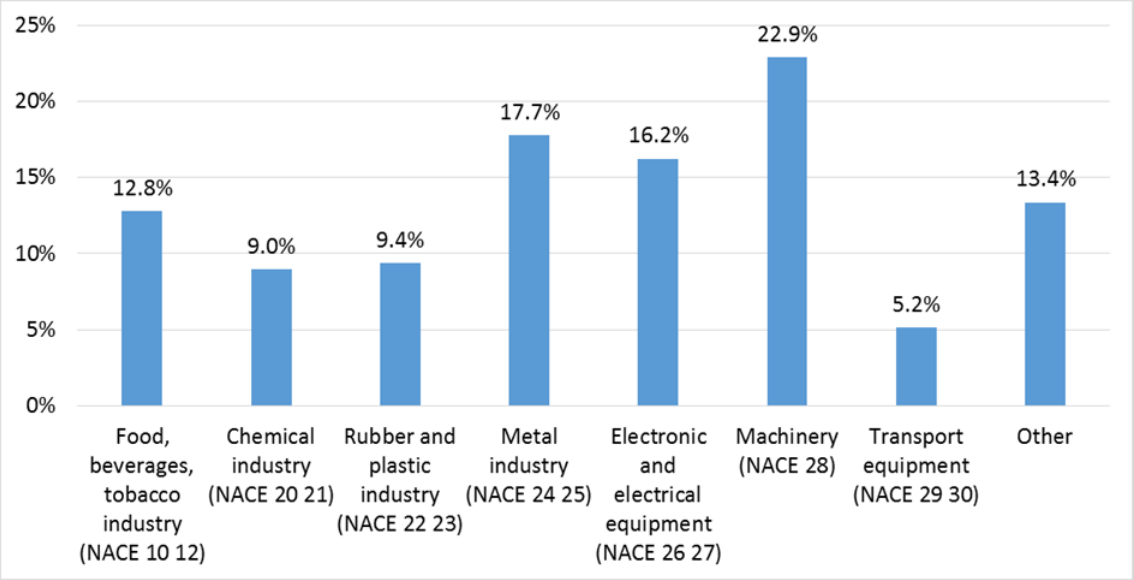


Source: Own analysis

The machinery sector (NACE 28) is the sector best represented in the sample of respondents (22.8%). The metal industry (NACE 24 25) and electronic and electrical equipment sectors (NACE 26 27) follow in second and third places, respectively. Transport equipment (NACE 29 30) is the sector that is least represented. The other category mainly comprises construction companies, paper & pulp companies, and textile companies.

[3] 44 very large companies (> 2 000 employees) were excluded from the analysis.

Figure 5: Company sector (n=524)

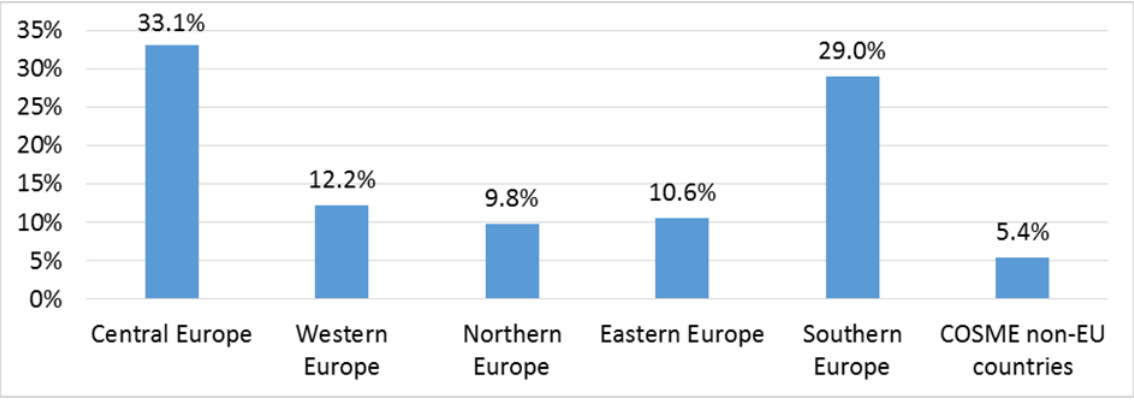


Note: Figures in brackets refer to NACE, rev. 2

Source: Own analysis

The majority of the respondents are located in Central and Southern Europe. Italy is the Member State with most respondents (18.6%), followed by Germany (12.7%) and Spain (7.6%). Czech Republic (6.8%) and Hungary (6.2%) complete the top 5. The sample contains respondents from all COSME countries with the exception of Ireland and Luxembourg.

Figure 6: Location of headquarters (n=369)[4,5]



Source: Own analysis

[4] 23 respondents from Belarus, India, Japan, Russia, South Africa, Switzerland, US, Ukraine and Bosnia and Herzegovina were excluded from the survey.

[5] Central Europe: Germany, Austria, Poland, Czech Republic, Slovakia, Hungary
Western Europe: France, Belgium, the Netherlands, Luxembourg, United Kingdom, Ireland
Northern Europe: Denmark, Sweden, Finland, Latvia, Lithuania, Estonia
Eastern Europe: Romania, Bulgaria, Slovenia, Croatia
Southern Europe: Spain, Portugal, Italy, Greece, Malta, Cyprus
COSME non-EU (which responded): Albania, Iceland, Serbia, Macedonia, Turkey

Looking at the company size across regions, Table 6 shows that in Southern Europe, there are more SMEs compared to other regions in Europe. 50.5% of all respondents from Southern Europe indicated that they are a small or micro-enterprise. In Central and Northern Europe, only 19.0% and 36.1% indicated that they are a small or micro-enterprise. The large majority of companies from Eastern Europe that responded to the questionnaire are medium-sized or large companies.

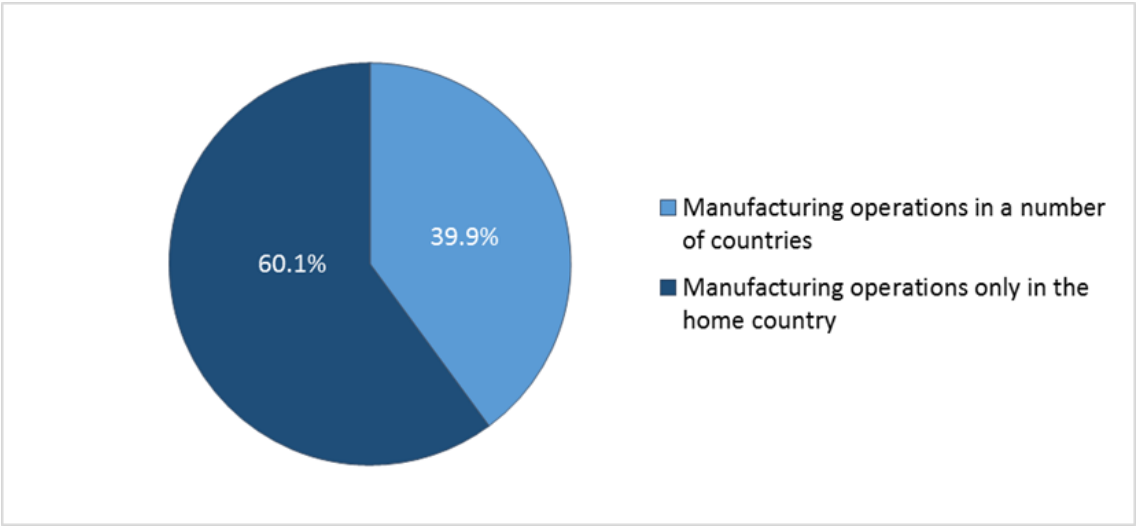
Table 6: Location of headquarters versus company size (n= 366)

	Location						
Company size	**Central Europe**	**Western Europe**	**Northern Europe**	**Southern Europe**	**Eastern Europe**	**COSME non-EU**	**Total**
	n=121	n=45	n=36	n=105	n=39	n=20	n=366
Large companies (250-2 000 employees)	24.0%	17.8%	13.9%	8.6%	30.8%	0%	17.2%
Medium-sized companies (50-249 employees)	57.0%	46.7%	50.0%	41.0%	46.2%	80.0%	50.5%
Small and micro companies (1-49 employees)	19.0%	35.6%	36.1%	50.5%	23.1%	20.0%	32.2%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: Own analysis

On average, the majority of respondents only have manufacturing operations in their home country (60.1%). Considering the average size of the companies (Figure 7), this comes as no surprise. Hence, Table 7 provides an overview of the coverage of manufacturing operations according to company size. Large companies are operating relatively more in a number of countries compared to SMEs which tend to focus on their home country.

Figure 7: Coverage of manufacturing operations (n=461)



Source: Own analysis

Table 7: Coverage of manufacturing operations over company size (n=458)

	Coverage of manufacturing operations		
Company size	**Manufacturing operations only in the home country**	**Manufacturing operations in a number of countries**	**Total**
	n=274	n=184	n=458
Large companies (250-2 000 employees)	13.1%	25.0%	17.9%
Medium-sized companies (50-249 employees)	55.1%	48.9%	52.6%
Small and micro companies (1-49 employees)	31.8%	26.1%	29.5%
Total	**100%**	**100%**	**100%**

Source: Own analysis

The international character of companies differs across the selected sectors. Companies active in the food, beverages and tobacco industry in our sample tend to concentrate their activities in the home country (78.7%), while several companies active in transport equipment operate in a number of countries.

Table 8: Coverage of manufacturing activities over various sectors (n=459)

	Coverage of manufacturing operations		
Sector	**Manufacturing operations only in the home country**	**Manufacturing operations in a number of countries**	**Total**
	n=275	n=184	n=459
Food, beverages, tobacco industry (NACE 10 12)	78.7%	21.3%	100%
Chemical industry (NACE 20 21)	65.9%	34.1%	100%
Rubber and plastic industry (NACE 22 23)	57.8%	42.2%	100%
Metal industry (NACE 24 25)	55.2%	44.8%	100%
Electronic and electrical equipment (NACE 26 27)	58.3%	41.7%	100%
Machinery (NACE 28)	52.1%	47.9%	100%
Transport equipment (NACE 29 30)	30.4%	69.6%	100%
Other	62.2%	37.8%	100%

Note: Figures in brackets refer to NACE, rev. 2

Source: Own analysis

Looking at the coverage of manufacturing activities across regions, it can be noted that Western European companies tend to operate in more countries, while several Southern and Eastern European companies operate only in the home country.

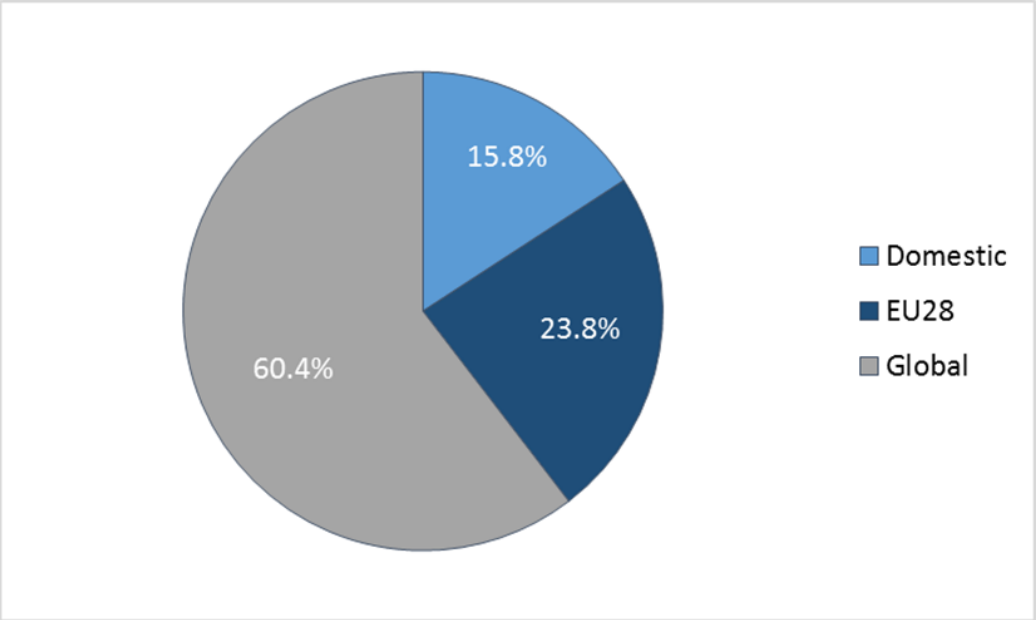
Table 9: Coverage of manufacturing activities over various locations (n=349)

	Coverage of manufacturing operations		
Location	**Manufacturing operations only in the home country**	**Manufacturing operations in a number of countries**	**Total**
	n=205	n=144	n=349
Central Europe	55.1%	44.9%	100%
Western Europe	44.7%	55.3%	100%
Northern Europe	56.3%	43.8%	100%
Southern Europe	63.5%	36.5%	100%
Eastern Europe	75.7%	24.3%	100%
COSME non-EU	55.0%	45.0%	100%
Total	**58.7%**	**41.3%**	**100%**

Source: Own analysis

The questionnaire also provided insights into market coverage, in addition to the coverage of manufacturing operations. It is not because a company only operates manufacturing operations locally that they cannot serve customers from a variety of countries. Figure 8 clearly shows that the majority of companies in our sample serve clients on a global scale (60.4%). A minority, only 15.8%, serve only their domestic market. Not surprisingly, mainly SMEs serve primarily local markets (see Table 10). However, it can be noted that a large proportion of the medium-sized companies with 50 to 249 employees tend to serve EU28 and international markets.

Figure 8: Coverage of market activities (n=480)



Source: Own analysis

Table 10: Coverage of market activities over company size (n=475)

	Market coverage			
Company size	**Domestic**	**EU28**	**Global**	**Total**
	n=75	n=113	n=287	n=475
Large companies (250-2 000 employees)	8.0%	12.4%	22.3%	17.7%
Medium-sized companies (50-249 employees)	37.3%	56.6%	53.3%	51.6%
Small and micro companies (1-49 employees)	54.7%	31.0%	24.4%	30.7%
Total	100%	100%	100%	100%

Source: Own analysis

The majority of companies that have a domestic market coverage, operate manufacturing operations from their home country (89.9%). Companies with a EU28 market coverage also tend to operate from their home country, although 38.9% operates manufacturing operations in several countries. Companies that cover the global market also tend to operate from multiple countries.

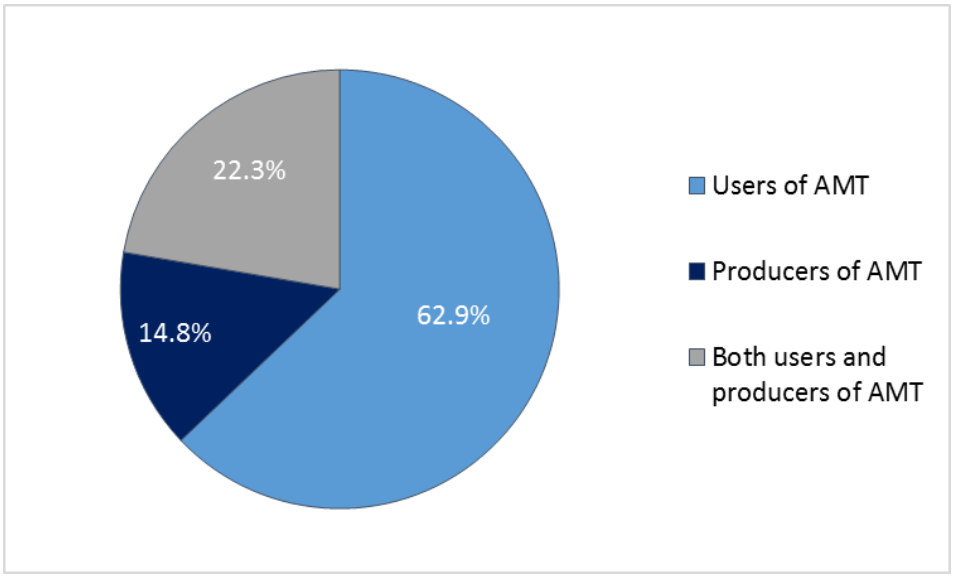
Table 11: Coverage of manufacturing and market activities (n=459)

	Market coverage			
Coverage of manufacturing operations	**Domestic**	**EU28**	**Global**	**Total**
	n=69	n=108	n=282	n=459
Manufacturing operations only in the home country	89.9%	61.1%	52.5%	60.1%
Manufacturing operations in a number of countries	10.1%	38.9%	47.5%	39.9%
Total	**100%**	**100%**	**100%**	**100%**

Source: Own analysis

An important variable for the analysis of the data is whether a company is a user or producer of AMT. As some companies are both users and producers, this option was also included in the questionnaire. 22.3% of the respondents are both users and producers, and they were asked to fill in the questionnaire from a user's perspective. The majority of companies (62.9%) that completed the questionnaire are users. This group of companies is well placed to provide insights on drivers and barriers related to the diffusion of AMT. 14.8% of the respondents indicate that they are a producer of AMT. They responded to the questionnaire from their own perspective, but were also asked to give their opinion from the perspective of their customers.

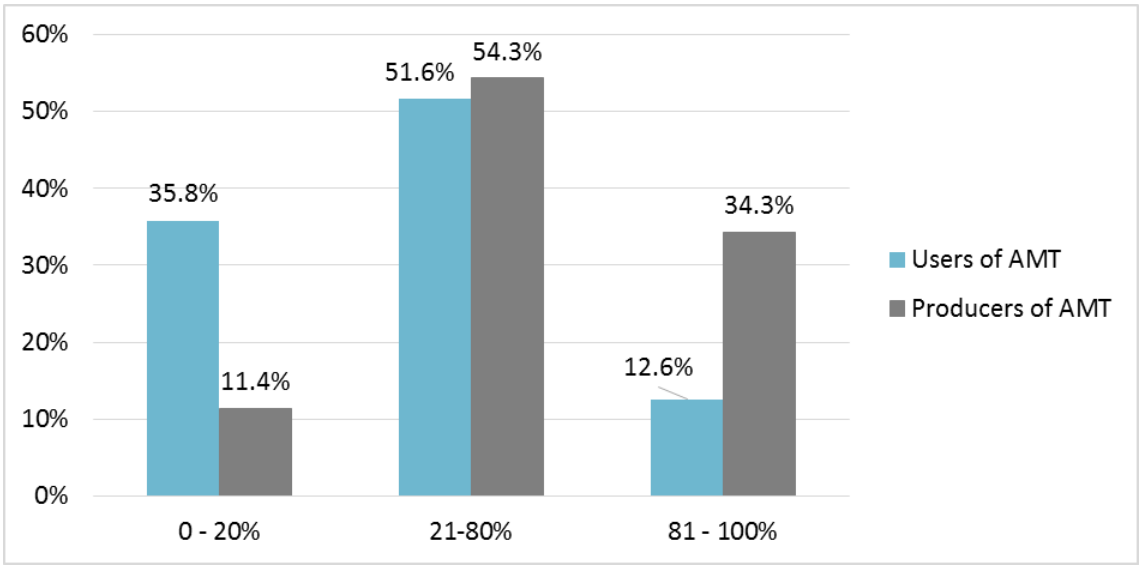
Figure 9: Users or producers of AMT (n=345)



Source: Own analysis

The users of AMT were also questioned about the percentage of their sales that products based on AMT represent (Figure 10). About 35.8% of the respondents has a share of 0-20% of their sales produced by using AMT, while 12.6% of the respondents has a share of 81-100%. Respondents who are producers have a higher share of 81-100% sales: 34.3%.

Figure 10: Percentage of sales produced using AMT (user perspective, n=215; and producer perspective, n=35)



Source: Own analysis

Looking at the company size of users, Table 12 shows that the highest share of sales produced by using AMT for small and micro companies is a share of between 0-20%. For large and medium-sized companies, the highest share of sales produced by using AMT is between 21-80%.

Table 12: Percentage of sales produced using AMT by company size (user perspective) (n=214)

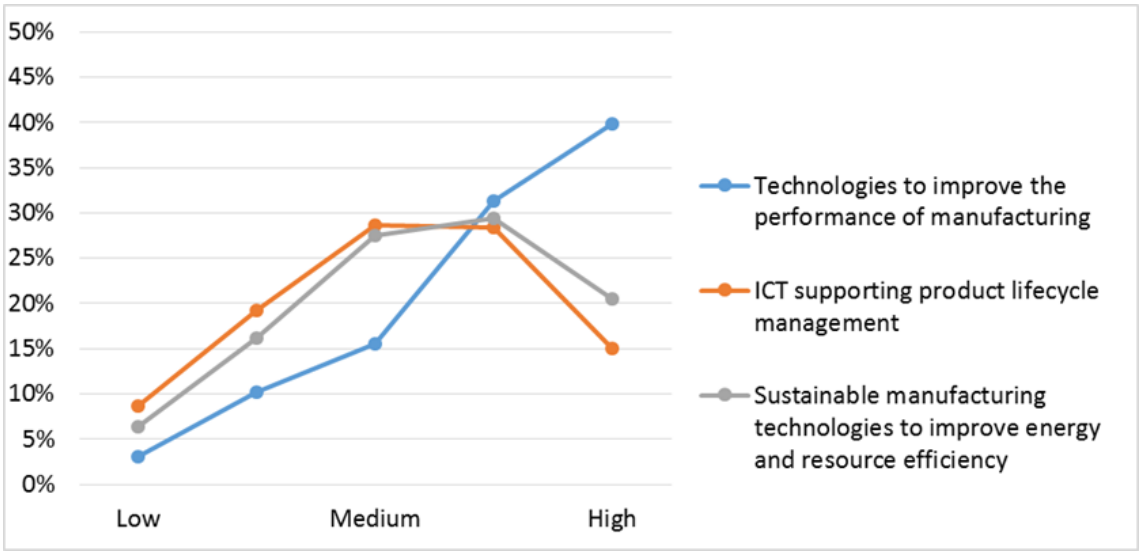
	Company size			
	Large companies (250-2 000 employees)	**Medium-sized companies (50-249 employees)**	**Small and micro companies (1-49 employees)**	**Total**
	n=43	n=124	n=47	n=214
0-20%	25.0%	38.0%	61.5%	37.1%
21-80%	55.6%	51.0%	34.6%	50.0%
81-100%	19.4%	11.0%	3.8%	12.9%
Total	**100%**	**100%**	**100%**	**100%**

Source: Own analysis

3.3.2 AMT profile

Three types of AMT were distinguished: high performance manufacturing technologies, ICT-enabled technologies and sustainable manufacturing technologies. Companies were asked to indicate the relevance of each type of AMT to their company on a scale of 1 (low) to 5 (high relevance for the company). As Figure 11 shows, technologies to improve the performance of manufacturing and enable innovative manufacturing processes are found to be highly relevant. The distribution of relevance of high performance technologies is increasing: a small amount of respondents (3%) indicated that high performance technologies have low relevance, while a large amount of respondents (40%) indicated the high relevance of high performance technologies. The distribution of relevance of the ICT-enabled and sustainable manufacturing technologies is more inverse U-shaped, with a lower amount of low and high relevance responses and a higher amount of medium relevance responses. On average, high performance technologies are more relevant than sustainable manufacturing technologies which are in turn more relevant than ICT-enabled technologies (on average 3.4 for sustainable manufacturing technologies, 3.2 for ICT-enabled technologies vs. 3.9 for high performance technologies).

Figure 11: Distribution of relevance of AMT (n=359-361)



Note: Scale 1 (Low) – 5 (High)

Source: Own analysis

Table 13 provides more detailed insights on the response rate compared to Figure 11. A difference is seen between high relevance versus low and medium relevance as for the analysis of various types of AMT, only the companies that considered the technology to be of high relevance are taken into account. 71.2% of respondents considered high performance manufacturing technologies to be of high relevance, but only 50.0% of the respondents in the case of sustainable manufacturing technologies did. However, of those respondents who indicated that sustainable manufacturing is only of low or medium relevance to them, several indicated that another type of AMT is of high relevance. There are multiple respondents who indicated more than one type of AMT as being of high relevance, whereas it is interesting to see that only 20.8% did not indicate a single high relevance for any type of AMT for their company. Of the respondents who indicated high relevance for a specific type, 26.0% indicated a high relevance for all three types of AMT (see Table 12).

Table 13: Overview of the (high versus low) relevance of AMT (n=361)

	High performance	***ICT-enabled***	***Sustainable***
	N (%)	N (%)	N (%)
High relevance[6]	257 (71.2%)	156 (43.5%)	180 (50.0%)
Low-medium relevance[7]	104 (28.8%)	203 (56.5%)	180 (50.0%)
Total	**361 (100%)**	**359 (100%)**	**360 (100%)**

Source: Own analysis

[6] High relevance: Respondent indicated 4 or 5 on a scale of 1 (low) to 5 (high relevance).

[7] Low-medium relevance: Respondent indicated 1, 2 or 3 on a scale of 1 (low) to 5 (high relevance).

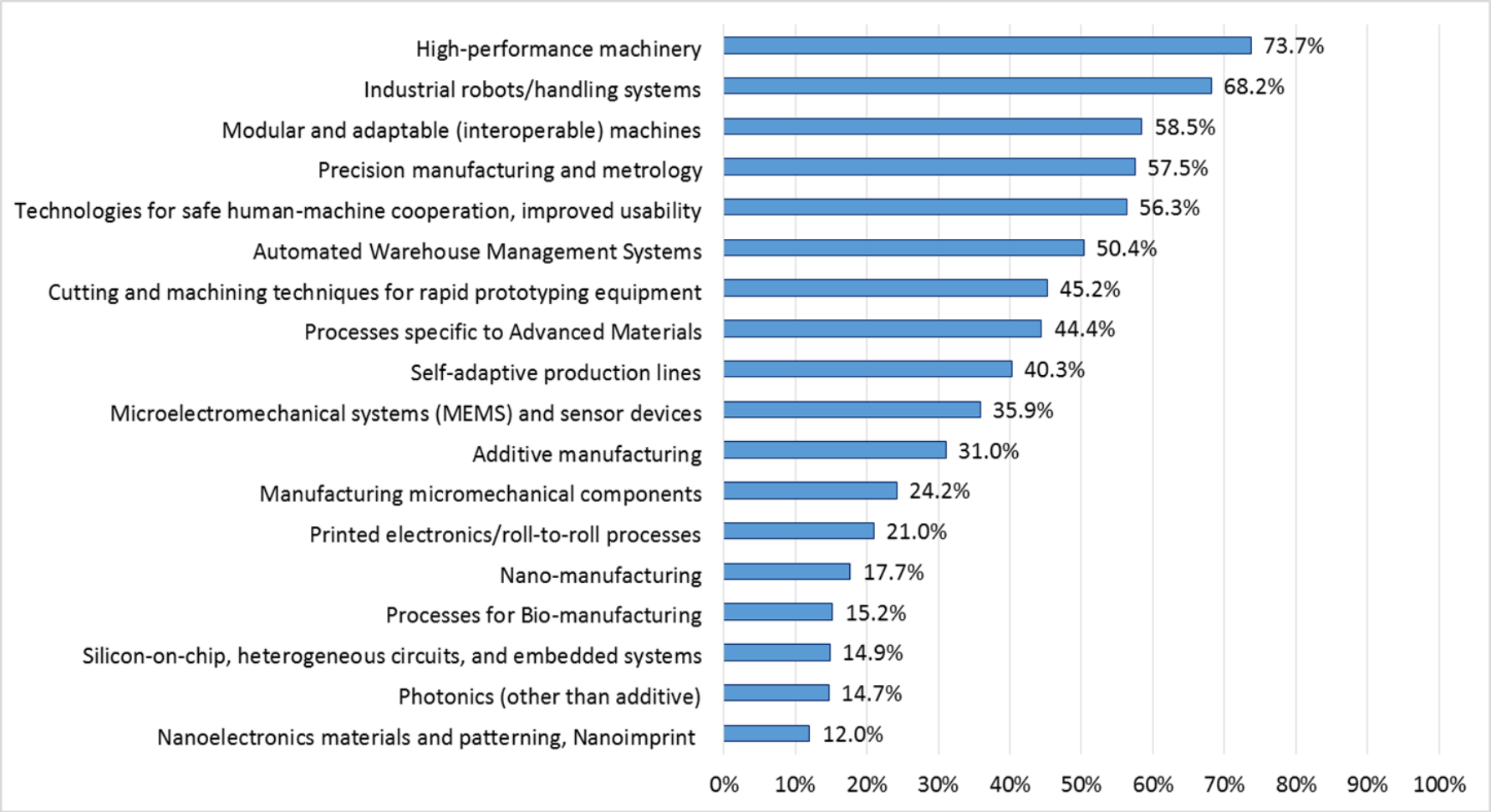
Table 14: Overview of the high relevance of AMT (n=365)

	%	N
High relevance of 1 AMT	21.9%	80
High performance		*61*
ICT-enabled		*10*
Sustainable		*9*
High relevance of 2 AMT	31.2%	114
High performance and ICT-enabled		38
ICT-enabled and Sustainable		13
High performance and Sustainable		63
High relevance of 3 AMT	26.0%	95
Low-medium relevance of AMT	20.8%	76
Total	**100%**	**365**

Source: Own analysis

Respondents could also indicate those specific high performance technologies that are relevant to their production processes. High performance machinery and industrial robots/handling systems are found to be very relevant whereas process for bio-manufacturing; silicon-on-chips, heterogeneous circuits and embedded systems; photonics; and nano-electronics materials and patterning, nano-imprint are considered to be of less relevance (see Figure 12). Hence, more traditional AMT like robotics are perceived as more relevant, compared to more innovative AMT such as nano-electronics materials, which are rather push technologies and probably less known to companies. In ICT-enabled technologies, supply chain management with suppliers/customers, network-centric production, optimisation of production networks; enterprise resource planning; and product life cycle management systems, product data management systems are considered the most relevant technologies (see Figure 13). Control system for shutting down machines; recycling and waste/disposal management technologies; and product life cycle optimisation, service life optimisation are the most relevant sustainable manufacturing technologies (see Figure 14). On average, no single technology is perceived as predominantly important. This points towards the multidisciplinary character of industrial applications and the importance of integrating several technologies.

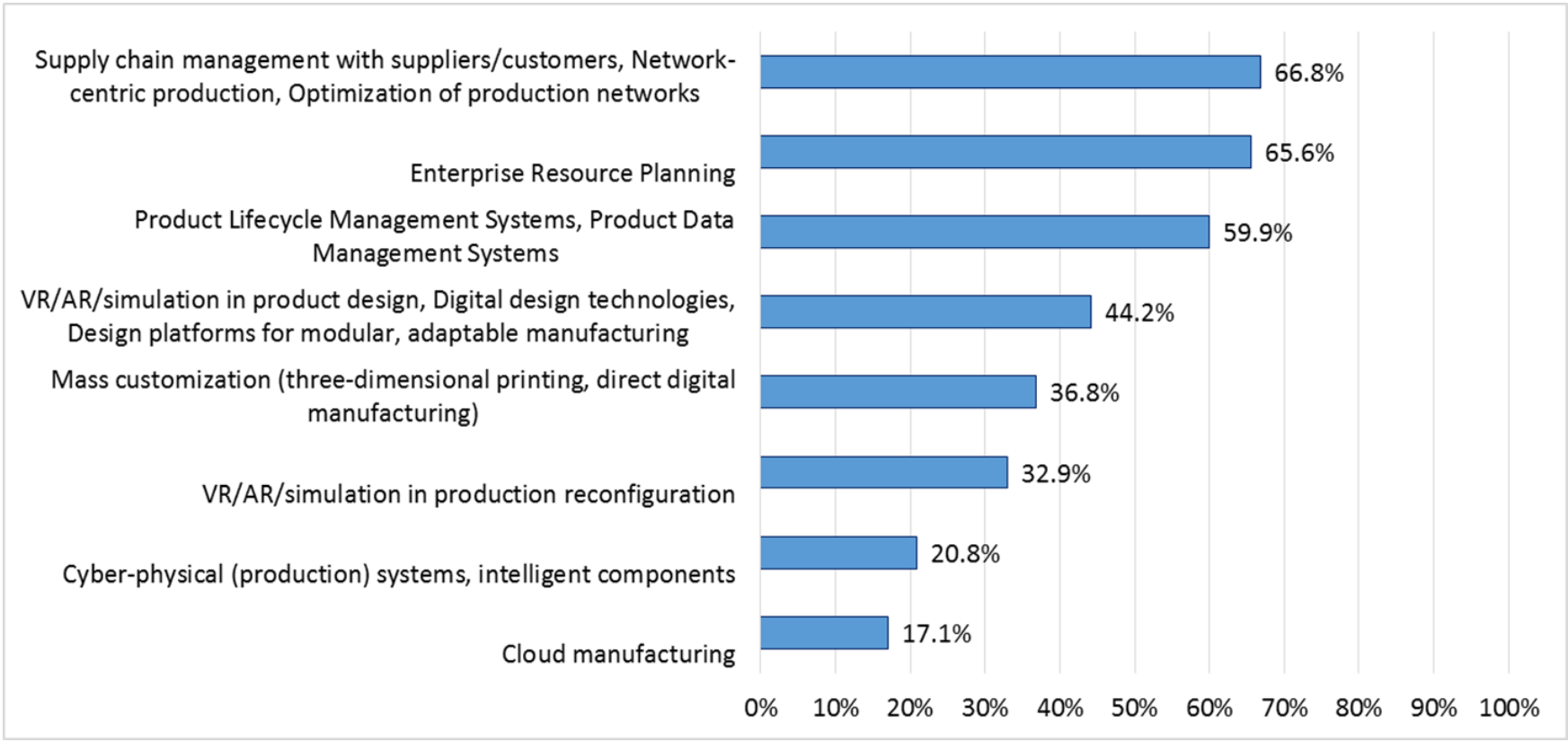
Figure 12: Relevance of specific high performance manufacturing technologies (in %) (n=258-266)



Note: Scale 0 (Not relevant) – 1 (Relevant)

Source: Own analysis

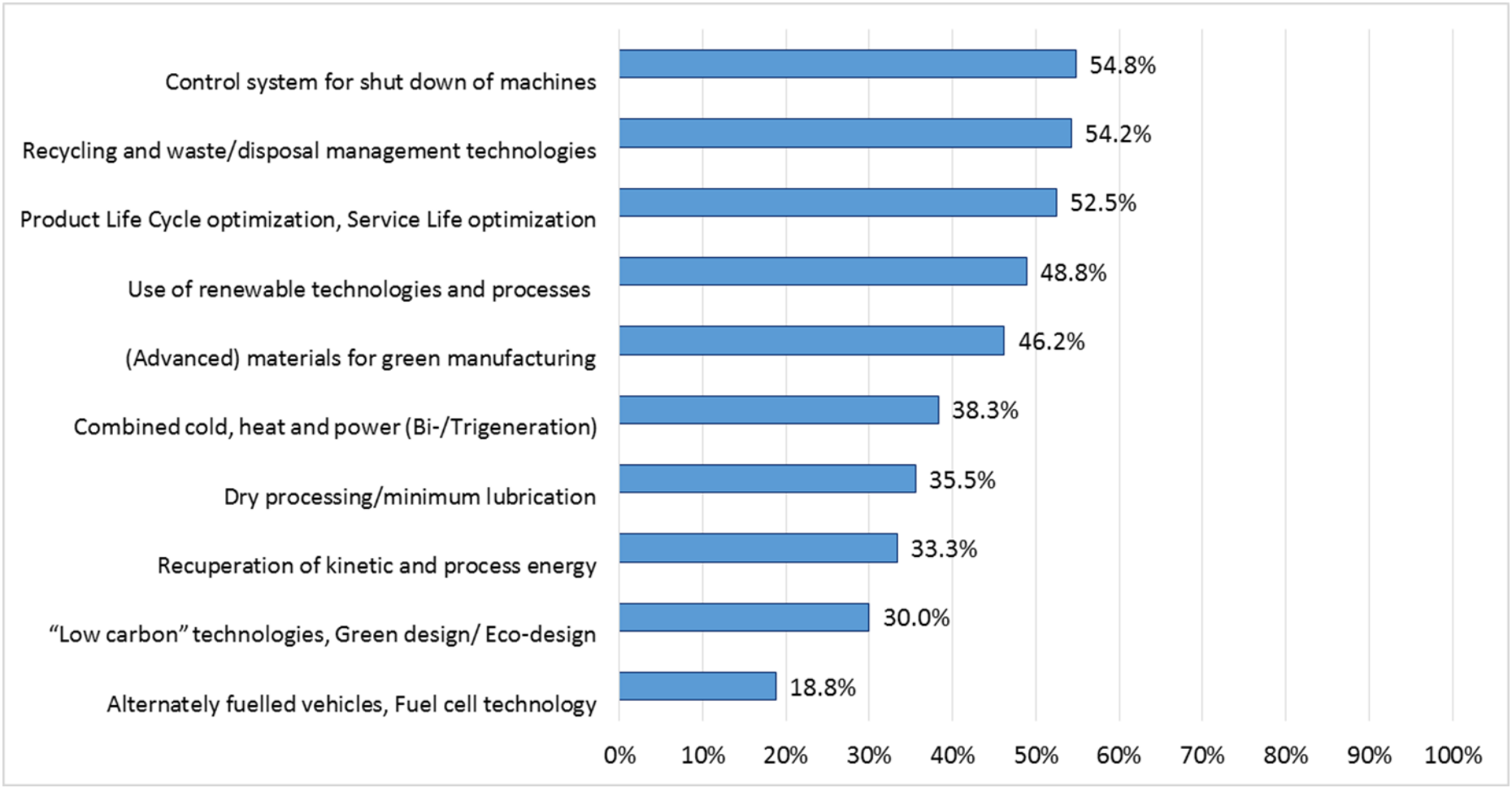
Figure 13: Relevance of ICT-enabled technologies (in %) (n=253-258)



Note: Scale 0 (Not relevant) – 1 (Relevant)

Source: Own analysis

Figure 14: Relevance of Sustainable Manufacturing Technologies (in %) (n=259-262)



Note: Scale 0 (Not relevant) – 1 (Relevant)

Source: Own analysis

On average, the respondents who are both users and producers of AMT have a higher relevance in all the three types compared to companies who are users or producers of AMT. Producers give, on average, a higher relevance to high performance technologies than users (4.1 versus 3.9), while users give, on average, a higher relevance to sustainable manufacturing technologies (3.4) compared to producers (3.1). Users and producers indicate a similar relevance for ICT-enabled technologies.

Table 15: Average relevance of AMT by user/producer (n = 340)

	High performance	***ICT-enabled***	***Sustainable***
	n=340	n=338	n=337
Users of AMT	3.9	3.2	3.4
Producers of AMT	4.1	3.2	3.1
Both users and producers of AMT	4.1	3.4	3.7
Total	**4.0**	**3,3**	**3.4**

Note: Scale 1 (Low) – 5 (High)

Source: Own analysis

Looking at the relevance of types of AMT by company size, Table 16 shows that for large companies, high performance manufacturing technologies are very relevant (4.2). Also ICT-enabled technologies and sustainable manufacturing technologies are on average highly relevant for large companies. Small and micro companies perceived all types of AMT as less relevant compared to large companies.

Table 16: Average relevance of AMT by company size (n=358)

Company size	***High performance***	***ICT-enabled***	***Sustainable***
	n=358	n=356	n=356
Large companies (250-2 000 employees)	4.2	3.4	3.8
Medium-sized companies (50-249 employees)	4.1	3.2	3.5
Small and micro companies (1-49 employees)	3.6	3.2	3.2
Total	**4.0**	**3.2**	**3.4**

Note: Scale 1 (Low) – 5 (High)

Source: Own analysis

Table 17 provides an overview of the average relevance of the various types of AMT by sector. The food, beverages, and tobacco industry is the only sector for which the relevance of high performance technologies is not on top. For this sector, sustainable manufacturing technologies are of relatively higher importance. ICT-enabled technologies are of high relevance to the electronic and electrical equipment and transport equipment sectors. In turn, both sectors consider sustainable manufacturing to be of less relevance.

Table 17: Average relevance of AMT by sector (n=293-299)

Sector	*High performance*	*ICT-enabled*	*Sustainable*
Food, beverages, tobacco industry (NACE 10 12)	3.8	3.3	3.8
Chemical industry (NACE 20 21)	4.1	3.3	3.7
Rubber and plastic industry (NACE 22 23)	4.0	2.7	3.4
Metal industry (NACE 24 25)	4.0	3.3	3.6
Electronic and electrical equipment (NACE 26 27)	4.0	3.4	3.1
Machinery (NACE 28)	4.0	3.2	3.3
Transport equipment (NACE 29 30)	3.8	3.6	3.3
Other	3.9	2.9	3.8

Note: Scale 1 (Low) – 5 (High)

Note: Figures in brackets refer to NACE, rev. 2

Source: Own analysis

For companies located in Western, Northern and COSME non-EU countries, high performance technologies are of high relevance (on average above 4.0). ICT-enabled technologies prove to be most relevant in Eastern Europe (3.5) and COSME non-EU countries (3.6), while sustainable manufacturing technologies are most relevant for Central Europe (3.5) and COSME non-EU countries (4.0). It has to be noted that COSME non-EU countries only represent a small sample size. For all regions, high performance technologies are the type of AMT with the highest relevance.

Table 18: Average relevance of AMT by location headquarters (n=279)

Location	*High performance*	*ICT-enabled*	*Sustainable*
	n=281	n=279	n=279
Central Europe	3.9	3.1	3.5
Western Europe	4.1	3.2	3.4
Northern Europe	4.2	3.3	3.2
Southern Europe	3.8	3.3	3.3
Eastern Europe	3.9	3.5	3.6
COSME non-EU[8]	4.0	3.6	4.0
Total	**3.9**	**3.3**	**3.4**

Note: Scale 1 (Low) – 5 (High)

Source: Own analysis

In addition to various types of AMT, the respondents were asked to assess their company's level of capacity with respect to:

- Product and service technology;
- Production technology;
- Use of ICT;
- Management processes to improve technological level.

[8] Only 8 companies from COSME non-EU countries responded to this question.

Most respondents considered their company to be around the industry average. Product and service technology and production technology, on average, scored slightly above the industry average while the use of ICT and management processes to improve technological level was scored slightly below industry average.

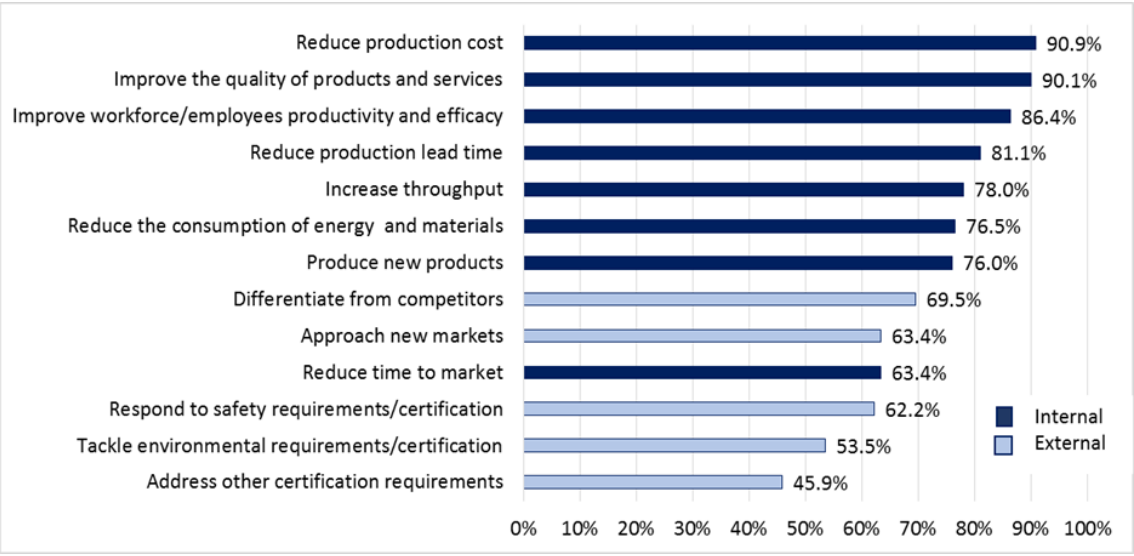
3.4 Drivers to invest in AMT

3.4.1 General findings

Figure 15 provides an overview of the various drivers to invest in AMT. The top three drivers are: reduction of production cost, improving the quality of products and services, and improving workforce/employee productivity and efficacy. Between 86.4% and 90.9% of the respondents indicated these drivers were the main objectives for their company to invest in AMT. Less than 50% of the respondents indicated that addressing other certification requirements is a driver to invest in AMT.

The various drivers to invest in AMT can be divided into internal and external drivers for the companies. Internal drivers refer to those that are the direct responsibility of a company and which management can influence directly. External drivers refer to those that take place outside the company and result from developments outside the company, over which the company itself has little influence. Figure 15 clearly indicates that the internal drivers (dark blue bars) are more frequently (63.4-90.9%) indicated by respondents as objectives than the external ones (light blue bars) (45.9-69.5%). It seems that the main goals of SMEs and large companies with less than 2 000 employees are to increase efficiency and quality, where they expect AMT to play a role.

Figure 15: Drivers to invest in AMT (user perspective) (n=141-143)

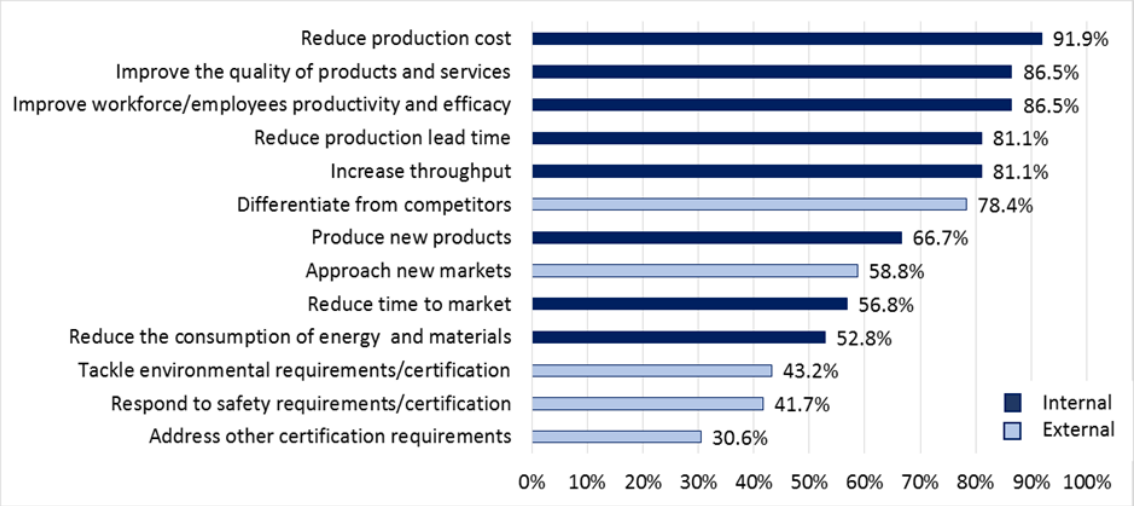


Note: Scale 0 (no objective) – 1 (objective)

Source: Own analysis

Figure 16 shows that producers have a similar perspective regarding users' drivers for AMT investment as the users themselves. Producers slightly over-rate their customers' external driver to stand out from competitors (78.4%) compared to users (69.5%). Table 19 provides a more detailed overview of the differences between users and producer perspective (regarding their users). 53% of the producers indicated that the reduction in consumption of energy and materials is a driver for their users to invest in AMT. 77% of the users themselves indicated that the reduction in consumption of energy and materials is a driver for investing. The reduction in consumption of energy and materials is more frequently a driver for users than producers perceive. The same is applicable to the external drivers that respond to safety requirements/certifications and addressing other certification requirements, where users indicate it more frequently as a driver than producers perceive.

Figure 16: Drivers to invest in AMT (producer perspective regarding users) (n=34-37)



Note: Scale 0 (no objective) – 1 (objective)
Source: Own analysis

Finally, producers indicated that the most important driver to invest in AMT is the further development of the existing product portfolio (Figure 17). Other frequent drivers were: specific requests from existing or potential customers (associations), development of new business options based on existing technological competencies and the possible long-term market opportunity. Evidence for short-term market opportunities as well as new input and inspiration from public research organisations were less frequently indicated as drivers to invest (45.2% and 28.6%, respectively). Seemingly, public research is not a motivation for producers to develop and sell AMT.

Table 19: Drivers to invest in AMT: users versus producers perspective (n=277-280)

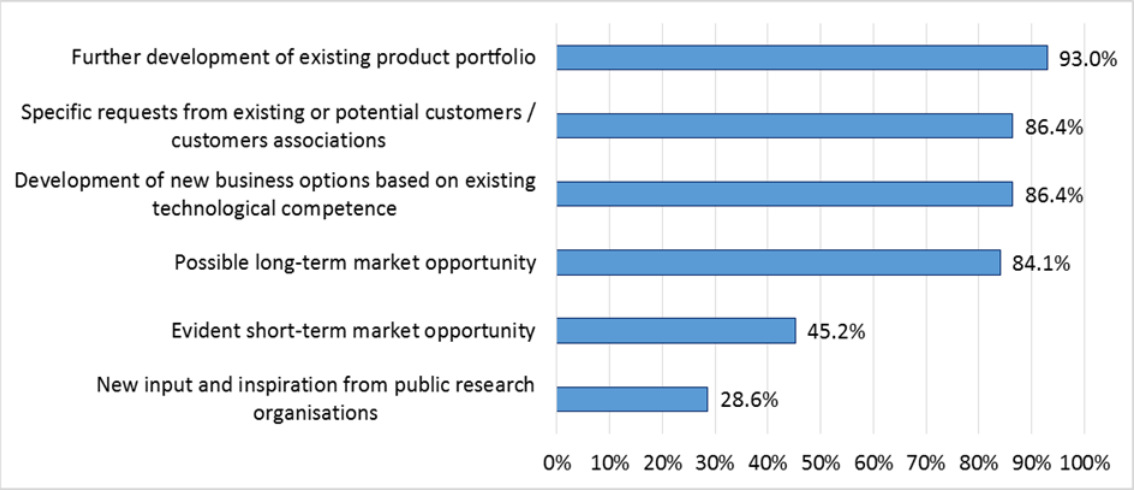
	Users[9]	Producers	Difference
	n=241-243	n=34-36	
Internal drivers			
Increase throughput	78.0%	81.1%	-3.1%
Reduce production lead time	81.1%	81.1%	0.0%
Reduce time to market	63.4%	56.8%	6.6%
Reduce production cost	90.9%	91.9%	-1.0%
Improve workforce/employee productivity and efficacy	86.4%	86.5%	-0.1%
Reduce the consumption of energy and materials	76.5%	52.8%	23.7%***
Improve the quality of products and services	90.1%	86.5%	3.6%
Produce new products	76.0%	66.7%	9.3%
External drivers			
Approach new markets	63.4%	58.8%	4.6%
Differentiate from competitors	69.5%	78.4%	-8.9%
Respond to safety requirements/certification	62.2%	41.7%	20.5%**
Tackle environmental requirements/certification	53.5%	43.2%	10.3%
Address other certification requirements	45.9%	30.6%	15.3%*

Note: Scale 0 (no objective) – 1 (objective)

Note: * significant at the 1% level, ** significant at the 5% level, *** significant at the 10% level

Source: Own analysis

Figure 17: Drivers to invest in AMT (producer perspective) (n=42-44)



Note: Scale 0 (no objective) – 1 (objective)

Source: Own analysis

[9] The respondents which indicated that they are both user and producer of advanced manufacturing equipment and technologies were asked to fill in the questionnaire from a user perspective.

3.4.2 Specific findings

3.4.2.1 Technology/AMT specific findings

In this study, three types of AMT are discussed: high performance technologies, ICT-enabled technologies and sustainable manufacturing technologies. Table 20 provides an overview of the various drivers distinguishing the three different AMT (for respondents who indicated high relevance of the specific technology to their company)[10].

The top three drivers that were previously identified relate to three types of technologies frequently indicated as drivers. Users which indicated the high relevance of sustainable manufacturing technologies more frequently indicated the reduction in consumption of energy and materials (87.3%) and tackling the environmental requirements/certification (64.7%) than high performance and ICT-enabled technologies.

Table 20: Drivers by type of AMT (user perspective) (n=106-184)

	High performance	ICT-enabled	Sustainable manufacturing
	n=184-186	n=106-108	n=132-134
Internal drivers			
Increase throughput	80.4%	77.4%	83.5%
Reduce production lead time	83.3%	83.3%	82.1%
Reduce time to market	67.2%	75.0%	68.7%
Reduce production cost	91.9%	92.6%	94.8%
Improve workforce/employee productivity and efficacy	86.0%	87.0%	88.1%
Reduce the consumption of energy and materials	76.3%	79.6%	87.3%
Improve the quality of products and services	93.0%	93.5%	92.5%
Produce new products	78.9%	82.2%	78.4%
External drivers			
Approach new markets	65.1%	65.7%	63.4%
Differentiate from competitors	74.7%	74.1%	73.1%
Respond to safety requirements/certification	64.3%	69.8%	67.4%
Tackle environmental requirements/certification	54.9%	57.0%	64.7%
Address other certification requirements	49.2%	50.9%	56.4%

Note: Scale 0 (no objective) – 1 (objective)

Source: Own analysis

[10] Only respondents that answered highly relevant e.g. 4 or 5 on a scale of 1 (low) to 5 (high relevance) are considered in this analysis

3.4.2.2 Findings related to location

Table 21 provides an overview of the various drivers of AMT by location of a company's headquarters. All regions are very concerned with the reduction in production costs. Western European companies seem to give high priority to efficiency, services and external drivers, while Southern European companies seem rather to tackle services in terms of reduction in production lead time (86.8%) and costs (88.7%), and improving the quality of products and services (90.6%). Both Western and Southern European companies are motivated by the external driver to differentiate themselves from competitors.

Table 21: Drivers by location (user perspective) (n=187-189)

	Central Europe	Western Europe	Northern Europe	Southern Europe	Eastern Europe	COSME non-EU[11]	Total
	n=67-68	n=23	n=15	n=52-53	n=20	n=8-10	n=187-189
Internal drivers							
Increase throughput	80.9%	91.3%	80.0%	65.4%	70.0%	100.0%	77.7%
Reduce production lead time	75.0%	95.7%	80.0%	86.8%	90.0%	70.0%	82.5%
Reduce time to market	51.5%	78.3%	60.0%	71.7%	65.0%	80.0%	64.0%
Reduce production cost	88.2%	91.3%	93.3%	88.7%	90.0%	100.0%	89.9%
Improve workforce/employee productivity and efficacy	89.7%	91.3%	80.0%	79.2%	95.0%	90.0%	86.8%
Reduce the consumption of energy and materials	77.9%	65.2%	60.0%	75.5%	85.0%	100.0%	76.2%
Improve the quality of products and services	89.7%	73.9%	86.7%	90.6%	100.0%	90.0%	88.9%
Produce new products	66.2%	78.3%	80.0%	73.6%	75.0%	90.0%	73.0%
External drivers							
Approach new markets	47.1%	82.6%	66.7%	58.5%	70.0%	100.0%	61.4%
Differentiate from competitors	51.5%	87.0%	53.3%	79.2%	65.0%	80.0%	66.7%
Respond to safety requirements/certification	56.7%	52.2%	66.7%	56.6%	80.0%	77.8%	60.4%
Tackle environmental requirements/certification	58.8%	43.5%	26.7%	49.1%	70.0%	100.0%	54.5%
Address other certification requirements	39.7%	43.5%	40.0%	35.8%	60.0%	80.0%	43.4%

Note: Scale 0 (no objective) – 1 (objective)

Source: Own analysis

[11] Only a limited number of responses were obtained from COSME countries which are not part of the EU. Therefore, this region was not further analysed in detail.

For companies with headquarters in Western Europe, approaching a new market is more frequently indicated as a driver than in Central Europe (82.6% versus 47.1%). Differentiating the company from competitors is for respondents in Central Europe, Northern Europe and Eastern Europe (51.5-65.0%) less frequently a driver for investing in AMT than for Western and Southern Europe (79.2-87.0%). Eastern European companies more frequently indicate tackling environmental requirements/certification (70.0%) as a driver than Northern Europe (26.7%). The same applies to the reduction in consumption of energy and materials: 85.0% of respondents in Eastern Europe indicated it as a driver, compared to 60.0% in Northern Europe. It appears that other regions seem to care less about the environment and certification issues than Eastern Europe. This may be due to the fact that companies in these regions have already tackled these issues in the past, whereas Eastern European companies are now concerned with coping with environmental standards and certification issues. To summarise, overall the regional differences are larger for external than for internal drivers.

3.4.2.3 Findings related to company size

SMEs consider differentiation from competitors as a driver more often than large companies (70.4%-72.7% versus 58.3%). On the other hand, increasing the throughput is less frequently a driver for small and micro companies: 58.5% versus 83.3%-84.1% for medium-sized and large companies. Small and micro companies are also less concerned with environmental requirements and certification (40.7%) (Table 22).

Table 22: Drivers by company size (user perspective) (n=239-241)

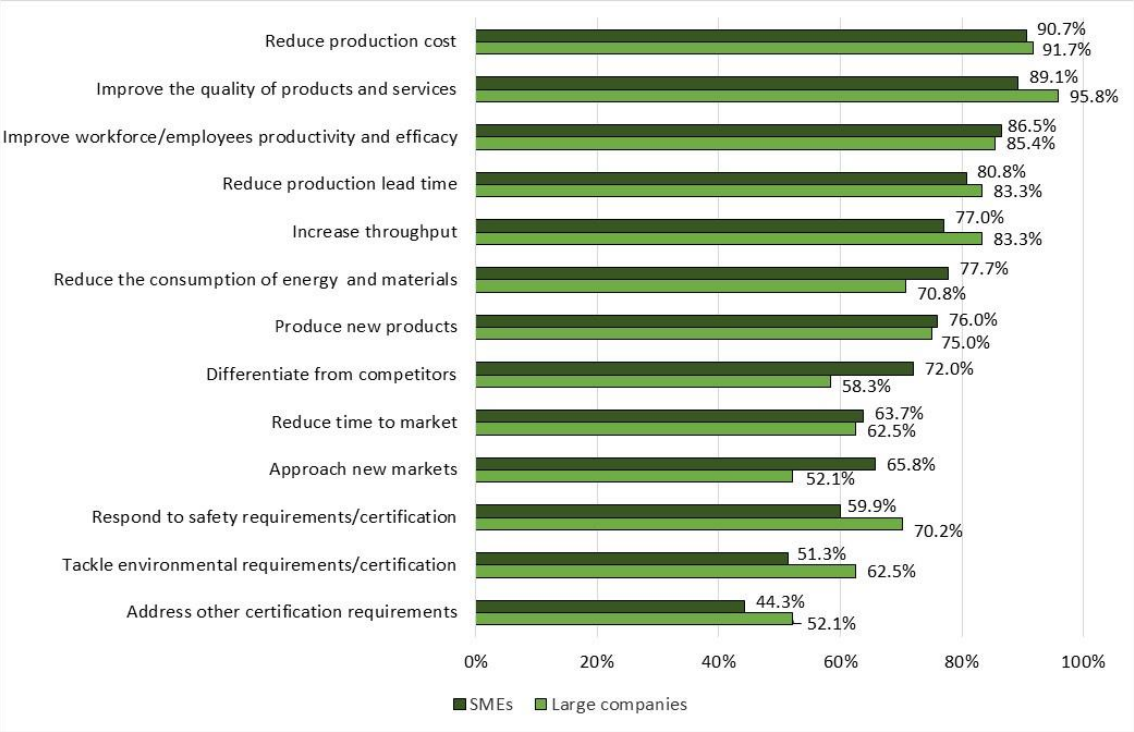
	Large companies	Medium-sized companies	Small and micro-companies	Total
	n=47-48	n=137-139	n=53-54	n=17
Internal drivers				
Increase throughput	83.3%	84.1%	58.5%	78.2%
Reduce production lead time	83.3%	84.9%	70.4%	81.3%
Reduce time to market	62.5%	62.6%	66.7%	63.5%
Reduce production cost	91.7%	94.2%	81.5%	90.9%
Improve workforce/employee productivity and efficacy	85.4%	89.9%	77.8%	86.3%
Reduce the consumption of energy and materials	70.8%	80.6%	70.4%	76.3%
Improve the quality of products and services	95.8%	90.6%	85.2%	90.5%
Produce new products	75.0%	76.3%	75.5%	75.8%
External drivers				
Approach new markets	52.1%	66.9%	63.0%	63.1%
Differentiate from competitors	58.3%	72.7%	70.4%	69.3%
Respond to safety requirements/certification	70.2%	63.8%	50.0%	61.9%
Tackle environmental requirements/certification	62.5%	55.5%	40.7%	53.6%
Address other certification requirements	52.1%	47.1%	37.0%	45.8%

Note: Scale 0 (no objective) – 1 (objective)

Source: Own analysis

The most important drivers for SMEs to invest in AMT are to reduce production costs (90.7%) and to improve the quality of products and services (89.1%) (Figure 18). For large companies (<2 000 employees), the most important driver is to improve the quality of products and services (95.8%). Approaching new markets and standing out from competitors seem to be more important for SMEs compared to large companies. Drivers related to certification, safety and environmental requirements are also more frequently identified by large companies.

Figure 18: Drivers by company type (user perspective) (n=239-241)



Note: Scale 0 (no objective) – 1 (objective)

Source: Own analysis

3.4.2.4 Findings related to company performance

Respondents with a high share of sales produced using AMT (81-100%) indicated more frequently that increased throughput and tackling environmental requirements/certification are drivers for investment in AMT, while they less frequently indicated that reduction of production lead time and reduction of time to market are drivers (see Table 23). Increased throughput is less frequently an internal driver for companies with a share of sales of 21-80% than for other companies.

Table 23: Drivers by performance (user perspective) (n=213-215)

	0-20%	*21-80%*	*81-100%*	*Total*
	n=76-77	n=110-111	n=26-27	n=213-215
Internal drivers				
Increase throughput	80.5%	74.5%	84.6%	77.9%
Reduce production lead time	80.5%	85.6%	70.4%	81.9%
Reduce time to market	59.7%	65.8%	55.6%	62.3%
Reduce production cost	90.9%	91.9%	85.2%	90.7%
Improve workforce/employee productivity and efficacy	83.1%	86.5%	88.9%	85.6%
Reduce the consumption of energy and materials	74.0%	74.8%	77.8%	74.9%
Improve the quality of products and services	87.0%	88.3%	100.0%	89.3%
Produce new products	76.3%	75.7%	74.1%	75.7%
External drivers				
Approach new markets	61.0%	60.4%	66.7%	61.4%
Differentiate from competitors	68.8%	67.6%	77.8%	69.3%
Respond to safety requirements/certification	57.1%	62.7%	66.7%	61.2%
Tackle environmental requirements/certification	49.4%	51.8%	55.6%	51.4%
Address other certification requirements	42.9%	44.5%	44.4%	43.9%

Note: Scale 0 (no objective) – 1 (objective)

Source: Own analysis

3.5 Barriers to the adoption of AMT

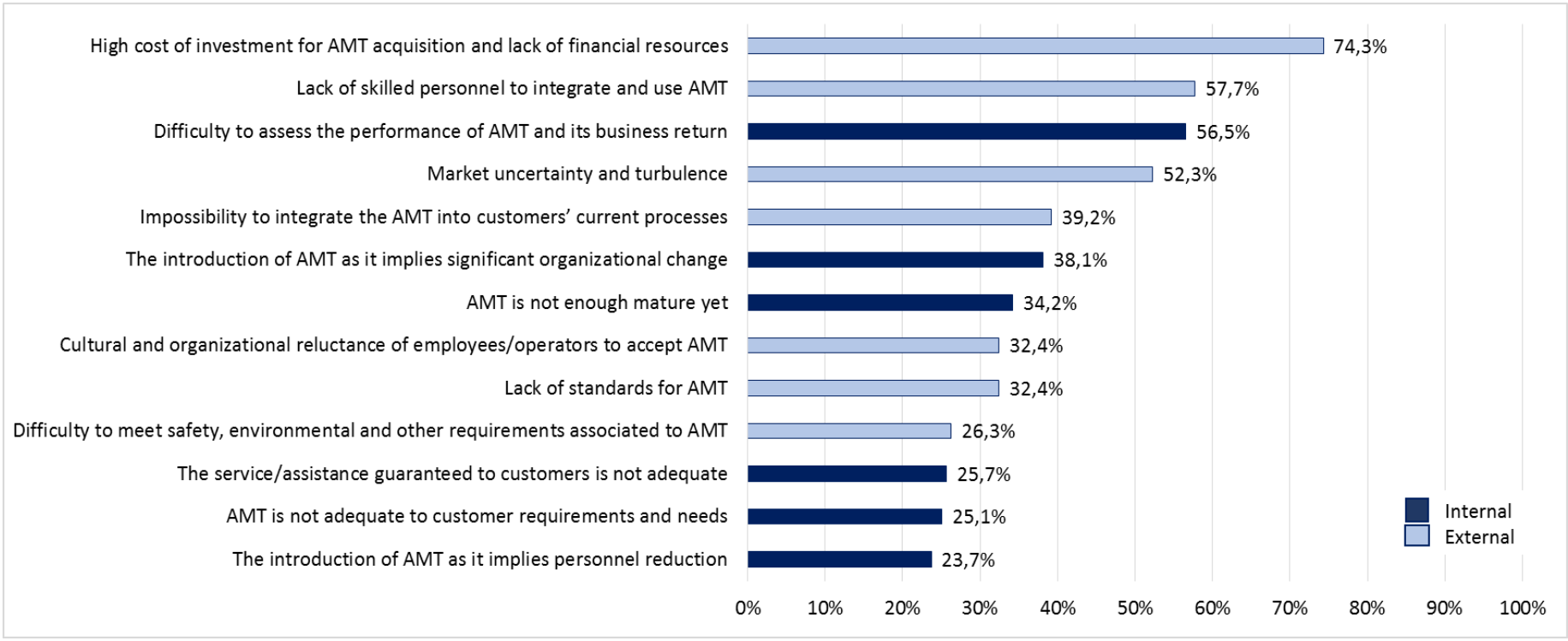
3.5.1 General findings

Figure 19 provides an overview of the various barriers to investing in AMT. The most important barrier was the high cost of investment for AMT acquisition and the lack of financial resources (74.3%). Between 52.3 and 57.7% of the respondents indicated difficulties in assessing the performance and business return, the lack of skilled personnel required to integrate and use AMT and market uncertainty and turbulence. Less frequent barriers were the inadequacy of the technologies in terms of customer requirements and needs and the personnel reduction implied by the introduction of it (25.1%).

As with the drivers, the barriers to invest in AMT can also be divided into internal and external barriers. Internal barriers refer to internal factors companies can influence directly and actively decide upon. External barriers refer to external factors that take place outside the company, resulting from developments outside the company and upon which the company itself has little influence. Figure 19 shows that, compared to the drivers, the barriers for users to investment in AMT are more evenly distributed between internal and external barriers. The most important barrier - high cost and financing - is an external barrier, while the least important barriers are internal to the company.

The producers indicated that lack of skilled personnel to integrate and use AMT and market uncertainty and turbulence are the most important barrier for their customers/users e.g. 74.3-75.0% (see Figure 20). Table 24 provides a more detailed overview of the differences between users and producer perspectives regarding their users. Producers, compared to users, more frequently think that the introduction of AMT is a barrier as it implies personnel reduction (41.2% versus 23.7%). Lack of skilled personnel to integrate and use AMT, market uncertainty and turbulence, and the cultural and organisational reluctance of employees/operators to accept AMT are also thought by producers to be more important barriers to investment (about their customers/users) than by the users themselves.

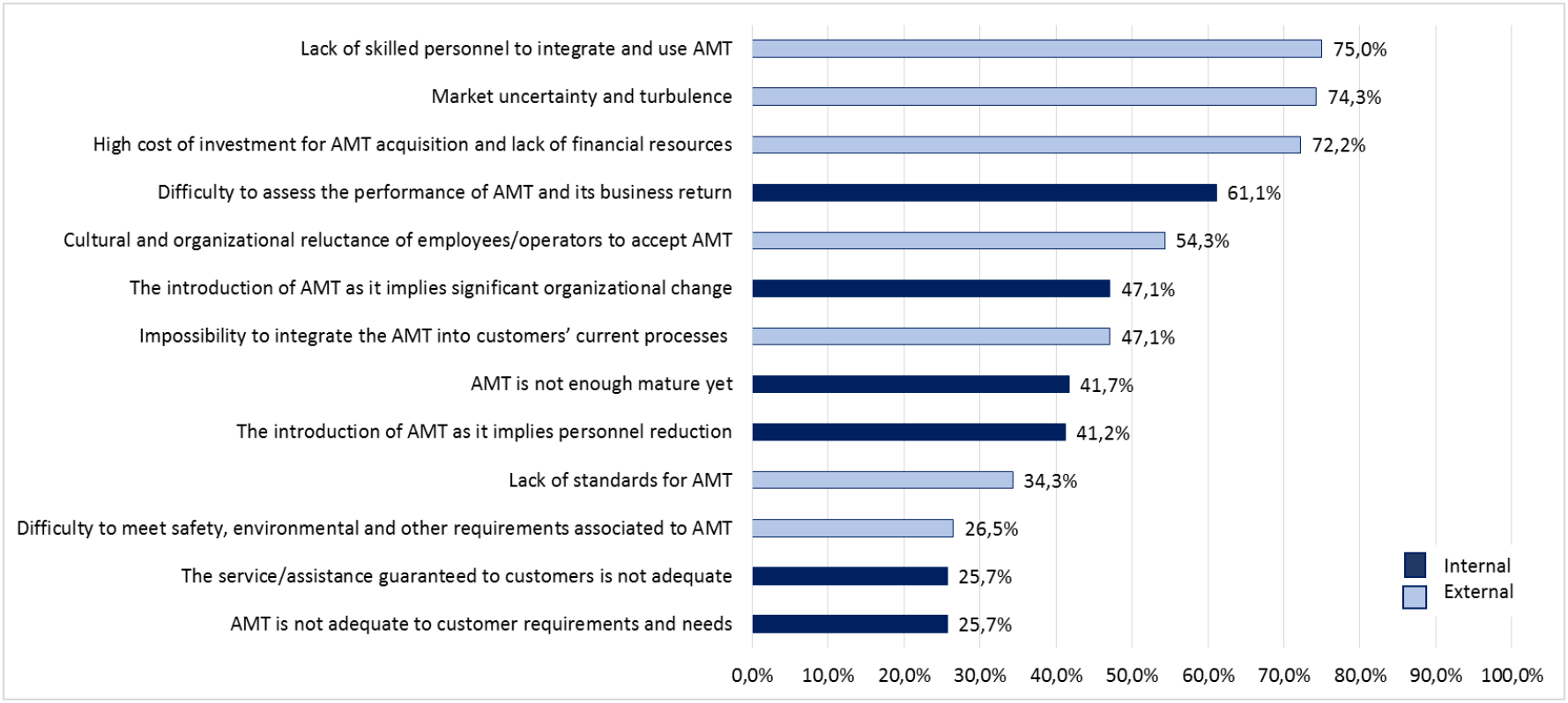
Figure 19: Barriers to the adoption of AMT (user perspective) (n=213-219)



Note: Scale 0 (no barrier) – 1 (barrier)

Source: Own analysis

Figure 20: Barriers to the adoption of AMT (producer perspective regarding users) (n=34-36)



Note: Scale 0 (no barrier) – 1 (barrier)

Source: Own analysis

Table 24: Differences in barriers: users' own and producers' perspective on them (n=247-255)

	Users[12]	Producers	Difference
	n=213-219	n=34-36	
Internal barriers			
AMT is not adequate to customer requirements and needs	25.1%	25.7%	-0.6%
AMT is not enough mature yet	34.2%	41.7%	-7.5%
The service/assistance guaranteed to customers is not adequate	25.7%	25.7%	0.0%
Difficulty to assess the performance of AMT and its business return	56.5%	61.1%	-4.6%
The introduction of AMT as it implies personnel reduction	23.7%	41.2%	-17.5%**
The introduction of AMT as it implies significant organisational change	38.1%	47.1%	-9.0%
External barriers			
Impossibility to integrate the AMT into customers' current processes (i.e. due to standards/process incompatibility)	39.2%	47.1%	-7.9%
Lack of skilled personnel to integrate and use AMT	57.7%	75.0%	-17.3%**
Difficulty to meet safety, environmental and other requirements associated to AMT	26.3%	26.5%	-0.2%
Lack of standards for AMT	32.4%	34.3%	-1.9%
Market uncertainty and turbulence	52.3%	74.3%	-22.0%**
High cost of investment for AMT acquisition and lack of financial resources	74.3%	72.2%	2.1%
Cultural and organisational reluctance of employees/operators to accept AMT	32.4%	54.3%	-21.9%**

Note: Scale 0 (no barrier) – 1 (barrier)

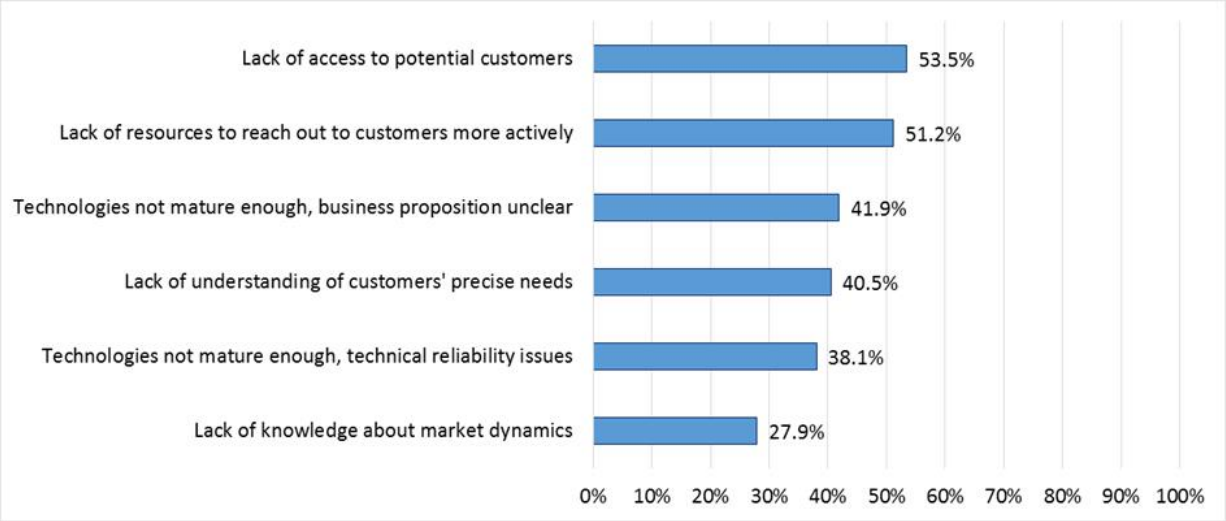
Note: * significant at the 1% level, ** significant at the 5% level, *** significant at the 10% level

Source: Own analysis

From a producer's perspective, the main factors hindering the supply of AMT to additional customers were marketing-related e.g. the lack of access to potential customers (53.5%), accompanied by the lack of resources to more actively reach out to customers (51.2%). A lack of knowledge about market dynamics was not really perceived to be a major barrier, as only 27.9% of the producers identify it as such.

[12] The respondents who indicated that they are both user and producer of advanced manufacturing equipment and technologies were asked to fill in the questionnaire from a user perspective.

Figure 21: Barriers to supply of AMT (producer perspective) (n=42-43)



Note: Scale 0 (no barrier) – 1 (barrier)
Source: Own analysis

3.5.2 Specific findings

3.5.2.1 Technology/AMT specific findings

Similar to the drivers, the barriers to investing in advanced manufacturing activities are also analysed according to high performance, ICT-enabled or sustainable manufacturing technologies[13] (see Table 25). Their inadequacy when meeting customer requirements and needs is more frequently a barrier for ICT-enabled (28.7%) than for high performance technologies (22.6%). The same applies to some external barriers such as the impossibility to integrate AMT into customers' current processes and a lack of skilled personnel to integrate and use AMT. Respondents who indicated that ICT-enabled technologies are highly relevant more frequently encounter a lack of skilled personnel to integrate and use AMT (59.6%) than those who indicated that sustainable manufacturing technologies are highly relevant (51.8%). Companies with highly relevant sustainable manufacturing technologies encounter more frequently the impossibility of integrating the technology into customers' current processes (40.9%) and the difficulty to meet safety, environmental and other requirements associated with AMT (27.7%) compared to companies with highly relevant high performance technologies (respectively 37.3% and 23.9%).

[13] Only respondents that answered highly relevant e.g. 4 or 5 on a scale of 1 (low) to 5 (high relevance) are considered in this analysis.

Table 25: Differences in barriers by AMT (user perspective) (n=151)

	High performance	*ICT-enabled*	*Sustainable*
	n=163-168	n=92-94	n=112-117
Internal barriers			
AMT is not adequate to customer requirements and needs	22.6%	28.7%	25.6%
AMT is not mature enough yet	34.7%	30.9%	37.6%
The service/assistance guaranteed to customers is not adequate	23.4%	23.4%	28.4%
Difficulty to assess the performance of AMT and its business return	57.3%	57.0%	58.8%
The introduction of AMT as it implies personnel reduction	22.4%	22.8%	26.3%
The introduction of AMT as it implies significant organisational change	35.2%	36.6%	39.5%
External barriers			
Impossibility to integrate the AMT into customers' current processes (i.e. due to standards/process incompatibility)	37.3%	39.4%	40.9%
Lack of skilled personnel to integrate and use AMT	55.8%	59.6%	51.8%
Difficulty to meet safety, environmental and other requirements associated to AMT	23.9%	25.0%	27.7%
Lack of standards for AMT	31.3%	29.0%	34.8%
Market uncertainty and turbulence	53.0%	53.8%	52.2%
High cost of investment for AMT acquisition and lack of financial resources	74.4%	69.5%	69.2%
Cultural and organisational reluctance of employees/ operators to accept AMT	31.3%	33.7%	36.3%

Note: Scale 0 (no barrier) – 1 (barrier)

Source: Own analysis

3.5.2.2 Findings related to location

Table 26 provides an overview of the various barriers to investment in AMT, based on the location of company headquarters. High cost of investment for AMT acquisition and lack of financial resources is more frequently a barrier for Western and Eastern European countries (95.5% and 81.3%) than for the other regions. A large share of the Western European companies indicated difficulties in assessing the performance of AMT and their business return (71.4%) while this was less frequently an issue for Eastern, Central and Northern European countries (50.8%-46.2%). 71.4% of Western European countries considered market uncertainty and turbulence a barrier, which was greater compared to other regions.

Table 26: Differences in barriers by location (user perspective) (n=166-172)

	Central Europe	*Western Europe*	*Northern Europe*	*Southern Europe*	*Eastern Europe*	*COSME non-EU*[14]	*Total*
	n=59-62	n=21-23	n=13	n=48-49	n=15-16	n=8-9	n=166-172
Internal barriers							
AMT is not adequate to customer requirements and needs	34.4%	30.4%	30.8%	30.6%	12.5%	22.2%	29.8%
AMT is not mature enough yet	33.9%	30.4%	38.5%	34.7%	31.3%	22.2%	33.1%
The service/assistance guaranteed to customers is not adequate	32.8%	13.0%	15.4%	25.0%	31.3%	33.3%	26.5%
Difficulty to assess the performance of AMT and its business return	50.8%	71.4%	46.2%	59.2%	50.0%	62.5%	56.0%
The introduction of AMT as it implies personnel reduction	22.0%	22.7%	23.1%	16.3%	31.3%	62.5%	23.4%
The introduction of AMT as it implies significant organisational change	41.7%	22.7%	15.4%	41.7%	56.3%	37.5%	38.3%
External barriers							
Impossibility to integrate the AMT into customers' current processes (i.e. due to standards/process incompatibility)	33.3%	39.1%	23.1%	55.1%	31.3%	44.4%	40.0%
Lack of skilled personnel to integrate and use AMT	55.0%	50.0%	53.8%	50.0%	53.3%	66.7%	53.3%
Difficulty to meet safety, environmental and other requirements associated to AMT	23.3%	18.2%	23.1%	33.3%	31.3%	62.5%	28.1%
Lack of standards for AMT	26.7%	19.0%	38.5%	37.5%	50.0%	50.0%	33.1%
Market uncertainty and turbulence	52.5%	71.4%	46.2%	49.0%	60.0%	50.0%	53.9%
High cost of investment for AMT acquisition and lack of financial resources	65.6%	95.5%	76.9%	69.4%	81.3%	75.0%	73.4%
Cultural and organisa-tional reluctance of em-ployees/operators to accept AMT	23.3%	40.9%	23.1%	37.5%	33.3%	87.5%	33.7%

Note: Scale 0 (no barrier) – 1 (barrier)

Source: Own analysis

[14] Only a limited number of responses were obtained from COSME countries which are not part of the EU. Therefore, this region was not further analysed in detail.

3.5.2.3 Findings related to company size

Table 27 provides an overview of the barriers to investing in AMT between various company sizes. Small and micro companies more frequently indicated that AMT are not appropriate to customer requirements and needs (35.4%) than medium-sized companies did. Assessing the performance and business return of AMT seems more challenging for small and micro companies compared to medium-sized companies. Small and micro companies encounter more hindrance from lack of skilled personnel to integrate and use AMT (64.6%) than other companies (53.7% and 56.5%).

Table 27: Differences in barriers by company size (user perspective) (n=211-217)

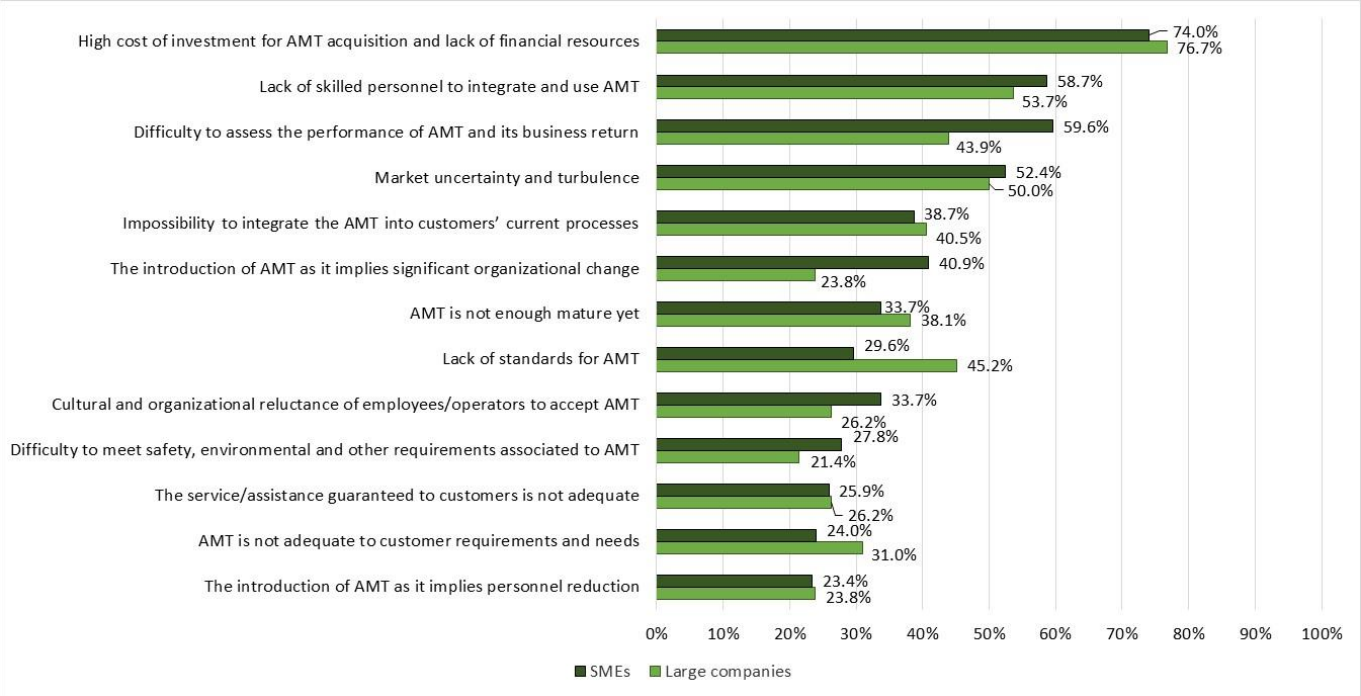
	Large companies	*Medium-sized companies*	*Small and micro-companies*	*Total*
	n=41-42	n=122-127	n=46-48	n=211-217
Internal barriers				
AMT is not adequate to customer requirements and needs	31.0%	19.7%	35.4%	25.3%
AMT is not mature enough yet	38.1%	31.5%	39.6%	34.6%
The service/assistance guaranteed to customers is not adequate	26.2%	22.2%	35.4%	25.9%
Difficulty to assess the performance of AMT and its business return	43.9%	55.6%	70.2%	56.6%
The introduction of AMT as it implies personnel reduction	23.8%	24.2%	21.3%	23.5%
The introduction of AMT as it implies significant organisational change	23.8%	41.9%	38.3%	37.6%
External barriers				
Impossibility to integrate the AMT into customers' current processes (i.e. due to standards/process incompatibility)	40.5%	36.8%	43.8%	39.1%
Lack of skilled personnel to integrate and use AMT	53.7%	56.5%	64.6%	57.7%
Difficulty to meet safety, environmental and other requirements associated to AMT	21.4%	25.4%	34.0%	26.5%
Lack of standards for AMT	45.2%	25.4%	40.4%	32.7%
Market uncertainty and turbulence	50.0%	54.0%	47.8%	51.9%
High cost of investment for AMT acquisition and lack of financial resources	76.7%	72.2%	78.7%	74.5%
Cultural and organisational reluctance of employees/operators to accept AMT	26.2%	32.8%	36.2%	32.2%

Note: Scale 0 (no barrier) – 1 (barrier)

Source: Own analysis

SMEs and large companies (<2 000 employees) indicated that high cost of investment for AMT acquisition and lack of financial resources is the main barrier to adopting AMT (Figure 22). SMEs, as opposed to large companies, more frequently think that the difficulty of assessing the performance of AMT and their business return is a barrier (59.6% versus 43.9%). The lack of skilled personnel and the introduction of AMT, in that it implies significant organisational change, are perceived to be more important barriers for SMEs than for large companies. The lack of standards for AMT is more frequently perceived as a barrier for large companies as compared to SMEs (45.2% versus 29.6%).

Figure 22: Differences in barriers by company type (user perspective) (n=211-217)



Note: Scale 0 (no barrier) – 1 (barrier)

Source: Own analysis

3.5.2.4 Findings related to company performance

For companies with a low share of sales produced by using AMT (0-20%), the following barriers are important: high cost of investment for AMT acquisition and lack of financial resources (87.7%); the difficulty to assess the performance of AMT and their business return (65.8%); and the lack of skilled personnel to integrate and use AMT (67.1%). On the other hand, the introduction of AMT as it implies personnel reduction, is not considered to be a major barrier by this group of companies (16.7%).

Companies who have a high share of sales produced using AMT (81-100%) have a lower frequency of external barriers compared to the other two groups, except for the market uncertainty and balance which occurs more frequently (54.2%). The internal barriers which occur more frequently compared to the other two groups are those related to the maturity of AMT (42.3%) and the barrier related to personnel reduction implied by the introduction of AMT (28.0%).

Table 28: Differences in barriers by performance (user perspective) (n=202-207)

	0-20%	***21-80%***	***81-100%***	***Total***
	n=70-73	n=105-108	n=24-26	n=202-207
Internal barriers				
AMT is not adequate to customer requirements and needs	30.1%	21.3%	16.0%	23.8%
AMT is not mature enough yet	34.2%	34.6%	42.3%	35.4%
The service/assistance guaranteed to customers is not adequate	25.0%	27.8%	16.0%	25.4%
Difficulty to assess the performance of AMT and its business return	65.8%	54.3%	52.0%	58.1%
The introduction of AMT as it implies personnel reduction	16.7%	25.9%	28.0%	22.9%
The introduction of AMT as it implies significant organisational change	32.4%	42.6%	28.0%	37.3%
External barriers				
Impossibility to integrate the AMT into customers' current processes (i.e. due to standards/process incompatibility)	46.6%	35.5%	28.0%	38.5%
Lack of skilled personnel to integrate and use AMT	67.1%	57.9%	40.0%	58.9%
Difficulty to meet safety, environmental and other requirements associated to AMT	28.2%	26.4%	20.0%	26.2%
Lack of standards for AMT	35.2%	32.1%	24.0%	32.2%
Market uncertainty and turbulence	49.3%	52.8%	54.2%	51.7%
High cost of investment for AMT acquisition and lack of financial resources	87.7%	68.5%	65.4%	74.9%
Cultural and organisational reluctance of employees/operators to accept AMT	37.1%	34.3%	12.5%	32.7%

Note: Scale 0 (no barrier) – 1 (barrier)

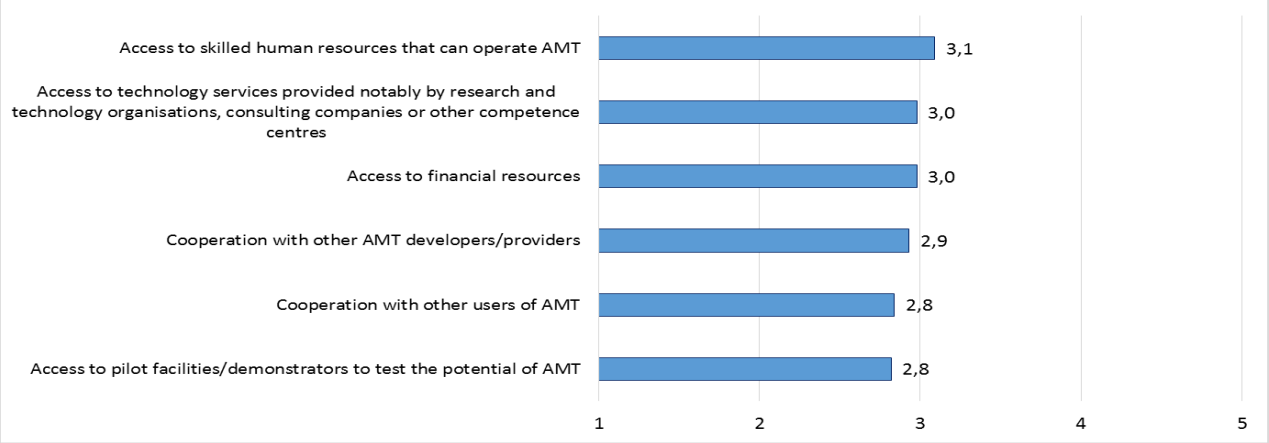
Source: Own analysis

3.6 Capacity to overcome barriers related to the adoption of AMT

3.6.1 General findings

An overview of the readiness to overcome various barriers to the adoption of AMT is provided in Figure 23. Readiness is measured on a scale from 1 (not ready) to 5 (well mastered). There is little difference between the capacity to overcome several barriers or the readiness of companies to overcome these barriers. On average, users consider themselves medium ready to overcome the barriers to adopting AMT: access to skilled human resources that can operate AMT (3.1), access to technology services provided notably by research and technology organisations, consulting, etc (3.0) and access to financial resources (3.0). There are also no large differences between the users' perspective on readiness and the producer perspective (on users) (see Figure 24). There is clearly room to enhance the readiness of users in several domains so that they become more ready to adopt AMT.

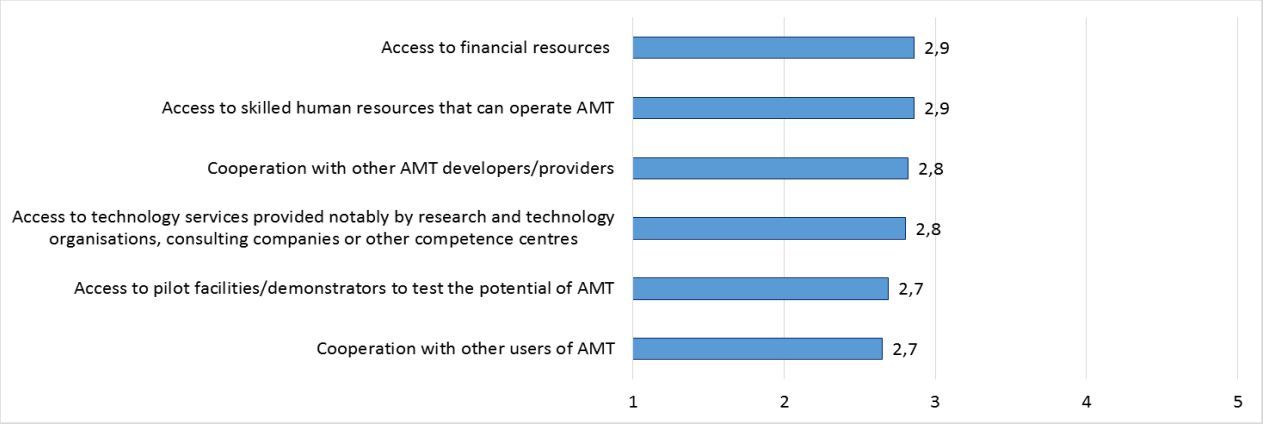
Figure 23: Average readiness by AMT (user perspective) (n=219-222)



Note: Scale 1 (Not ready) – 5 (Well mastered)

Source: Own analysis

Figure 24: Average readiness by AMT (producer perspective regarding users) (n=34-36)

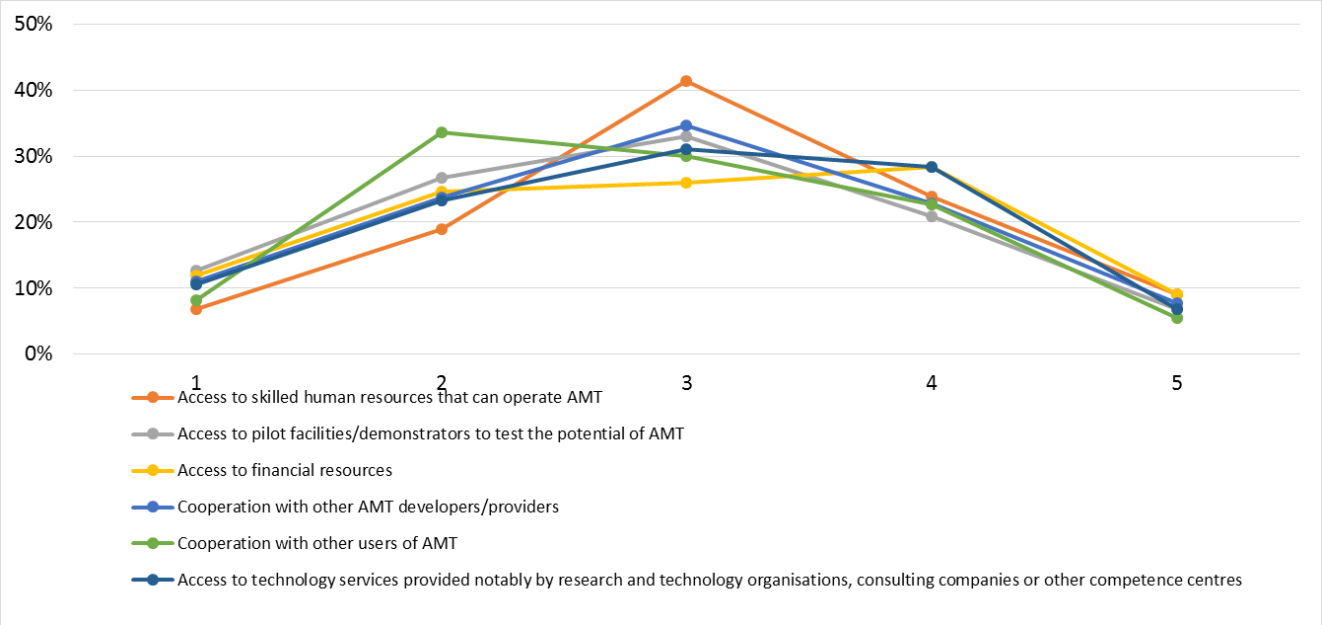


Note: Scale 1 (Not ready) – 5 (Well mastered)

Source: Own analysis

Figure 25 provides more insight into the specific response behaviour, indicating a reverse U-shaped response where the largest share of respondents indicate they are medium ready to overcome challenges.

Figure 25: Distribution of readiness by AMT (user perspective) (n=219-222)



Note: Scale 1 (Not ready) – 5 (Well mastered)

Source: Own analysis

Producers on average feel they have mastered a general understanding of technological dynamics in the field and an understanding of technological opportunities resulting from the application of AMT (average score of about 4 on a scale from 1 to 5). They have least mastered access to relevant intermediary organisations of users like associations and chambers (2.3). Apparently, it is not straightforward for producers to gain access to intermediary organisations of users.

Figure 26: Average readiness by AMT (producer perspective) (n=37)

Note: Scale 1 (Not ready) – 5 (Well mastered)

Source: Own analysis

3.6.2 Specific findings

3.6.2.1 Technology/AMT specific findings

As with the drivers and barriers, the readiness to invest in AMT of respondents who indicated that high performance, ICT-enabled or sustainable manufacturing technologies are highly relevant[15] to their company is also analysed. Companies where high performance technologies are relevant on average have a higher readiness to cooperate with other users of AMT (2.9) than companies with ICT-enabled (2.9) and sustainable manufacturing technologies (2.9). Overall, high performance manufacturing technologies companies are on average more ready to overcome challenges than companies active in ICT-enabled and sustainable manufacturing technologies.

Table 29: Average readiness by AMT (user perspective) (n=154)

	High performance	ICT-enabled	Sustainable
	n=167-170	n=94-96	n=116-118
Access to skilled human resources that can operate AMT	3.2	3.1	3.2
Access to pilot facilities/demonstrators to test the potential of AMT	2.9	2.9	2.9
Access to financial resources (e.g. loans, innovation grants, etc.)	3.1	3.1	3.1
Cooperation with other AMT developers/providers	3.0	3.0	2.9
Cooperation with other users of AMT	2.9	2.9	2.9
Access to technology services provided notably by research and technology organisations, consulting companies or other competence centres	3.0	3.0	3.0

Note: Scale 1 (Not ready) – 5 (Well mastered)

Source: Own analysis

3.6.2.2 Findings related to location

All regions think that they are medium ready to access skilled human resources who can operate AMT. With regard to accessing pilot facilities/demonstrators to test the potential of technologies, companies in Northern Europe consider themselves on average more ready than others (3.1). Central, Southern and Eastern European companies on the other hand are on average medium ready to access financial resources (2.7, 2.9 and 2.9) while other regions indicate a lower readiness. Central European companies indicate a lower readiness towards the cooperation with other users (2.7) than those in other regions (which are on average medium ready). Southern and Eastern European companies excel in overcoming the barrier to cooperating with other AMT developers and providers (3.1 and 3.1), which may be explained by the fact that cooperating in the supply chain is one way to face the challenges related to a lack of internal critical mass.

[15] High relevance: respondent indicated 4 or 5 on a scale of 1 (low) to 5 (high relevance).

Table 30: Average readiness by location (user perspective) (n=169-172)

	Central Europe	*Western Europe*	*Northern Europe*	*Southern Europe*	*Eastern Europe*	*COSME non-EU*[16]	*Total*
	n=61-62	*n=22-23*	*n=13*	*n=47-49*	*n=16-17*	*n=8*	*n=169-172*
Access to skilled human resources that can operate AMT	3.1	3.1	3.6	3.2	3.0	2.9	3.1
Access to pilot facilities/ demonstrators to test the potential of AMT	2.7	2.5	3.1	2.9	2.9	3.0	2.8
Access to financial resources (e.g. loans, innovation grants, etc.)	3.0	2.5	2.5	3.1	2.9	3.6	2.9
Cooperation with other AMT developers/providers	2.8	2.8	2.9	3.1	3.1	3.9	3.0
Cooperation with other users of AMT	2.7	2.9	2.9	2.9	3.3	3.4	2.9
Access to technology services provided notably by research and technology organisations, consulting companies or other competence centres	2.8	2.9	2.9	3.1	3.3	3.1	3.0

Note: Scale 1 (Not ready) – 5 (Well mastered)

Source: Own analysis

3.6.2.3 Findings related to company size

Large companies are on average more ready to access skilled human resources to operate AMT (3.3) and access pilot facilities/demonstrators to test the potential of AMT (3.0). Small and micro companies on the other hand, have on average a higher readiness to cooperate with other AMT developers/providers (3.2) and other users of AMT (2.9).

[16] Only a limited number of responses were obtained from COSME countries which are not part of the EU. Therefore, this region was not further analysed in detail.

Table 31: Average readiness by company size (user perspective) (n=217-220)

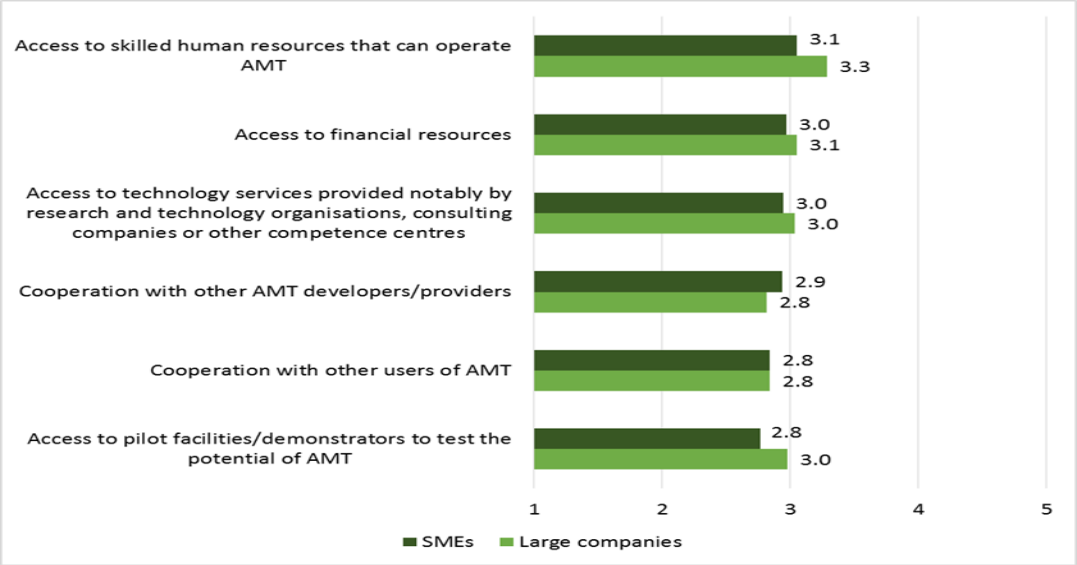
	Large companies	*Medium-sized companies*	*Small and micro-companies*	*Total*
	n = 44-45	*n = 125-127*	*n = 46-47*	*n = 217-220*
Access to skilled human resources that can operate AMT	3.3	3.0	3.2	3.1
Access to pilot facilities/ demonstrators to test the potential of AMT	3.0	2.8	2.8	2.8
Access to financial resources (e.g. loans, innovation grants, etc.)	3.1	3.1	2.6	3.0
Cooperation with other AMT developers/providers	2.8	2.9	3.2	2.9
Cooperation with other users of AMT	2.8	2.8	2.9	2.8
Access to technology services provided notably by research and technology organisations, consulting companies or other competence centres	3.0	2.9	3.0	3.0

Note: Scale 1 (Not ready) – 5 (Well mastered)

Source: Own analysis

Large companies are on average more ready to overcome barriers to the adoption of AMT than SMEs, where the only exception is the barrier related to cooperation with other AMT developers/providers (see Figure 27). SMEs evaluate their capacity to overcome the barriers access to pilot facilities and demonstrators to test the potential of AMT and access to skilled human resources to operate AMT at a lower level than large companies do.

Figure 27: Average readiness by company type (user perspective) (n=217-220)



Note: Scale 1 (Not ready) – 5 (Well mastered)

Source: Own analysis

3.6.2.4 Findings related to company performance

Respondents with a high share of sales produced using AMT (81-100%) are on average more ready to overcome barriers to the adoption of AMT than respondents with a low share of sales (0-20%). All readiness factors are above 3 for the first group of respondents, while none of the readiness factors is above 3 for the latter group of respondents. Clearly companies with more experience with AMT evaluate their capacity to overcome barriers to the adoption of AMT as less critical.

Table 32: Average readiness by performance (user perspective) (n=208-210)

	0-20%	*21-80%*	*81-100%*	*Total*
	n=73-74	n=109-111	n=26	n=208-210
Access to skilled human resources that can operate AMT	2.7	3.2	3.7	3.1
Access to pilot facilities/demonstrators to test the potential of AMT	2.5	2.9	3.4	2.8
Access to financial resources (e.g. loans, innovation grants, etc.)	2.6	3.1	3.4	2.9
Cooperation with other AMT developers/providers	2.8	2.9	3.4	2.9
Cooperation with other users of AMT	2.7	2.9	3.3	2.8
Access to technology services provided notably by research and technology organisations, consulting companies or other competence centres	2.7	3.1	3.4	3.0

Note: Scale 1 (Not ready) – 5 (Well mastered)

Source: Own analysis

3.7 Conclusion from the quantitative analysis

The most important driver of AMT investment by users is financial and refers to the need to reduce production costs. **Equally important, however, is the aim to improve the quality of products and services and to improve the productivity and efficacy of employees.** These drivers are rather innovation and HR-related issues in contrast to more traditional competitive arguments that drive producers, e.g. further development of existing product portfolio or specific requests from existing or potential customers and customer associations.

Internal drivers are more frequently indicated as drivers to invest in AMT as compared to external drivers. Distinguishing between three main types of AMT (e.g. High performance manufacturing technologies, ICT-enabled technologies and sustainable manufacturing technologies), few differences in drivers for users to invest in AMT can be identified. For the users active in ICT-enabled and sustainable manufacturing technologies, only the drivers "reduce the consumption of energy and materials" and "tackle environmental requirements/certification" are significantly more important.

Certain regions also show a difference in main objectives to invest in AMT. For example, for 90% of respondents located in Western Europe, the ability to approach new markets by investing in AMT is an important driver. Contrarily, only 46% of respondents located in Central Europe identified this as an important driver. For companies in Western and Southern Europe, the objective of being able to stand out from competitors is an important driver to invest in AMT, while for companies in Central, Northern and Eastern Europe this is only the case for about 60% of the respondents. The difference in the importance awarded to the driver "tackle environmental requirements/certification" between Eastern (73%) versus Northern Europe (25%) is also remarkable.

The main barrier for users to adopting AMT is the "high cost of investment for AMT acquisition and lack of financial resources". When asking producers what they consider to be the most important barriers for their users when adopting AMT the "cost of investment" ranks in second place, while "market uncertainty and turbulence" is judged to be the most important barrier. **Users identify the "difficulty to assess the performance of AMT and their business return to be an important barrier while producers tend to underestimate the importance of this barrier for their users. Vice versa, producers identify the barrier "introduction of AMT as it implies personnel reduction" as important for their users, while for users, this is the least important barrier to adopting AMT.**

For the producers, the most important barriers to adopting AMT are the "development of new business options based on existing technological competence" and "possible long-term market opportunity". Distinguishing between three main types of AMT, it seems that respondents active in ICT-enabled technologies and sustainable manufacturing technologies face more barriers compared to respondents active in high performance manufacturing technologies.

Regions tend to differ in the barriers they face to adopt AMT. For example, the internal barrier "AMT is not appropriate to customer requirements and needs" is not important for Eastern Europe (0%), while it is of importance to the other regions. The barrier "the service/assistance guaranteed to customers is not adequate" is not important for Northern and Western European respondents (9%

resp. 14%), while it is of moderate importance to the other regions. “Impossibility to integrate the AMT into customers’ current processes (i.e. due to standards/process incompatibility)” is judged to be an important barrier in Southern Europe while it is of less importance to Central and Northern Europe. “Market uncertainty and turbulence” is of high importance in Western Europe while it is considered of medium importance to Northern European respondents.

While the drivers for adopting AMT are quite similar for users and producers when considering their customers, several barriers are perceived differently by both groups of respondents.

The capacity of users to overcome barriers to the adoption of AMT can be considered average. In their evaluation of their capacity to overcome several barriers, **the users feel they do not master the capacity to overcome barriers to the adoption of AMT very well. The producers feel well prepared to overcome the challenges related to the “understanding of technological opportunities resulting from the application of AMT” and “general understanding of technological dynamics in the field”**. They are less well prepared to “access relevant intermediary organisations of users like associations and chambers” and “access additional markets”. The readiness to overcome certain barriers differs slightly for the three main types of AMT (high performance manufacturing technologies, ICT-enabled technologies and sustainable manufacturing technologies). In particular, the barrier to cooperating with users and developers/providers of AMT seems more difficult to overcome for respondents active in ICT-enabled technologies and sustainable manufacturing technologies.

Northern European respondents seem to be better at overcoming the barrier to accessing pilot facilities/demonstrators to test the potential of AMT. On the other hand, Western and Northern European respondents struggle most to get access to financial resources. **Southern European respondents excel in overcoming the barrier to cooperation with other AMT developers/producers.**

The most important driver for SMEs to invest in AMT is to reduce production costs, while the most important driver for large companies (<2 000 employees) is to improve the quality of products and services (user perspective). Both types of company see the high costs of investment for AMT acquisition and lack of financial resources as the main barrier to the adoption of AMT. The difficulty in assessing the performance of AMT and their business return, as well as the lack of skilled personnel, prove to be more important barriers for SMEs as compared to large companies. SMEs are also less ready to overcome barriers to the adoption of AMT. Especially **with regard to access to pilot facilities and demonstrators to test the potential of AMT, SMEs evaluated their capacity to overcome this barrier as significantly lower compared to large companies (<2 000 employees)**.

4 First insights on policy recommendations

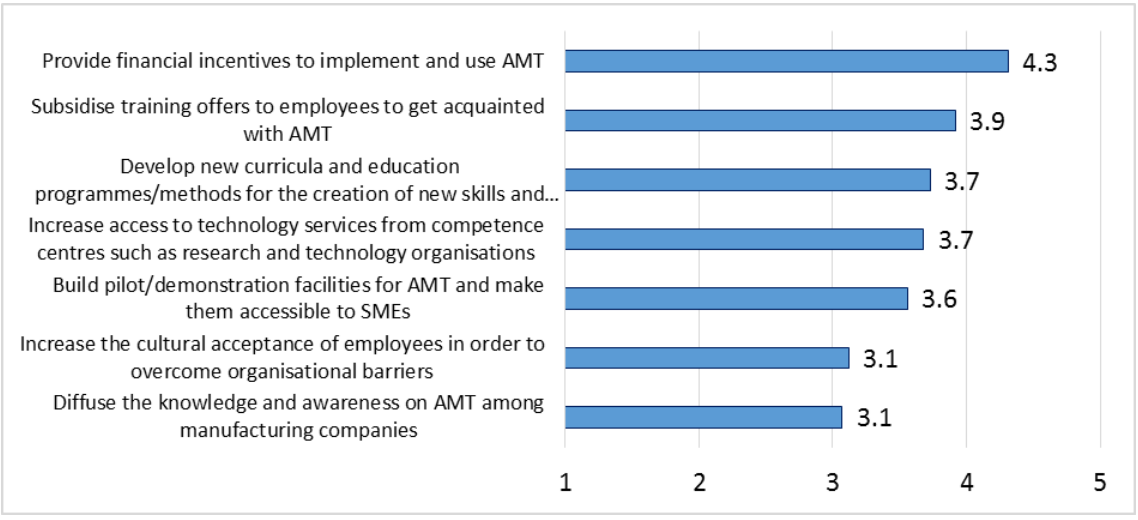
In the case studies, the interviewees are asked what Europe could do to improve the use of AMT in Europe. The responses from the interviewees could be grouped under ten major topics: (1) support for AMT investments; (2) information for SMEs; (3) managing regulation; (4) training of personnel; (5) improving competitiveness of labour force; (6) regulation of competition; (7) reducing bureaucracy; (8) avoiding market disturbance; (9) managing the EU's innovation system; (10) support for new Member States (see Annex C).

The insights obtained through the case studies formed the basis for the formulation of questions in the questionnaire with regard to policy measures. The aim was to obtain a quantitative confirmation of the most important policy measures that have the potential to improve the adoption of advanced manufacturing products and technologies. In the next phase of the study, specific attention was devoted to the identification of specific needs for support services that European SMEs require.

4.1 General findings

The policy measure that was judged to be the most important is the provision of financial incentives to implement and use AMT (4.3), followed by providing subsidies for training offers to employees to get acquainted with AMT (3.9) and the need to develop new curricula and education programmes/methods for the creation of new skills and competencies (3.7). Hence, in addition to financial support, the respondents expressed a clear need for policy measures that are related to human capital. Diffusion of knowledge and awareness creation proves to be less essential for the adoption of AMT in companies (3.1). Also the need for policy measures to increase the cultural acceptance of employees in order to overcome organisational barriers seems to be less prominent (3.1). Figure 29 provides more insight into the specific response behaviour, clearly indicating the need to provide financial incentives.

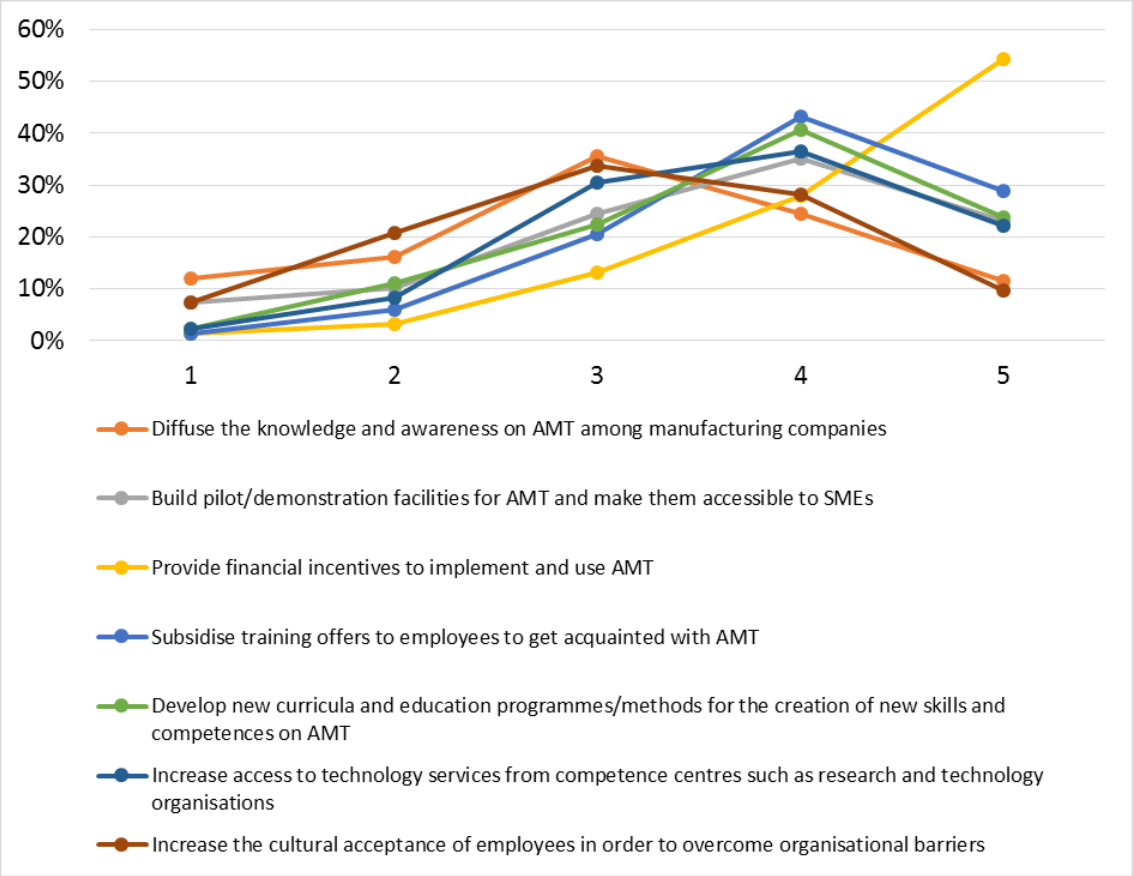
Figure 28: Average policy measures (user perspective) (n=216-219)



Note: Scale 1 (No influence) – 5 (Strong influence)

Source: Own analysis

Figure 29: Distribution policy measures (user perspective) (n=216-219)

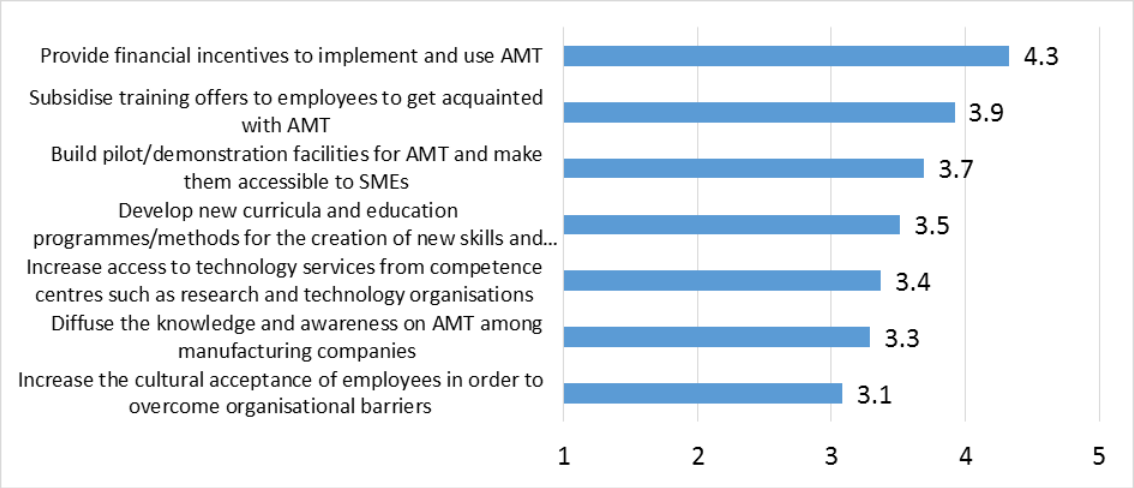


Note: Scale 1 (No influence) – 5 (Strong influence)

Source: Own analysis

Producers' opinion regarding policy measures that could motivate/enable their customers to introduce AMT into their companies was also sought. Again, the need to provide financial incentives received the highest score (4.3). The necessity to subsidise training offers to employees in order to get them acquainted with AMT was also acknowledged as important (3.9). Policy measures designed to stimulate the construction and accessibility of pilot and demonstration activities for SMEs are judged by producers to be more important than users judge them to be. This may be due to the fact that users do not always fully understand the benefits of pilot and demonstration activities. The difference is, however, not statistically significant as shown in Table 33.

Figure 30: Average policy measures (producer perspective regarding users) (n=35-36)



Note: Scale 1 (No influence) – 5 (Strong influence)

Source: Own analysis

Table 33: Difference in policy measures: user versus producer perspective (n=35-216)

	Users[17]	***Producers***	***Difference***
	n=216-219	n=35-36	
Diffuse the knowledge and awareness on AMT among manufacturing companies	3.1	3.3	-0.2
Build pilot/demonstration facilities for AMT and make them accessible to SMEs	3.6	3.7	-0.1
Provide financial incentives to implement and use AMT	4.3	4.3	-0.02
Subsidise training offers to employees to get acquainted with AMT	3.9	3.9	0
Develop new curricula and education programmes/methods for the creation of new skills and competences on AMT	3.7	3.5	0.2
Increase access to technology services from competence centres such as research and technology organisations	3.7	3.4	0.3*
Increase the cultural acceptance of employees in order to overcome organisational barriers	3.1	3.1	0.04

Note: Scale 1 (No influence) – 5 (Strong influence)

Note: * significant at the 1% level, ** significant at the 5% level, *** significant at the 10% level

Source: Own analysis

[17] The respondents who indicated that they are both user and producer of advanced manufacturing equipment and technologies were asked to fill in the questionnaire from a user perspective.

4.2 Specific findings

4.2.1 Technology/AMT specific findings

As with the drivers and barriers to invest in AMT, the possible policy measures by respondents who indicated that high performance, ICT-enabled or sustainable manufacturing technologies are highly relevant[18] for their company were also analysed. As can be seen from Table 34, there is little difference between the desired policy measures for all three types of AMT. The provision of financial incentives to implement and use AMT is ranked number one in all three groups of technologies (respectively 4.4, 4.5 and 4.4 for high performance, ICT-enabled and sustainable manufacturing technologies).

Table 34: Average policy measures by AMT (user perspective) (n=92-169)

	High performance	***ICT-enabled***	***Sustainable***
	n=166-169	n=92-95	n=113-115
Diffuse the knowledge and awareness on AMT among manufacturing companies	3.1	3.3	3.1
Build pilot/demonstration facilities for AMT and make them accessible to SMEs	3.7	3.8	3.7
Provide financial incentives to implement and use AMT	4.4	4.5	4.4
Subsidise training offers to employees to get acquainted with AMT	4.0	4.0	4.0
Develop new curricula and education programmes/methods for the creation of new skills and competences on AMT	3.8	3.9	3.9
Increase access to technology services from competence centres such as research and technology organisations	3.8	3.7	3.9
Increase the cultural acceptance of employees in order to overcome organisational barriers	3.2	3.3	3.3

Note: Scale 1 (No influence) – 5 (Strong influence)

Source: Own analysis

[18] Highly relevant: respondent indicated 4 or 5 on a scale of 1 (low) to 5 (high relevance).

4.2.2 Findings related to location

All regions indicate that the need to provide financial incentives to implement and use AMT is important. The need to subsidise training offers to employees in order to get them acquainted with AMT also receives high scores in all regions, with the exception of Central Europe where this policy measure is judged slightly less important compared to other regions. Policy measures to develop new curricula and education programmes/methods for the creation of new skills and competences on AMT are important for Eastern (4.12) and Northern European (3.92) companies.

Table 35: Average of policy measures by location (user perspective) (n=167)

	Central Europe	*Western Europe*	*Northern Europe*	*Southern Europe*	*Eastern Europe*	*COSME non-EU*[19]	*Total*
	n=62	*n=22*	*n=13*	*n=45*	*n=17*	*n=8*	*n=167*
Diffuse knowledge and awareness on AMT among manufacturing companies	2.5	3.5	3.0	3.4	3.9	3.6	3.1
Build pilot / demonstration facilities for AMT and make them accessible to SMEs	3.4	3.6	3.7	3.8	3.9	3.6	3.6
Provide financial incentives to adopt and use AMT	4.3	4.5	4.3	4.5	4.4	3.8	4.4
Subsidise training offers to employees to get acquainted with AMT	3.7	4.2	4.1	3.9	4.3	3.9	3.9
Develop new curricula and programmes / methods for the creation of new skills and competences on AMT	3.6	3.8	3.9	3.7	4.1	3.9	3.7
Increase access to technology services from competence centres such as research and technology organisations	*3.6*	*3.5*	*3.4*	*3.6*	*4.2*	*3.6*	*3.7*
Increase the cultural acceptance of employees in order to overcome organisational barriers	3.0	3.2	2.5	3.4	3.4	3.9	3.2

Note: Scale 1 (No influence) – 5 (Strong influence)

Source: Own analysis

[19] Only a limited number of responses were obtained from COSME countries which are not part of the EU. Therefore, this region was not further analysed in detail.

In addition, policy measures that can increase access to technology services from competence centres such as research and technology organisations, consulting companies, etc. prove to be valuable to stimulating Eastern European companies (4.24) to adopt AMT. The higher ranking of this specific policy measure by companies located in Eastern Europe might be caused by the fact that the range of competence centres offering these services is more limited in these countries. Companies located in Northern Europe place less value on policy measures to increase the cultural acceptance of employees in order to overcome organisational barriers (2.54).

4.2.3 Findings related to company size

When considering the company size, all the respondents indicated that policy measures that provide financial incentives to implement and use AMT would strongly influence their ability to introduce these technologies in their company. Subsidies for training offers in order for employees to get acquainted with AMT is estimated to be a strong influence for large companies (4.1), but is considered to be a smaller influence for medium-sized companies (3.8). Small and micro companies indicated that they would strongly benefit from all policy measures, with the exception of policy measures that stimulate the diffusion of knowledge and awareness of AMT among manufacturing companies (3.3) and that increase the acceptance of employees in order to overcome organisational barriers (3.2).

Table 36: Average of policy measures by company size (user perspective) (n=215)

	Large companies	***Medium-sized companies***	***Small and micro companies***	***Total***
	n=43	*n=124*	*n=46*	*n=215*
Diffuse the knowledge and awareness on AMT among manufacturing companies	3.0	3.0	3.3	3.1
Build pilot/demonstration facilities for AMT and make them accessible to SMEs	3.7	3.4	3.8	3.6
Provide financial incentives to implement and use AMT	4.6	4.3	4.2	4.3
Subsidise training offers to employees to get acquainted with AMT	4.1	3.8	4.0	3.9
Develop new curricula and education programmes/methods for the creation of new skills and competences on AMT	3.8	3.7	3.8	3.7
Increase access to technology services from competence centres such as research and technology organisations	3.9	3.6	3.7	3.7
Increase the cultural acceptance of employees in order to overcome organisational barriers	3.2	3.1	3.2	3. 1

Note: Scale 1 (No influence) – 5 (Strong influence)

Source: Own analysis

4.2.4 Findings related to company performance

Analysing policy measures that would motive companies to introduce AMT in their company from a performance perspective provides similar insights compared to previous sections. Again, policy measures that provide financial incentives to implement and use AMT are considered to have a strong influence. This is more pronounced in the group of companies that have a percentage of sales between 81-100% (4.4) and the ones which have a share between 0-20% (4.4). Policy measures that stimulate training offers to get employees acquainted with AMT are also judged to have a strong influence. Here, the influence is more pronounced in the group of companies that have a percentage of sales between 81-100% (3.8 versus 3.8 and 3.6 in the other two groups).

Table 37: Average of policy measures by company (user perspective) (n=208)

	0-20%	***21-80%***	***81-100%***	***Total***
	n=75	n=107	n=25	n=208
Diffuse the knowledge and awareness on AMT among manufacturing companies	3.1	3.0	3.5	3.1
Build pilot/demonstration facilities for AMT and make them accessible to SMEs	3.5	3.7	3.3	3.6
Provide financial incentives to implement and use AMT	4.4	4.3	4.4	4.3
Subsidise training offers to employees to get acquainted with AMT	3.9	3.9	4.1	3.9
Develop new curricula and education programmes/methods for the creation of new skills and competences on AMT	3.6	3.8	3.8	3.8
Increase access to technology services from competence centres such as research and technology organisations	3.6	3.7	3.7	3.7
Increase the cultural acceptance of employees in order to overcome organisational barriers	3.0	3.2	2.9	3.1

Note: Scale 1 (No influence) – 5 (Strong influence)

Source: Own analysis

5 Overall conclusion from the quantitative and qualitative analyses

Financial considerations play a pivotal role as a barrier to adopt AMT as confirmed in the qualitative and the quantitative findings. The high costs of investing in AMT and the difficulty of assessing the business return are regarded as important barriers to the adoption of these technologies. At the same time, financial considerations are also a major driver to invest in AMT for users with a view to reducing the production costs. This driver is equally important for both large companies and SMEs.

The second most important driver for adopting AMT is human capital related. Investing in AMT is seen as instrumental to improving productivity and efficacy in the workplace. A related barrier, however, is the need for skilled personnel with the right qualifications and specific competencies. A lack of skilled personnel prevents companies from acquiring new technologies; although when properly operated, they could result in optimised processes. For micro companies, human capital-related motives are seen as a barrier rather than a driver.

Thirdly, **users of advanced manufacturing equipment and technologies tend to invest in it in order to improve the quality of their products and services**. This is an equally important driver for both large companies and SMEs. When the demand situation is favourable, AMT are used to increase capacity or improve process performance. A major barrier here, however, is market uncertainty and turbulence. The European market is currently regarded as passive, while increasing competition is now experienced by players active in Asian countries. Producers of AMT, however, see market uncertainty and turbulence as the most important barrier for their customers, indicating that there is still a lack of stable momentum in industrial modernisation.

The need for standards or a response to specific requirements and certification issues is seen as less important by users of AMT. It is not regarded as an important driver, nor is it considered to be a major barrier for either large companies or SMEs. This conclusion is also confirmed by the qualitative analysis.

In general, **internal drivers of investment in AMT are more frequently mentioned than external drivers**, indicating that there is positive motivation through observed benefits of advanced manufacturing as a business model, rather than a passive adaptation to external market developments. The perception of producers is quite well aligned with the position of users. The main drivers are nearly all internal drivers, while the main barriers are mainly external and linked to a lack of resources.

Considering the three types of AMT, high performance manufacturing technologies are rated more important than ICT-enabled and sustainable manufacturing technologies. It seems that **investment in ICT-enabled and sustainable manufacturing technologies faces more barriers than investment in high performance manufacturing technologies**. In particular, respondents who indicated that ICT-enabled technologies are highly relevant, more frequently encountered a lack of skilled personnel to integrate and use AMT. They also faced more difficulty integrating the technology into their current customers' processes. Within the three types, no single technology is considered really important, but rather a group of technologies is, which points towards the multidisciplinary character of industrial applications and the need to integrate various KETs.

The analysis reflects the various stages of market development among Member States. While Western European companies see AMT as a suitable means to access new markets and differentiate themselves from competitors, this effect is less pronounced in Central, Northern and Eastern Europe. Southern European companies consider differentiation from competitors a more important driver than the ability to approach new markets. Western and Southern European companies view the difficulty of assessing the performance of AMT and their business return as the most important internal barrier, whereas high investment costs and a lack of financial resources are considered to be the most important external barriers for Western and Eastern European companies. Western and Southern European companies seem to have a wider strategic, external view when investing in new AMT. The quantitative analyses revealed more differences across the various European regions compared to the qualitative analyses where no significant differences were identified.

On average, **users consider themselves to be medium ready to overcome barriers related to the adoption of AMT**. The **producers,** on the other hand, **master the capacity to overcome barriers related to understanding technological opportunities and associated dynamics quite well**. They feel less comfortable in accessing additional markets and relevant intermediary organisations of users. Overall, high performance manufacturing technologies companies are on average more ready to overcome challenges than ICT-enabled and sustainable manufacturing technology-active companies. Southern European companies seem to be more ready to cooperate with other AMT developers and providers, while Eastern European companies are more ready to cooperate with other users of AMT compared to companies in other European regions.

In line with our findings, **policy support appears to be welcome in three main areas**. Firstly, the provision of financial incentives to implement and use AMT is important to enable companies to embrace AMT. Secondly, subsidies for training of employees to get acquainted with AMT and support to new curricula and programmes for the creation of new skills and competences are essential to foster the introduction of AMT in European companies. Thirdly, policy measures that aim to stimulate access to additional markets and relevant intermediary organisations of users might help producers to overcome these barriers. These insights were further detailed into specific targeted policy measures and practical recommendations regarding the adoption of advanced manufacturing products and technologies in the next phase of the study.

6 Next steps

The qualitative and quantitative analyses provide some insights into specific needs for developing support services that European SMEs require. For example, the firm-level questionnaire points towards specific support services that address the needs of SMEs. For SMEs, it is often quite difficult to identify the pilot facility or demonstrator that can help them to bring their technology/product to the market. In order to help SMEs to gain access to state-of-the-art facilities, the European Commission has mapped technological service centres active in the field of Key Enabling Technologies[20]. Other initiatives offer one-stop shop access to SMEs to support them in gaining access to infrastructure, equipment, services and assistance. ACTPHAST, for example, serves as a unique one-stop shop for supporting photonics innovation by European companies[21]. It supports and accelerates the innovation capacity of companies by providing them with direct access to the expertise and state-of-the-art facilities of Europe's leading photonics research centres (the ACTPHAST Partners), enabling companies to exploit the commercial potential of applied photonics. A similar initiative in the area of AMT might help SMEs to overcome some barriers identified in this study. This will be further explored in the next phase of the study.

SMEs also seem to struggle with assessing the performance of AMT and their business return, in addition to finding skilled personnel. A regional initiative in Flanders (Belgium), called Made Different, has been created to address these issues, amongst others[22]. The aim of the Made Different action plan is to strengthen Flanders' manufacturing industry and make it a world leader in AMT. One of its activities is to offer specific guidance to manufacturing companies to turn themselves into agile, high-tech organisations. Seven transformations are identified, including human centred production as employees are recognised as a significant asset for anchoring production locally (see box 1).

Box 1: Seven transformations of the Made Different programme[23]

- **Transformation 1**: World Class Manufacturing Technologies consists of improving and innovating machines and productive equipment
- **Transformation 2**: End-to-end Engineering aims at increasing value along the different stages of value chains
- **Transformation 3**: Digital Factory addresses the introduction of the digital world in factories
- **Transformation 4**: Human centred Production aiming at skills and knowledge development
- **Transformation 5**: Production Network focuses on the improvement of the networks that surround companies: suppliers, partners, etc.
- **Transformation 6**: Eco Production addresses the products´ life cycle and looks for solutions to improve the reuse and recycling of materials and products
- **Transformation 7**: Smart Production Systems aspires at improving companies´ capacity of response to changes in demand

[20] https://ec.europa.eu/growth/tools-databases/ketsobservatory/kets-ti-inventory/map
[21] http://www.actphast.eu/
[22] http://www.madedifferent.be/en/
[23] http://www.madedifferent.be/en/projects/7-transformations-en

In addition to access to knowledge, SMEs are often also in need of additional financial means to adopt AMT. The ActPhast initiative, for example, provides up to €80 000 for SME projects and up to €40 000 for large companies[24]. The European Commission has also launched a call (INNOSUP-03-2017[25]) with the objective of establishing one-stop shop access for SMEs to technology services and/or facilities from a network of technology infrastructures in the field of advanced manufacturing for clean production. In addition, it aims to use the established network to enable SMEs to integrate innovative AMT for clean production into their production process and make informed decisions for further investment. The call foresees award grants to SMEs with a maximum of €60 000 (full costs not covered).

In the next phase of the study, information on best practices such as the UK Catapult Centre on high value manufacturing, the German AiF/IGF system for joint industrial research between SMEs and the example mentioned in Box 2 will be explored, allowing the consortium to describe which business support services are required for EU companies to adopt AMT and which type of organisations are best suited to provide these services.

Box 2: Example of company training in the area of advanced manufacturing equipment[26]

B. Braun is one of the world's leading manufacturers of medical devices. It faced a skills gap in its existing workforce as increasingly sophisticated equipment was introduced into plant operations. The company reviewed the key competencies that workers require in order to understand the theory of how the equipment works and the principles that govern production line operations in an advanced manufacturing plant. These competencies include mechanical, electrical, hydraulic and pneumatic functions.

The company set up a highly innovative programme to train the existing workforce in the use and operation of advanced manufacturing equipment. A Progression-Based System (PBS) was introduced to make sure that all employees receive basic training in each of these functional areas. The underlying strategy behind the PBS is to train all workers in these core competencies and then help the employee learn to apply this theoretical background to the operation, maintenance and repair of equipment in the plant. Training is divided into five levels: entry, basic, intermediate, comprehensive and advanced (with a master's level under development). The expectation is that each employee will advance to the comprehensive level. All training was initially provided by a local vocational school but has since then been expanded to include the local community colleges as well. PBS has allowed B. Braun to retrain and upskill its employees, and the better skilled workforce has, in turn, helped the company reduce its operating and maintenance costs. The programme is now being introduced to other B. Braun facilities in the US.

[24] http://www.actphast.eu/

[25] http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/6088-innosup-03-2017.html

[26] http://www.areadevelopment.com/advanced-manufacturing/Q2-2016/Best-Practices-Advanced-Manufacturing-Culture-454577.shtml

The American Small Business Innovation Research Programme (SBIR) and British Small Business Research Initiative (SBRI) were also examined in more detail as they provide insight into how a country can act as a lead-user in order to promote the adoption and deployment of specific technologies through both public and private markets. Both the SBIR and the SBRI follow a demand-driven rationale based on key public agencies' missions, which are related to concrete market opportunities. Firstly, a feasibility study is conducted, then direct R&D support is brought to the small businesses. The third stage aims at technically supporting the businesses in their search for private investments and if relevant, connects with public procurement procedures. In the American context, any successful SBIR applicant is granted with a sole contract. The SBIR is an example of an initiative that puts a country or any public entity/agency in the position of (1) coach, (2) lead user and (3) frame for businesses to commercialise key technologies[27].

Interesting regional initiatives with regard to the adoption and deployment of AMT were also explored. For example, the Pays-de-la-Loire region intends to maximise the diffusion of advanced manufacturing techniques towards regional SMEs (see Box 3).

Box 3: Regional initiative in the area of advanced manufacturing techniques[28]

The Pays-de-la-Loire region has invested €10 million over two years in order to create a "pathway towards advanced manufacturing for SMEs". The plan includes awareness raising actions (innovation days, "web is industry" workshop in 2015 during the Web2Day digital festival), funding of technological diagnostics, training actions and funding of collaborative R&D projects and demonstrators accessible to regional SMEs. The region has also invested €10 million over the last two years in order to accelerate the adoption of robots by regional industrial SMEs by creating a "robotisation pathway". Regional companies can also count on the financial support from the national public investment bank *BPI France* that has awarded €1.2 billion of loans under the "Industry of the Future" programme, which displays a range of four thematic loans:

- "*Prêts verts*" (green loans) for companies that undertake actions to increase their resource efficiency;
- "*Prêts robotique*" (robotics loans) targeting companies which invest in structuring projects integrating automated production processes, including robots;
- "*Prêts pour l'industrialisation*" (industrialisation loans) in order to cover material and immaterial spending following the achievement of R&D projects to sustain the industrialisation and commercialisation of innovative products, processes or services;
- "*Prêts numériques*" (digital loans) for companies engaged in the digitalisation of processes to improve competitiveness.

[27] Padilla P (2016) Policy learning through strategic intelligence

[28] Regional Innovation Report Pays-de-la-Loire (https://ec.europa.eu/growth/tools-databases/regional-innovation-monitor/sites/default/files/report/2016_RIM%20Plus_Regional%20Innovation%20Report_Pays%20de%20la%20Loire.pdf)

7 Annexes

7.1 ANNEX A: Case company descriptions

Table 38: Case company descriptions

Company code	Basic data	Region/ country	User/ producer	AMT investments	Drivers/barriers
North 1	- SME - Family-owned - Fast growth from 2000 to 2009 - Financially doing well - Main investments made in 2003, 2004 and 2009	North/Finland	User/Producer	Sustainable manufacturing technology: factory facilities and sustainable technology (2003 and 2009)	- The company heavily invests in sustainability to improve its competitive edge. Being able to show the customer that the company is capable of operating very sustainably and convince the customer of its ability to provide high quality, sustainable products. Productivity and quality of performance come first, but after this, sustainability is also important to the customer - Sustainability is an image issue for the customers - The factory is a very good working environment for the staff
				ICT-enabled intelligent manufacturing technology: product development (2004, continuously)	- Flexible automation improves productivity in the heavy manufacturing industry - Computer capacity has grown, enabling the development of automation system flexibility
				High performance manufacturing technology (not invested)	- The manual assembly process on one-off products is not suitable for automation. Part production is outsourced to suppliers

Company code	Basic data	Region/ country	User/ producer	AMT investments	Drivers/barriers
North 2	- Large company - Limited liability company - Fast growth in 2014 - Financially weak performance - Massive investments in 2013-2014	North/Finland	User	High performance manufacturing technology: robot lines	- Financial support for research would improve readiness for investing. The company has previously received EU support - Production line investments are partly paid, up front, by the customer, as part of the contract - The municipality built a direct road from the plant to the harbour in 2013-2014. A straight train connection would be a great improvement - The company does not have problems finding staff for production. To some extent, they train their own staff in robot programming. - Customer requirements are central drivers. If the customer demands something, our company invests - Sufficient payback is a prerequisite for investments - Sufficient demand is a prerequisite for investment - Lack of know-how can be a barrier to investing in AMT - Finding people with experience from the relevant industry for engineering and product development is challenging in Finland, the company trains new people and recruits experienced people from abroad - New standards and certificates with higher requirements add to costs
North 3	- SME - Family-owned - Slow growth after 2009 - Profitability low - Main investments 10-15 years ago,	North/Sweden	User	High performance manufacturing technology: robots	- No external support, invests own company money - Finding knowledgeable staff is not a problem - The main objective of investing in automation is to improve the efficiency of the production process and reduce staffing. - The central objective of improving the process is pricing pressure from customers - The company is not much affected by legislative issues

Company code	Basic data	Region/ country	User/ producer	AMT investments	Drivers/barriers
	additional investments yearly			Sustainable manufacturing technology	- If the financial situation is good, we invest more - External financial support could help, but so far little has been done to get this support - The main objective of investing in environmentally friendly technology is energy savings - The problem is assessing whether or not the company can save money on an investment
East 1	- SME - Family-owned - Fast growth 2008–2014 - Solid financing - Main investments 2006–2007, expansion 2013–2014	East/Hungary	User/Producer	ICT-enabled intelligent manufacturing technology: automation of PCB development and manufacturing	- Higher efficiency in our R&D processes - Development of electronic boards using computers - Development of products without pilot/model development - Simulation of complex functions - Testing and simultaneously improving the quality without any additional investments - Achieving high performance improvements in manufacturing our electronic products - Automated manufacturing of PCBs - Programmable manufacturing processes - Automated quality control - We offer a much better quality of products for a lower price on the market - We are much more flexible than before - Higher quality/lower price - More efficient manufacturing processes – less waste and scrap

Company code	Basic data	Region/ country	User/ producer	AMT investments	Drivers/barriers
				ICT-enabled intelligent manufacturing technology: intelligent calibration lab	- Using the lab improves our financial situation – our better financial situation is one of the reasons we invested in this equipment - We are able to develop, produce and calibrate our products – this is why our customers want to work with us - This is our unique selling point - Our lab is our best school - Higher quality requirements - All meters have to be calibrated and certified
				ICT-enabled intelligent manufacturing technology: simulation of development and manufacturing pro-cesses	- Flexibility and speed of R&D and manufacturing - Only some exceptions - More efficient manufacturing processes – less waste and scrap
				ICT-enabled intelligent manufacturing technology: GPRS and Bluetooth com-munication technologies	- Without this technology we would lose our customers - All suppliers, on the market, offer this technology - The market requires such data transfer technologies
				Sustainable manufacturing technology: long-life meter devices	- Because of the high demand for digital meters with low energy consumption (long-life meters), we invest in the development of new products
				High performance manufacturing technology: additive manufacturing technologies – 3D printers (not invested)	- Too expensive - There is no subvention in Hungary or in the EU

Company code	Basic data	Region/ country	User/ producer	AMT investments	Drivers/barriers
East 2	- SME - Family-owned - Solid finances - Growing - Investing 5–10% in R&D yearly	East/Serbia	User/Producer	High performance manufacturing technology: development of welding and cutting tools which are compatible with well-known robot brands	- R&D is a part of a project. We share the development costs with the customers - We are only two to three kilometres away - We offer our customers continuous availability for maintenance and operator training - We offer good quality at a fair price - Our engineers are ready to learn and adopt their competencies to new challenges. This allows us great flexibility, not only in R&D, but also in manufacturing - Our automated welding tools improve the process performance of our customers. Clearly, this is the main reason they invest in this technology - Our customers want to have a good supplier, who is always there if they have a problem
				ICT-enabled intelligent manufacturing technology: GSM communication technology – communication between the developer and the automated tool	- With this technology we are able to ensure the function of our manufacturing tools, without long disturbances. Thus, this boosts the competitiveness of our products and our services - With this communication technology we are learning about the behaviour of our products, in practical use - Improvements of maintenance - The customer wants a production with minimum disturbances. This technology ensures better control of our tools

Company code	Basic data	Region/ country	User/ producer	AMT investments	Drivers/barriers
				High performance manufacturing technology: automation of manufacturing processes (not invested)	- This technology is too expensive – the effects of this technology on the performance of single unit manufacturing is not significant - Each project is a new challenge for our engineers. They develop the tool, test it and install it in the customer's manufacturing process. These processes cannot be automated - The company produces highly specialised products – it is not mass production
				High performance manufacturing technology: additive manufacturing technology – 3D printer	- No subsidies in the country - The engineers should learn how to develop mechanical parts with the help of this technology – it would cost us too much time and money - There is no information about this technology in the region

Company code	Basic data	Region/ country	User/ producer	AMT investments	Drivers/barriers
East 3	- SME - Privately owned limited company - Solid finances - Fast growth between 2010 – 2014 - Invests heavily in 2013 (about €1 million in AMT)	East/Croatia	User/Producer	ICT-enabled intelligent manufacturing technology: Product life cycle management system	- Because of the need to possess a PLC management system in our company, we were ready to invest as much as needed. Moreover, we got a subsidy from the Croatian government that significantly helps our situation - There is a huge demand for customised products. This technology gives us a very quick response to demand - Our managers and engineers are able to follow the whole process (PLC) using their smart devices. It reduces their reaction time drastically and, of courses, improves our competitiveness - Using this technology, we are able to answer important questions from our customers in real time (e.g. during our meetings) regardless of the location - This technology enables better management of collaborative workflows between different competence centres in our company - At the very beginning of the adoption process, the problem was to find skilled labourers who could integrate the technology into our existing system - Another issue is motivating our employees to learn. Moreover, a big challenge has been the adaptation of existing organisational routines and processes - Because we are developing and producing products according to customer requests, the integration of a digital system that enables design, building, and management of development and production with greater visibility and control is a crucial factor for our business. The SAP-software that we have integrated covers all aspects of product management. It supports us in managing, tracking and controlling all product-related information over the complete product and asset life cycle. Clearly, it is essential for our work - This technology provides us with much better quality control, in all phases of the process. This is also a very important factor for our customers - Using this technology, we are able to indicate production bottlenecks more effectively - Our system is vulnerable to a range of external attacks. However, we are constantly working on the security of our data

Company code	Basic data	Region/ country	User/ producer	AMT investments	Drivers/barriers
				High performance manufacturing technology: additive manufacturing technologies – 3D printers	- Technology is too expensive. There are no partners who would be ready to cooperate and co-finance - There is a lack of demand for products, which would be produced using additive manufacturing. The reason for this is mainly the cost factor - Our competitors do not use 3D printers in production, but rather in design and development - We do not have any practical experience in using this technology, in our plant. We would have to invest in developing our engineers' capabilities, and it would cost too much time and money - 3D printers would not significantly improve our production - The integration of additive manufacturing technology, in our production, is difficult and too complex - We see a use for 3D printers in development and design. This is why we are considering adopting this technology in our development processes
East 4	- SME - invests heavily, in 2015	East/Serbia	User/Producer	High performance manufacturing technology: CNC technology	- Demand pull – High demand for machine elements with the highest-precision components - These machines provide us with very high development and manufacturing flexibility, which is the prerequisite for our competitiveness - We could not produce these components without the CNC machines - High quality is the most important criterion
				ICT-enabled intelligent manufacturing technology: computer based development and programming of CNC machines	- This technology improves the flexibility of our development and manufacturing processes - Better linkage between development and manufacturing processes - Our development and manufacturing have to be compatible with those of our customers - The risk of scrap is drastically reduced - We have far less waste material

Company code	Basic data	Region/ country	User/ producer	AMT investments	Drivers/barriers
				High performance manufacturing technology: automation of production processes	- The technology is too expensive for us - At this time, we do not see a high demand for mass production of machine elements with the highest-precision components. Maybe in the near future, but in that case, we have to work on price reduction to be competitive on the global market - Our main advantage is our flexibility in development and production. We are not competitive in mass production (our prices are higher than those of Asian manufacturing companies). This is one of the main reasons why we do not invest in automated manufacturing - We cannot find enough engineers in the region who could programme and operate such complex manufacturing systems
South 1	- Large company - Financial break-even	South/Spain	User	Investing in AMT (general)	- The excessive concentration of sales to a few large customers introduces an element of risk in increasing productive capacity. Any loss of a single customer could compromise the return on investment - High bureaucracy of applications for European grants for R&D and innovation and low success rates
				High performance manufacturing technology: industrial robots	- Improve product quality - Reduce labour costs - Reduce lead time
				High performance manufacturing technology: handling systems	- Improve employee safety - Reduce labour costs - Reduce lead times
				High performance manufacturing technology: automated warehouse management	- Improve employee safety - Reduce labour costs - Reduce delivery times - Avoid mistakes in goods identification

Company code	Basic data	Region/ country	User/ producer	AMT investments	Drivers/barriers
				High performance manufacturing technology: ICTs applied to machinery/ production control through computers, and mobile devices – smart phones	- Provide complete remote control of the factory flow and machinery to production and maintenance managers
				Sustainable manufacturing technology: control system for shutdown of machines	-
South 2	- SME - Family-owned - Good financial situation - Growing	South/Spain	User/Producer	High performance manufacturing technology: factory facilities	- This is going to enable growth for several years. As part of this investment, the production facilities are planned for a very high standard of technology to be demonstrated to customers and to be effective and flexible in their own production
				High performance manufacturing technology: production automation (not invested)	- Although the company is a producer of highly automated production equipment, it has made only limited investments in automation, in its own production - The main reasons for this are its type of production and how production is organised in the value chain - First, the products are customised (one-off) products with limited opportunity for repetition or economies of scale - In production, the company focuses on assembly, and the part production is to a large extent outsourced to a highly devoted supplier network - The assembly work is to a large extent manual
South 3	- SME - Good financial situation - Growing	South/Spain	User/Producer	Sustainable manufacturing technology: sustainable manufacturing technology and logistics	- Increased capacity - Safety is the first issue - Very important in our company because of our culture - Need to be up-to-date and remain competitive

Company code	Basic data	Region/ country	User/ producer	AMT investments	Drivers/barriers
South 4	- Large company - Listed company - Growing turnover - Company return growing since 2013	South/Italy	User	High performance manufacturing technology: industrial robots/handling systems	- Adopted and running in practice
				High performance manufacturing technology: automated warehouse management systems	- Adopted and running in practice
				High performance manufacturing technology: additive manufacturing	- Adopted and running in practice - This technology is, currently, only in use as a prototyping phase. The company is very interested in exploring its advantages in the production phase as well
				ICT-enabled intelligent manufacturing technology: VR/simulation in product design	- Conducted some tests - The company has carried out a project for the introduction of these technologies but results have not been exciting in terms of experienced advantages. Consequently, these technologies are not adopted in practice - There are multiple reasons. The first one is of a cultural type. The company has a deep, lean manufacturing culture and tradition. Lean manufacturing favours people involvement. This is done by using a wide set of management/organisation instruments, which are supported by paper documents as a tool, enabling information sharing and intra-organisational dialogue. Thus, digital tools are not immediately suited to lean manufacturing practices, at least with the concept of company culture - The second reason is that the background of the company derives from “times and methods” practices. Thus, people do not have competencies capable of appreciating and using digital tools - Finally, some experiences were recently gained with simulation, but they did not provide a positive result

Company code	Basic data	Region/ country	User/ producer	AMT investments	Drivers/barriers
				ICT-enabled intelligent manufacturing technology: supply chain management with suppliers/customers	- Adopted and running in practice - Interesting experiences with electronic Kanban, with suppliers - The current system needs additional work for updating information. One of the main barriers experienced is the cultural readiness of people (both in the company and in supplier companies) to understand and change their operation processes accordingly
				ICT-enabled intelligent manufacturing technology: enterprise resource planning	- Adopted in practice
				Sustainable manufacturing technology: dry processing/minimum lubrication	- Adopted
				Sustainable manufacturing technology: combined cooling, heating and power	- The company has established a partnership with its energy provider, for the installation of a co-generation system to minimise heating costs of the manufacturing/assembly processes. Through this solution, the company is also able to sell energy, in the network
				High performance manufacturing technology: technologies for safe human-machine cooperation (not adopted)	- The company is currently exploring the viability and advantages of such technologies. There are ongoing projects on man-machine cooperation, for assembly operations
				High performance manufacturing technologies: processing alloy construction materials (not adopted)	- Not applicable with the present process

Company code	Basic data	Region/ country	User/ producer	AMT investments	Drivers/barriers
				High performance manufacturing technology: processing composite materials (not adopted)	- At the moment, the company is not using composite materials in its products
				High performance manufacturing technology: manufacturing micro-mechanical components (not adopted)	- Very few micro-mechanical components are used. When employed, components are bought from external suppliers
				ICT-enabled intelligent manufacturing technology: VR/simulation in production reconfiguration (not adopted)	- There are multiple reasons. The first one is of a cultural type. The company has a deep, lean manufacturing culture and tradition. Lean manufacturing favours people involvement. This is done by using a wide set of management/organisation instruments, which are supported by paper documents as a tool, enabling information sharing and intra-organisational dialogue. Thus, digital tools are not immediately suited to lean manufacturing practices, at least with the concept of company culture - The second reason is that the background of the company derives from "times and methods" practices. Thus, people do not have competencies capable of appreciating and using digital tools Finally, some experience was recently gained with simulation, but it did not provide an enthusiastic result

Company code	Basic data	Region/ country	User/ producer	AMT investments	Drivers/barriers
				ICT-enabled intelligent manufacturing technology: product life cycle management systems (not adopted)	- A significant attempt to adopt this technology has been made in the past, but with negative results. The barrier has mainly been of an organisational type. In fact, while product development is carried out centrally at the corporate level, logistics and manufacturing operations are at the local level. By definition, the PLM should integrate all information from design to end-of-life. However, company organisation makes the integration of such information difficult, since product development and manufacturing/logistics are supported by separate systems that do not communicate. The only link between the systems is the Bill of Material. Investments needed to integrate the two systems and the organisational distance in terms of systems and priorities between the different functions and units make it very complex to achieve agreement
				Sustainable manufacturing technology: recuperation of kinetic and process energy (not adopted)	- The process is not very energy-consuming, except for furnaces. Thermal insulation has been adopted for this
				Sustainable manufacturing technology: recycling and waste/disposal management technologies (not adopted)	- Waste and end-of-life products are recycled by external operators. Only plastic process scraps are re-melted in production. There are difficulties in employing recycled materials in new products, since regulatory constraints do not allow the use of contaminated materials for the production of parts that will have to interact with food - End-of-life take-back options that could enable remanufacturing practices or the extraction of spare parts are currently excluded due to the prohibitive logistical costs and the low core value
				Sustainable manufacturing technology: Sustainable nanotechnology (not adopted)	- Nanotechnologies are only employed with some surface finishing treatments (anti-fingerprint, anti-scratch coatings)

Company code	Basic data	Region/ country	User/ producer	AMT investments	Drivers/barriers
South 5	- SME - Family-owned - Economic situation improving after the crisis in 2009 - Growth 30%, in last years	South/Italy	User	High performance manufacturing technology: robot island	- Competition is a relevant driver pushing new investments for differentiation and innovation. The sector in which the company operates is very concentrated and products are nearly commodities. Thus, the risk of losing customers due to competitors' market tactics is very high and AMT might be a way to differentiate products, processes and services - In the case of promising technologies, such as industrial robots, the initial lack of specific competencies in this technology has been a barrier to acquisition. The company suffers from the unavailability of permanent skilled employees dedicated to research and innovation. Flexible solutions to identify and introduce these employees, in a sustainable way, would be needed. In the end, the company has opted to invest in AMT as a new engineer with expertise in robot programming has been introduced into the workforce - Performance is normally managed - Customer requirements are a fundamental driver for the adoption of AMT. The company constantly researches new applications that could be addressed using its materials and production capabilities. For this reason, the R&D manager attends meetings organised by Fab Lab and participates in creative meetings, organised by networks of entrepreneurs from various sectors - Often new customers' requirements, or the opportunity to offer new solutions, pushes through the acquisition of dedicated production tools, such as the robotised system that the company has introduced - Materials regulations are often drivers of product performance (e.g. fire behaviour) and process improvements - In a wider perspective, sustainability issues can drive new opportunities for materials producers. The [product name] material was created to reduce the big amount of process waste

Company code	Basic data	Region/ country	User/ producer	AMT investments	Drivers/barriers
Central 1	- SME	West/Netherlands	User/Producer	Sustainable manufacturing technology: dry processing/minimum lubrication	- Sufficient demand and willingness to accept new technologies - Support customers to move forward towards greater efficiency

Company code	Basic data	Region/ country	User/ producer	AMT investments	Drivers/barriers
Central 2	- SME	Central/France	User	High performance manufacturing technology ICT-enabled manufacturing technology	- Internal resources to reinvest in the adoption and integration of AMT are scarce in a cost-based competition environment such as the one in which the company operates. The company is not able to access EU funding opportunities. Thus, the financial situation is a significant barrier to AMT adoption - The demand situation, in general, is not a direct driver significantly addressing AMT adoption decisions - Competitive pressure, based on costs, is a driver towards the adoption of AMT to increase efficiency - The company's lack of access to new specialised resources, able to cope with AMT (technicians, programmers, developers, etc.) and the "culture shock" technology changes produce among current employees affects AMT adoption capabilities very negatively - The need to guarantee constant productivity performance is a barrier to new technology adoption decisions. The impossibility of assessing ex ante AMT performance, in the company-specific industrial production context, generates a high risk that the company is not willing to sustain - Customer requirements are the trigger for the production of new products and the adoption of new materials and tools. Flexibility capabilities and the development of new products for customers are important success factors in the market in which the company operates. AMT are seen as enablers to meet market success factors. The example of the innovations made to support customers' changing materials is significant. Thus, the demand situation is an important driver - The instability of political decisions regarding tax policies and support for innovation implies additional uncertainty about available resources to be dedicated to innovation activities. On the other hand, the company is not perceived as being affected by EU policies in support of innovation and investments - AMT adoption decisions do not seem to be directly linked to sustainability issues - Together with taxation, the high cost of labour is judged to be a strong factor hindering the company's competitiveness and ability to reinvest resources for innovation

Company code	Basic data	Region/ country	User/ producer	AMT investments	Drivers/barriers
Central 3	- Large company - Growth in the last five years	Central/UK	User/Producer	High performance manufacturing technology: additive manufacturing	- Major driver behind most decisions: improve our response ability; quite often investments are made in a competitive context - A lot of our investments are long-term and we seek IP protection - We are not usually constrained by our margins, so we seek improvements, but not just profit maximisation - Impact of regulations etc. We are not in highly regulated industries, although we serve them. Our concern is that regulators don't overregulate and that regulations are uniformly enforced - Long-term investment
Central 4	- SME - Solid finance - Moderate growth	Central/Germany	User	High performance manufacturing technology: investment in press machine automation	- This was one of our biggest investments over the last five years. We are investing in automation of our biggest hydraulic-electric press machine - The main reason for this investment is a reduction in labour costs - We have higher demand for large batch production. The manual production of these parts, in this amount, is no longer efficient - The integration of the automated production system into our manufacturing process positively influences our competitive situation because, with this technology, we are able to produce top quality much faster - Our production employees, in particular the machine operators, do not have any problem working with automated machines. They are even more satisfied, because robots take on the difficult and harmful tasks - This technology allows us a much higher production speed and quality - We are able to offer bigger lot sizes and better product quality - The machine allows us to reduce production failures - Higher quality requirements - Integration of these new robots into our manufacturing processes positively influences our productivity and resource consumption

Company code	Basic data	Region/ country	User/ producer	AMT investments	Drivers/barriers
				ICT-enabled intelligent manufacturing technology: simulation in construction	- There is a huge demand for products that are being constructed and manufactured using simulation technology - This technology is making us more competitive in the market, because we are able to offer such data to our customers - The integration of this technology into our manufacturing increases the opportunity to obtain contracts - The main problem is the lack of competencies within our production - Our cutting machine operators are not competent to work with the data produced by our constructors. Thus, we have to invest much in their training - There is a lack of machine operator (mechanic) employees who are able to work as ICT workers - The second problem is the willingness or the motivation of our machine operators to change their existing routines - Our human resource management needs new concepts for competency development, in particular for development and adjustment of competencies of semi-skilled and unskilled production employees, who are directly working on and with the new automated machines - This technology enables us to have much greater flexibility in the construction and production of our tools - We are able to offer our customers data that enables them to better plan their production processes - The integration of new digital technology in our manufacturing process provides us with better data management. Thus, we are able to manage our resource consumption, on the one hand, and control our emission of harmful substances into the environment, on the other

Company code	Basic data	Region/ country	User/ producer	AMT investments	Drivers/barriers
				Sustainable manufacturing technology: smart technology for linking energy positions with the aim of reducing energy costs	- We are saving resources and of course money indirectly - There is support from the Kreditanstalt für Wiederaufbau bank in Germany - The main advantage of this process is the minimal loss of energy in our system
				High performance manufacturing technology: additive manufacturing technologies – 3D printers	- Redesigning our production processes would be too expensive - There is no demand for aluminium products manufactured using 3D printers. - 3D printed aluminium parts are too expensive. We are working with big lots and this technology is not adequate, for our manufacturing - We use cold-forming by impact extrusion in our manufacturing process. 3D printers would not improve our manufacturing processes at all
Central 5	- SME - Family-owned - Moderate 8% growth - Invested heavily, from 2014 – 2015	Central/Germany	User	High performance manufacturing technology: CNC cylindrical grinding machine	- We have favourable opportunities for external financing - We have problems with competitive labourers, who are able to work with this technology. We have to develop our own employees, because we cannot find adequate workers in the labour market, in our region - This technology enables us to achieve a higher three micro-meter precision and thus increases our quality enormously - The requirements of our customers from the machine sector represent the main driver for this investment

Company code	Basic data	Region/ country	User/ producer	AMT investments	Drivers/barriers
				ICT-enabled intelligent manufacturing technology: 3D modelling CAD/CAM	- We have problems with high competitive pressure. The competitors who are able to produce favourable prices threaten our business - Our unique selling point is the quality that we are able to offer, with our high precision technology - It is really difficult to find new labour in our region that is capable of working with this technology. Thus, we have to re-qualify our own employees. This costs too much in time and money - This technology allows us to programme our machines centrally, controlling them from our design and construction unit. This improves our processes significantly - Our customers send us the documentation for production as digital CAD/CAM data. We have to be able to work with this data. This was the main reason for our integrating this technology into our manufacturing process
				Sustainable manufacturing technology: LED lighting	- We were able to finance the adoption of this technology from our cash flow - All high precision machines have their own lighting, installed directly on the machine, which improves the quality of the work - The higher quality requirements of our customers from the machine sector, but also from the automotive sector, represent important drivers for investments in such technologies. Every single step in quality improvement and cost saving makes our business more competitive on the market - This technology enables significant reduction of our energy consumption and thus, positively influences our competitiveness

Company code	Basic data	Region/ country	User/ producer	AMT investments	Drivers/barriers
				High performance manufacturing technology: additive manufacturing technologies (not made)	- This technology is too expensive and we do not have the demand that would cover the investment - We are producing large batch sizes. Thus, 3D printing is not suitable for our production - We would not achieve higher competitiveness with this technology, because our niche is the automotive industry, where we are produce large batches - We do not have competencies for additive manufacturing - We are producing large batch sizes. Thus, 3D printing is not suitable for our production

7.2 ANNEX B: Main drivers and barriers identified in the case studies

Table 39: Drivers and barriers related to financial situation

Financial situation	
Drivers	Internal: + Investing in AMT can improve the financial situation through lower cost and better products and services + The ultimate goal for any investment is to improve or at least maintain the financial situation in a changing situation, and this is what is expected from AMT as well + The necessity that causes AMT to stay competitive is a central driver for investment in AMT External: + External financial support can be a driver for investing in AMT + Financial support for research can improve readiness to invest in AMT + Co-creation and co-financing with customers is a central driver for investing in AMT + Public investment in infrastructure can, as an indirect support, be a driver for investment in AMT
Barriers	Internal: - Weak financial situation and poor access to capital markets - Company does not have the necessary skills and resources to apply for public funding External: - Lack of public financial support for AMT investments at a national or EU level - Complex bureaucracy in applying for public funding - Lack of opportunity for financial cooperation with customers - Uncertainty of demand - Weak payback due to limited impact on processes and performance - Technology is too expensive

Table 40: Drivers and barriers related to demand situation

Demand situation	
Drivers	External: + Sufficient demand situation is a prerequisite for investment in AMT + The demand situation can be improved through improved customer value. AMT can help to improve this value, both in products and services + Value for the customer is achieved through high quality products and services. ICT-enabled technology is part of the product and an enabler of services. Continuous availability for maintenance and training of operators are ICT-enabled services, which can affect how the customers invest in new technology
Barriers	Internal: - The demand for products produced using AMT is not strong enough to guarantee the return on investment in the user organisation External: - Limited demand or uncertainty regarding future demand is a barrier to investment. For instance, excessive concentration of sales on a few large customers introduces an element of risk in increasing productive capacity, as the loss of a single customer could compromise the return on investment - Little demand for mass produced products reduces the need and opportunity for automation of processes

Table 41: Drivers and barriers related to competitive situation

Competitive situation	
Drivers	Internal: + Through the use of AMT, companies can achieve unique product and service characteristics differentiating them from the competition. In some cases, the AMT can provide a unique selling proposition, for the company + AMT can improve process performance, improve product and service quality, allow for faster reaction to customer needs, improve production speed, improve development flexibility and production processes, etc. + The use of AMT can also allow for more competitive pricing of products and services. In some cases, AMT can provide both better product or service quality and a lower price than the competition External: + Introduction of AMT can also be a necessity to keep up with the competition + The use of AMT-like sustainable technology can improve the image of the company. Being able to show customers that you are able to operate sustainably can convince the customer of your ability to provide high quality, sustainable products and services + Competitors already possess or can offer services based on AMT
Barriers	Internal: - Lack of competency to compete in economies of scale reduces the need to automate, and possibility of, automating processes

Table 42: Drivers and barriers related to know-how, competence and skills

Know-how, competence and skills	
Drivers	Internal: + Internal access to necessary know-how, competence and skills is a driver for implementing new AMT + AMT can provide data about production, products or services. This is a good opportunity for the technology provider and users to learn and develop knowledge and competencies. + Training of staff is often necessary, as experienced labour is not available External: + Providers support users in developing the necessary know-how, competence and skills
Barriers	Internal: - Lack of trained or experienced labour force in the region - Lack of managerial know-how regarding new AMT - Use of new technologies, such as additive manufacturing, requires completely new knowledge of how to design and produce a product or service. Especially in small companies, the time and money needed for this investment can be hard to find - In large companies, the complex organisational situation, with decentralised units in charge of different products, can become a barrier to the adoption of new technologies. The complexity of the organisation affects internal communication and decision-making - Organisational culture and know-how, in the company and in the value network, do not support implementation of high-tech digital tools. For instance, lean manufacturing involving factory employees in development can be a barrier to implementation of digital tools External: - Lack of engineers in the region

Table 43: Drivers and barriers related to process performance

Process performance	
Drivers	Internal: + Products cannot be produced by other means + AMT can provide increased capacity, compared with traditional means + AMT improve process performance and service levels through higher quality, faster production, greater flexibility in development and production, higher productivity, etc. + Flexible automation can provide reductions in labour costs and improvements in labour productivity, in a heavy manufacturing industry + AMT improve the flexibility of both manufacturing and R&D + AMT improve the working environment in the factory. Sustainable technology can improve the situation both inside and outside the factory + AMT can improve machine usability through improvements in maintenance + AMT provide better communication and linkage between the product development and manufacturing processes + AMT improve information management and communication in internal and external processes + AMT provide more freedom for the design of products and services External: + The growing capacity of computers enables the development of increasingly flexible automation systems. This is a technical enabler for AM technology, now and in the future
Barriers	Internal: - The need for constant, undisrupted process performance is a barrier to implementation of new technology - Integration of AMT, in existing processes, requires extensive re-engineering and training of personnel - Earlier failures to implement a specific technology can become a barrier, even though technology develops and the situation changes - Unreliable technology cannot be introduced into production External: - AMT are not suitable for the production (manual assembly, one-of-a-kind) that is not mature enough or is too expensive in comparison to existing technology - The technologies are too expensive or the effect on the manufacturing process is insufficient to cover the extra cost of investment

Table 44: Drivers and barriers related to customer requirements

Customer requirements	
Drivers	Internal: + In small flexible companies, such as the interviewed AMT provider companies, customer requirements and the fulfilment of these requirements are at the core of their business model. AMT help these suppliers to provide solutions to these requirements through better performance of products, better service and product quality and greater price flexibility + AMT provides the means for undisturbed operations in the manufacturing process + AMT enables production of a higher quality at a lower price External: + Price pressure from customers + Customers requiring new products and services + Customers requiring increased speed of production + Customers requiring high quality of products and services + Customers requiring data transfer technologies + Sustainability is an image issue for customers
Barriers	Internal: - In mass production of user companies, growing customer requirements are not the main drivers of the adoption of innovative manufacturing technologies

Table 45: Drivers and barriers related to legislative, regulation, political situation

Legislative, regulatory and political situation	
Drivers	External: + Regulation can be a market driver creating new markets for sustainable technology. This can also be a driver for investment in AMT. For instance, high requirements in terms of technology can make investment in AMT profitable + Certification and standards provide a platform for a market + Regulation can also push companies to use greener manufacturing technology or to develop processes + A driver could be the automation of physically heavy tasks, avoiding exposure to dangerous chemicals, or improving ergonomics or safety + Material regulations are often drivers of product performance (e.g. fire behaviour) and process improvements
Barriers	Internal: - Applying for EU subsidies is a bureaucratic process requiring skills and resources that many SMEs do not possess External: - Instability of political decisions regarding tax policies and support for innovation implies additional uncertainty over available resources to be dedicated to innovation activities - Old regulations can be a barrier to developing and adopting AMT. For instance, re-usage of components is, in some areas, still hindered by regulatory issues - Lack of national support for investing in AMT - Lack of information about new technology can, in certain regions, be a barrier to investment in AMT - Lack of standards for new AMT, such as additive manufacturing

Table 46: Drivers and barriers related to sustainability

Sustainability	
Drivers	Internal: + Sustainability is becoming a new element affecting innovation decisions, in order to pursue environmental compliance and develop a sustainable image + More efficient manufacturing processes – less waste and scrap + Reduces environmental impact through emission control + Sustainability is an image issue for customers External: + National support for sustainable technology and investment + Usage of waste and scrap
Barriers	External: - New standards and certificates, with higher requirements, raise costs - Difficulties of using recycled materials due to regulatory constraints - End-of-life take-back options that could enable remanufacturing are excluded due to high logistical cost and low core value

7.3 ANNEX C: Case company comments on EU policy

At the end of the interviews, the interviewees were asked what the EU could do to improve the use of AMT in Europe. The comments from the interviewees were grouped under ten major topics. These are:

1) Support for AMT investments;
2) Information for SMEs;
3) Managing regulation;
4) Training of personnel;
5) Improving labour force competitiveness;
6) Regulation of competition;
7) Reducing bureaucracy;
8) Avoiding market disturbances;
9) Managing the EU's innovation system;
10) Support for new Member States.

1. Support for AMT investments

- At a national and European level, there are few policy support actions in favour of investment in AMT. In regions like Singapore, the government is making it easier for companies to invest in automation and in the US, re-industrialisation is supported through public subsidies. If there were more AMT-friendly policies, Europe would be more competitive than it is today. Industry would have more support in improving its processes, validating new technologies and investing in new equipment and technologies.

- European policy supports research and development, but in industry there is a need for investing in technologies which have been previously validated in labs or industrial environments. The EU could increase the speed of introducing AMT into companies through labs accessible to companies at competitive prices, through know-how transmission to companies and through incentives to invest in new technologies.

- Currently, the majority of European programmes cover technology development until TRL 7. This is a strong barrier to market for industrial companies that have to supply AMT to manufacturers, especially if they are SMEs and they lack sufficient company resources to cover the required investments. New instruments that contribute to removing this barrier such as Fast Track to Innovation Pilot projects[29] are very welcome.

[29] The Fast Track to Innovation (FTI) pilot is a fully-bottom-up measure in Horizon 2020 to promote close-to-the-market innovation activities; it is open to all types of participants (https://ec.europa.eu/programmes/horizon2020/en/h2020-section/fast-track-innovation-pilot).

- Incorporation of subsidies in R&D and technological innovation projects, not only up to the value of the amortisation during the project, but also to the total investment value of new AMT equipment.
- Delocalisation of EU subsidy management to national or regional entities, while retaining EU supervision. Some key agents could take up this responsibility at a national level, i.e. the Spanish Centre for the Development of Industrial Technology (CDTI – www.cdti.es) is a public organisation under the Ministry of Science and Innovation, the objective of which is to help Spanish companies increase their technological profile. This state-owned company was set up in 1977 and, since then, has financed more than 15 000 technology development projects.
- Too much focus is placed on working together with universities and research institutes, whereas direct B2B contact can be more fruitful when discussing implementation of new but proven technologies.
- New demonstration initiatives for SMEs would help companies get in contact with AMT and prefigure and assess their potentialities, because without this step, the technologies of the future will remain a dream for entrepreneurs.
- It is difficult for SMEs to approach universities and research centres, because there is the perception that they are far from the industrial sector and that their research developments are rarely applicable for the industry.
- It is also difficult to participate in EU projects. First of all, it is difficult for industrial people to have a broad understanding of all the different formats and instruments and be able to navigate among them. To do this, it is often necessary to employ dedicated consultants to screen the different options and indicate those most suitable for the company. Even university or research consultants are too expensive to hire for their expertise. Moreover, participation in EU projects is extremely challenging for SMEs. The submission phase requires documents and details that are difficult to provide at early stages when the development project has not yet started. Often, full-time resources are needed to fill out the required documents, preventing these resources from working on their daily tasks in production which is difficult for small enterprises. In this regard, it could be more useful to provide resources and skills rather than money in order to bring companies closer to research centres and university competencies.
- Another approach, which is found to be very useful, is matching; this entails bringing groups of people from different sectors and backgrounds together to discuss different topics (e.g. digital economy, business models, etc.). This works as a networking and cross-fertilisation opportunity where entrepreneurs are able to make contacts with other entrepreneurs to exchange opinions, discuss novelties and find new opportunities. In this regard, matchmaking, fab-labs and networking events are seen as useful initiatives for disseminating new visions and competencies across the industry. The marketing orientation of the entrepreneur is the engine for such a matching activity.
- For a company, it is important that the EU can ensure availability of capital.

2. Information for SMEs

- Getting EU grants via national institutions that represent providers of EU subsidies is a huge problem for manufacturing companies in Croatia as well as in other developing countries, in the region. However, there is an enormous lack of competencies in these institutions in terms of designing calls and managing the submitted project proposals. For a country such as Croatia, the procedures for the approval of grants by European institutions take too long. The situation surrounding the evaluation of applications, before official funding, is also considered too long.
- SMEs need more information on the possibilities offered by sustainable manufacturing technologies. They do not know how to improve their manufacturing processes while at the same time becoming more sustainable.
- SMEs are not well informed of the possibilities of European grants for R&D and innovation.
- There is a lack of institutions that could help with informing SMEs on the possibilities regarding adoption of AMT. Even if they know about the grants, they do not know how to participate as there is a lack of knowledge about EU project-writing in the region.
- As for the company, the main problem with EU funds is the intermediary function of consulting companies, whose function is to supervise and make the processes easier. However, because of the profitable nature of their work, they are motivated to get as many projects as possible. In this process, the SMEs do not get enough information on the funding opportunities. The solution to this problem would be to establish more independent local or regional non-profit organisations that could supervise EU projects for manufacturing SMEs and provide them with the required information.

3. Managing regulations

- Perseverance is needed in taxation and other public policies. When policies are fluctuating, entrepreneurs and managers cannot build their strategic decisions and investments on existing or planned policies.
- Regulation in Europe is often too strict and impedes the development of new technologies. Ideally, regulation follows new technological developments and helps companies to comply with regulatory conditions so that they can compete on equal terms. Administrations should more rigorously contest non-compliant companies.
- Standards, certification and other qualification procedures should help to improve and assure products and processes, and differentiate companies that do not comply with these standards and certifications. Sustainability, environmental regulation and safety are crucial to many European companies. Especially in the area of sustainable manufacturing technologies, regulation is a market driver.

- Companies working illegally without paying taxes, selling without applying VAT, or complying with different VAT in their home countries, have a clear but uncompetitive advantage. This needs to be stopped.
- In the field, the RoHS directive and other compliance legislation plays a part. What is needed and wanted is a level playing field.

4. Training of staff

- Lack of experienced staff is a challenge to all companies, but there are differences in the kind of expertise that the companies are lacking. While one company lacks export sales personnel, another company lacks competent engineers. Some companies may require more expertise to assess investments in AMT. Due to the small number of case companies analysed, we cannot determine what is causing these variations in staff requirements.
- The EU should make it more attractive for companies to gain access to training programmes.
- Suppliers should receive support to develop good training programmes that allow for the development of good techniques for transferring technology to customers.
- Another important topic is the improvement of training and skills, and how policy makers can support training and education.

5. Improving labour force competitiveness

- Labour force competitiveness is crucial to creating the environment for entrepreneurship and investment. Creating an environment of efficiency and flexibility in the work force is more important than cutting salaries. One company stated that local agreements are needed in the labour market.

6. Regulation of competition

- In areas such as gas, electricity and oil, there are problems with companies having a monopolistic position in the market. They are reluctant to adopt new technologies and it is difficult for AMT providers to gain new projects in these sectors. The EU should increase its efforts to work on regulating the competition.
- Europe should also work on entry barriers to Asian products, which are a problem for European companies.
- In Eastern Europe, there is a lack of information on suppliers and potential customers of AMT. Without good contacts with the local industry, it is hard for SMEs to find customers. There is a need for more associations or clusters which could organise workshops, seminars and brokerage events. The EU should invest more in improving this service in these countries.
- EU tax/customs regulation hinders trade and impairs competitiveness for companies in bordering countries.

7. Reducing bureaucracy

- Another important factor limiting the generation of interesting innovative solutions for companies is the rigidity of the scheme of EU funded projects. EU projects usually last three to four years. During its development, the project risks becoming technologically obsolete as the company and the technological environment evolve in these four years. In this regard, the project plan may become a major constraint because it is rigid. The contract is often perceived as a prison, because technology development needs to look to the future and not to be stuck in the past. For a company not to have the possibility of easily changing project targets and objectives during development is perceived to be a strong barrier to the effectiveness of European funded projects. In order to overcome these barriers, it is suggested that EU projects should adopt a more flexible modulation system that would enable it to reshape the project concept at an intermediate point if needed. For example, there could be a mid-term project redesign option, to rethink objectives and use cases that would simplify any current amendment difficulties.

8. Avoiding market disturbance

- EU support should be easy to apply for. Today it requires too many resources and know-how. However, there should not be too much support and too many subsidies as they can affect the competitive situation in the market as large companies with more resources get more financial support.

9. Managing the EU's innovation system

- SME's innovation priorities and problems are well represented by regional and national intermediary institutions and the regional innovation system is seen as working reasonably well. However, companies believe that the regional system is not sufficiently able to influence European policy. European institutions are perceived as being unstable in their decisions and unable to carry forward precise and coherent political and economic strategies in support of SMEs. The result is that, for companies adopting AMT, fluctuating taxation policies deeply hinder the capability to remain competitive and, in particular, to innovate. Moreover, it is perceived that every improvement gained through efforts towards the adoption of new technologies, lean production and managerial innovation is absorbed by the increasing fiscal pressure.

- Other important hindering factors for the competitiveness of companies are the different competitive conditions among different EU countries. Discrepancies in the costs of labour, commercial policies and forms of protectionism in some countries and European impositions above national economic affairs seem to undermine the potential for fair competition among companies in the European market.

- European institutions should go beyond their administrative role and promote policies to create a favourable, competitive framework within which companies can invest in AMT. Possible measures could be the introduction of higher tax credits for innovation and the acquisition of

new competencies, the decrease of labour taxation and the addressing of specific territory needs.

- Furthermore, it is necessary to design actions to introduce SMEs to the opportunities of European funding innovation programmes which are too wide and complicated for SMEs.

10. Support for new Member States

- It is difficult for SMEs from new Member States to find and get customers who are willing to work and cooperate with them. Companies from developed European countries often have prejudices against SMEs from developing countries such as Serbia. They doubt that they can achieve the required quality. The solution involves arranging brokerage events, workshops and seminars in places such as the Hungarian-Serbian border region.

7.4 ANNEX D: Questionnaire used for the case studies

Background

The European Commission considers that the European industry is a leader in production of AMT, but is lagging behind other world regions in the use of these technologies in its own production processes. This interview is part of the project "An analysis of drivers, barriers and readiness factors of European companies for adopting advanced manufacturing products and technologies", funded by the European Commission. The objective of the project is to find out which factors are driving or slowing down the diffusion of AMT in the European industry and to make policy recommendations to the EU, based on the findings. The project is led by *Fraunhofer ISI*, in Germany, in cooperation with *IDEA Consult* of Belgium, *ITIA* of Italy and *VTT* of Finland.

The results of the interviews, in 15 companies, will be used to create an in-depth understanding of the drivers of, and barriers to, use of AMT in European industry and to plan for an industry questionnaire. Interview answers from an individual company will not be reported or published without the express agreement of that company.

In this project, we focus on three main groups of AMT: ***high performance manufacturing technology, ICT-enabled technology and sustainable manufacturing technology***. In the interview, we hope you will consider what all three of these groups mean to your company.

The structure of the interview is based on four parts:

1. Part 1 (on the next page) includes a list of potential AMT. Please take 3-5 minutes to become familiar with them;
2. Part 2 of the interview focuses on your company's business, on a general level;
3. Part 3 focuses on how your company utilises AMT;
4. Part 4 focuses on input for policy-making.

1. Advanced manufacturing technology

In the table below we list a number of AMT. These are the focus of our study, but the list is not exclusive. You may have some other technologies in mind.

Table 47: Relevance of AMT

1. High Performance Manufacturing Technologies
- Industrial robots/handling systems
- Automated warehouse management systems
- Technologies for safe human-machine cooperation
- Processing alloy construction materials
- Processing composite materials
- Manufacturing micro-mechanical components
- Additive manufacturing
- Other
2. ICT-Enabled Technologies
- VR/simulation in production reconfiguration
- VR/simulation in product design
- Supply chain management with suppliers/customers
- Product life cycle management systems
- Enterprise resource planning
- Other
3. Sustainable Manufacturing Technologies
- Dry processing/minimum lubrication
- Recuperation of kinetic and process energy
- Control system for shut down of machines
- Combined cold, heat and power (Bi-/Trigeneration)
- Recycling and waste/disposal management technologies
- Energy efficient technologies
- Sustainable nanotechnology
- Biomanufacturing
- Other

2. Business environment

1. Describe your main business, products and services

2. How have market conditions for your products/services changed over the last five years?

3. What are your company's main competitive means?
   a. Economies of scale (low cost due to high volume)
      a. Low cost of labour
      b. High automation level
   b. High quality niche products
   c. Flexibility and customisation
   d. Something else
4. How has the competitive situation developed over the last five years?

5. How has your company's (business unit's) financial situation been over the last five years? What are the main factors affecting the financial situation?

6. On a scale from 1 – 5 (1 = basic level, 3 = average industry level, 5 = leading edge technology), how would you describe the technological level in your company? Why?
   a. Product technology
   b. Production technology
   c. Use of ICT
   d. Management support to improve technological level

3. Use of AMT

1. What could be the drivers and barriers for European companies to invest in AMT?
   a. In High Performance Manufacturing Technologies
   b. In ICT-Enabled Technologies
   c. In Sustainable Manufacturing Technologies

2. How is national and European policy supporting or preventing investment in AMT, in your country or Europe?

3. What AMT have you invested in and why?
   What were the main drivers for investing?

4. What AMT have you decided not to invest in and why?
   What were the main barriers to investment?

5. Regarding the investment you already made (see above): how did the following drivers and barriers affect the investment decision?

6. Regarding the technology you are interested in but have not yet invested in: How have the following drivers and barriers affected the investment decision?

Positive Decision	How much did it affect the investment decision? (5 high – 1 low)	Comments
Financial situation		
Demand situation		
Competitive situation		
Know-how, competence and skills		
Process performance		
Customer requirements		
Legislative, regulation, political situation		
Sustainability		
Other external drivers?		

7. Regarding the technology you are interested in but have not yet invested in: How have the following drivers and barriers affected the investment decision?

Negative Decision	How much did it affect the investment decision? (5 high – 1 low)	Comments
Financial situation		
Demand situation		
Competitive situation		
Know-how, competence and skills		
Process performance		
Customer requirements		
Legislative, regulation, political situation		
Sustainability		
Other external drivers?		

8. You are also a producer of AMT. Based on your contacts with your clients can you indicate the dominant drivers and barriers that affected their investment decisions in Europe?

Decision-making	How much did it affect the investment decision? (5 high – 1 low)	Comments
Financial situation		
Demand situation		
Competitive situation		
Know-how, competence and skills		
Process performance		
Customer requirements		
Legislative, regulation, political situation		
Sustainability		
Other external drivers?		

4. Input to policy-making

1. How does regulation affect your business?
    a. Standards, certification and other qualification procedures
    b. Environmental regulation
    c. Tax framework
    d. Certification framework
    e. Regulatory conditions
    f. Other

2. In which of the abovementioned areas do you think EU or national policy could motivate you to take additional investment and, if yes, how?

3. What could the EU do to improve the use of AMT in Europe?

7.5 ANNEX E: Online questionnaire for AMT users and producers

EASME/COSME/2014/014

Online questionnaire for Advanced Manufacturing Technologies users and producers

On behalf of the **European Commission** our consortium has been commissioned to perform a study "An analysis of drivers, barriers and readiness factors of European companies for adopting advanced manufacturing products and technologies".

An online questionnaire has been designed to gather information from companies using or producing Advanced Manufacturing Technologies in the various Member States. We are particularly interested in identifying the main **drivers** and **barriers** related to the diffusion of **Advanced Manufacturing Technologies** and knowing how companies perceive the drivers and barriers related to the diffusion of Advanced Manufacturing Technologies in the European industry. The findings will provide input for policy **recommendation** for the European Union. For more information we refer to the support letter from the European Commission to **companies** and **organisations**. It is your opportunity to let the voice of European manufacturing to be heard!

You are kindly invited to participate in this online questionnaire. We estimate that it will take you approximately **10 minutes** to complete the questionnaire. Your answers will be treated **strictly confidential** and will be processed **anonymously**.

Thank you very much for your time and support.

Els Van de Velde
Senior Expert Competitiveness and Innovation
IDEA Consult

Olivier Chassagne
European Commission
DG GROW, Unit F.1 - Innovation Policy for Growth

Page 1 - Company Profile

1. **Firm size**

- ○ Micro company (< 10 employees)
- ○ Small company (10-49 employees)
- ○ Medium company (50-249 employees)
- ○ Large company (250-2000 employees)
- ○ Very large company (> 2000 employees)

2. **Firm sector**

- ☐ Food, beverages, tobacco industry (NACE 10 12)
- ☐ Chemical industry (NACE 20 21)
- ☐ Rubber and plastic industry (NACE 22 23)
- ☐ Metal industry (NACE 24 25)
- ☐ Electronic and electrical equipment (NACE 26 27)
- ☐ Machinery (NACE 28)
- ☐ Transport equipment (NACE 29 30)
- ☐ Other, please specify

Page 2

3. **What is the location of your headquarter?**

- Albania
- Armenia
- Austria
- Belgium
- Bulgaria
- Croatia
- Cyprus
- Czech Republic
- Denmark
- Estonia
- Finland
- France
- Germany
- Greece
- Hungary
- Iceland
- Ireland
- Italy
- Latvia
- Lithuania
- Luxembourg
- The former Yugoslav Republic of Macedonia
- Malta
- Moldova
- Montenegro
- Netherlands
- Poland
- Portugal
- Romania
- Serbia
- Slovakia
- Slovenia
- Spain
- Sweden
- Turkey
- United Kingdom
- Other, please specify

4. **What is the coverage of your manufacturing operations?**

- Manufacturing operations only in the home country
- Manufacturing operations in a number of countries

5. **What is your market coverage?**

- Domestic
- EU28
- Global

Page 3 - Advanced Manufacturing Technologies

6. **Please indicate the relevance of the following types of Advanced Manufacturing Technologies for your company: High performance technologies, ICT-enabled and Sustainable manufacturing technologies**

	Low				High
Technologies to improve the performance of manufacturing (quality, throughput, cost) and to enable innovative manufacturing processes					
ICT supporting product lifecycle management (design, manufacturing, maintenance, End-Of-Life, Industry 4.0)					
Sustainable manufacturing technologies to improve energy and resource efficiency of manufacturing					

7. **Please indicate if your company is a user of Advanced Manufacturing Technologies in its production processes, or a producer of Advanced Manufacturing Technologies:**

- ○ User of advanced manufacturing equipment/technologies
- ○ Producer of advanced manufacturing equipment/technologies
- ○ Both user and producer of advanced manufacturing equipment/technologies

Page 4

Toon pagina als

7. Please indicate if your company is a user of Advanced Manufacturing Technologies in its production processes, or a producer of Advanced Manufacturing Technologies:...

is gelijk aan *Both user and producer of advanced manufacturing equipment/technologies*

You have indicated that you are both a user and producer of Advanced Manufacturing Technologies. We would like to ask you to fill in this questionnaire from a user perspective. Thank you.

Page 5

8. **How would you assess your company's level of capacity with respect to the following aspects?**

	Basic	Industry average	High (leading edge)
Product/service technology	○	○	○
Production technology	○	○	○
Use of ICT	○	○	○
Management processes to improve technological level	○	○	○

Page 6

Toon pagina als

7. Please indicate if your company is a user of Advanced Manufacturing Technologies in its production processes, or a producer of Advanced Manufacturing Technologies:...

is gelijk aan *Producer of advanced manufacturing equipment/technologies*

9. **You indicated that you are a producer of Advanced Manufacturing Technologies.**
What are central motivations for your firm to develop and produce advanced manufacturing technologies:

	Yes	No
Further development of existing product portfolio	○	○
Development of new business options based on existing technological competence	○	○
Specific requests from existing or potential customers / customers associations	○	○
New input and inspiration from public research organisations	○	○
Evident short-term market opportunity	○	○
Possible long-term market opportunity	○	○

Page 7

Toon pagina als

7. Please indicate if your company is a user of Advanced Manufacturing Technologies in its production processes, or a producer of Advanced Manufacturing Technologies:...

is gelijk aan *Producer of advanced manufacturing equipment/technologies*

10. What are central hindering factors for your firm to supply advanced manufacturing technologies to additional customers:

	Yes	No
Lack of knowledge about market dynamics	○	○
Lack of access to potential customers	○	○
Lack of understanding of customers' precise needs	○	○
Technologies not mature enough, technical reliability issues	○	○
Technologies not mature enough, business proposition unclear	○	○
Lack of resources to reach out to customers more actively	○	○

Page 8

Toon pagina als

7. Please indicate if your company is a user of Advanced Manufacturing Technologies in its production processes, or a producer of Advanced Manufacturing Technologies:...

is gelijk aan *Producer of advanced manufacturing equipment/technologies*

11. How prepared do you feel to overcome challenges in the course of developing larger markets for Advanced Manufacturing Technologies:

	Not ready				Well mastered
General understanding of technological dynamics in the field	○	○	○	○	○
Understanding of technological opportunities resulting from the application of Advanced Manufacturing Technologies	○	○	○	○	○
Understanding of business opportunities resulting from the application of Advanced Manufacturing Technologies	○	○	○	○	○
Access to markets you currently serve	○	○	○	○	○
Access to additional markets	○	○	○	○	○
Access to relevant intermediary organizations of users like associations and chambers	○	○	○	○	○

Page 9 - Main objectives to use Advanced Manufacturing Tech

Toon pagina als

7. Please indicate if your company is a user of Advanced Manufacturing Technologies in its production processes, or a producer of Advanced Manufacturing Technologies:...

is gelijk aan *Producer of advanced manufacturing equipment/technologies*

12. **You indicated that you are a producer of Advanced Manufacturing Technologies.**
What do you think are the main objectives for your customers to invest in Advanced Manufacturing Technologies?

	Yes	No
Increase throughput	○	○
Reduce production lead time	○	○
Reduce time to market	○	○
Reduce production cost	○	○
Improve workforce/employees productivity and efficacy	○	○
Reduce the consumption of energy and materials	○	○
Improve the quality of products and services	○	○
Produce new products	○	○
Approach new markets	○	○
Differentiate from competitors	○	○
Respond to safety requirements/certification	○	○
Tackle environmental requirements/certification	○	○
Address other certification requirements	○	○
Other, please specify	○	○

Page 10

Toon pagina als

7. Please indicate if your company is a user of Advanced Manufacturing Technologies in its production processes, or a producer of Advanced Manufacturing Technologies:...

is gelijk aan *User of advanced manufacturing equipment/technologies*

of

7. Please indicate if your company is a user of Advanced Manufacturing Technologies in its production processes, or a producer of Advanced Manufacturing Technologies:...

is gelijk aan *Both user and producer of advanced manufacturing equipment/technologies*

13. **You indicated that you are a user of Advanced Manufacturing Technologies.**
What are the main objectives for your company to invest in Advanced Manufacturing Technologies?

	Yes	No
Increase throughput	○	○
Reduce production lead time	○	○
Reduce time to market	○	○
Reduce production cost	○	○
Improve workforce/employees productivity and efficacy	○	○
Reduce the consumption of energy and materials	○	○
Improve the quality of products and services	○	○
Produce new products	○	○
Approach new markets	○	○
Differentiate from competitors	○	○
Respond to safety requirements/certification	○	○
Tackle environmental requirements/certification	○	○
Address other certification requirements	○	○
Other, please specify	○	○

Page 11 - Main hindering factors to use AMT

Toon pagina als

7. Please indicate if your company is a user of Advanced Manufacturing Technologies in its production processes, or a producer of Advanced Manufacturing Technologies:...

is gelijk aan *Producer of advanced manufacturing equipment/technologies*

14. What do you think are the main factors hindering your customers to invest in Advanced Manufacturing Technologies?

	Yes	No
Advanced Manufacturing Technology is not adequate to customer requirements and needs	○	○
Advanced Manufacturing Technology is not enough mature yet	○	○
The service/assistance guaranteed to customers is not adequate	○	○
Impossibility to integrate the Advanced Manufacturing Technology into customers' current processes (i.e. due to standards/process incompatibility)	○	○
Lack of skilled personnel to integrate and use Advanced Manufacturing Technology	○	○
Difficulty to meet safety, environmental and other requirements associated to Advanced Manufacturing Technology	○	○
Lack of standards for Advanced Manufacturing Technology	○	○
Difficulty to assess the performance of Advanced Manufacturing Technology and its business return	○	○
Market uncertainty and turbulence	○	○
High cost of investment for Advanced Manufacturing Technology acquisition and lack of financial resources	○	○
The introduction of Advanced Manufacturing Technology as it implies personnel reduction	○	○
The introduction of Advanced Manufacturing Technology as it implies significant organizational change	○	○
Cultural and organizational reluctance of employees/operators to accept Advanced Manufacturing Technology	○	○
Other, please specify	○	○

Page 12 - Main hindering factors to use AMT

Toon pagina als

7. Please indicate if your company is a user of Advanced Manufacturing Technologies in its production processes, or a producer of Advanced Manufacturing Technologies:...

is gelijk aan *User of advanced manufacturing equipment/technologies*

of

7. Please indicate if your company is a user of Advanced Manufacturing Technologies in its production processes, or a producer of Advanced Manufacturing Technologies:...

is gelijk aan *Both user and producer of advanced manufacturing equipment/technologies*

15. What are the main factors hindering your company to invest in Advanced Manufacturing Technologies?

	Yes	No
Advanced Manufacturing Technology is not adequate to customer requirements and needs	○	○
Advanced Manufacturing Technology is not enough mature yet	○	○
The service/assistance guaranteed to customers is not adequate	○	○
Impossibility to integrate the Advanced Manufacturing Technology into customers' current processes (i.e. due to standards/process incompatibility)	○	○
Lack of skilled personnel to integrate and use Advanced Manufacturing Technology	○	○
Difficulty to meet safety, environmental and other requirements associated to Advanced Manufacturing Technology	○	○
Lack of standards for Advanced Manufacturing Technology	○	○
Difficulty to assess the performance of Advanced Manufacturing Technology and its business return	○	○
Market uncertainty and turbulence	○	○
High cost of investment for Advanced Manufacturing Technology acquisition and lack of financial resources	○	○
The introduction of Advanced Manufacturing Technology as it implies personnel reduction	○	○
The introduction of Advanced Manufacturing Technology as it implies significant organizational change	○	○
Cultural and organizational reluctance of employees/operators to accept Advanced Manufacturing Technology	○	○
Other, please specify	○	○

Page 13 - Firm-level readiness to use Advanced Manufacturing

Toon pagina als

7. Please indicate if your company is a user of Advanced Manufacturing Technologies in its production processes, or a producer of Advanced Manufacturing Technologies:...

is gelijk aan *Producer of advanced manufacturing equipment/technologies*

16. How do you evaluate the capacity of your customers to overcome the following barriers to the adoption of Advanced Manufacturing Technologies (readiness to their adoption)?

	Not ready				Well mastered
Access to skilled human resources that can operate Advanced Manufacturing Technologies	○	○	○	○	○
Access to pilot facilities/demonstrators to test the potential of Advanced Manufacturing Technologies	○	○	○	○	○
Access to financial resources (ex. loans, innovation grants, etc.)	○	○	○	○	○
Cooperation with other Advanced Manufacturing Technologies developers/providers	○	○	○	○	○
Cooperation with other users of Advanced Manufacturing Technologies	○	○	○	○	○
Access to technology services provided notably by research and technology organisations, consulting companies or other competence centres	○	○	○	○	○
Other, please specify	○	○	○	○	○

Page 14

Toon pagina als

7. Please indicate if your company is a user of Advanced Manufacturing Technologies in its production processes, or a producer of Advanced Manufacturing Technologies:...

is gelijk aan *User of advanced manufacturing equipment/technologies*

of

7. Please indicate if your company is a user of Advanced Manufacturing Technologies in its production processes, or a producer of Advanced Manufacturing Technologies:...

is gelijk aan *Both user and producer of advanced manufacturing equipment/technologies*

17. How do you evaluate your capacity to overcome the following barriers to the adoption of Advanced Manufacturing Technologies (readiness to their adoption)?

	Not ready				Well mastered
Access to skilled human resources that can operate Advanced Manufacturing Technologies					
Access to pilot facilities/demonstrators to test the potential of Advanced Manufacturing Technologies					
Access to financial resources (ex. loans, innovation grants, etc.)					
Cooperation with other Advanced Manufacturing Technologies developers/providers					
Cooperation with other users of Advanced Manufacturing Technologies					
Access to technology services provided notably by research and technology organisations, consulting companies or other competence centres					
Other, please specify					

Page 15

Toon pagina als

7. Please indicate if your company is a user of Advanced Manufacturing Technologies in its production processes, or a producer of Advanced Manufacturing Technologies:...

is gelijk aan *Producer of advanced manufacturing equipment/technologies*

18. Which policy measures from public authorities do you think would motivate/enable your customers to introduce Advanced Manufacturing Technologies in their companies?

	No influence				Strong influence
Diffuse the knowledge and awareness on Advanced Manufacturing Technologies among manufacturing companies					
Build pilot/demonstration facilities for Advanced Manufacturing Technologies and make them accessible to SMEs					
Provide financial incentives to implement and use Advanced Manufacturing Technologies					
Subsidise training offers to employees to get acquainted with Advanced Manufacturing Technologies					
Develop new curricula and education programs/methods for the creation of new skills and competences on Advanced Manufacturing Technologies					
Increase access to technology services from competence centres such as research and technology organisations , consulting companies, etc.					
Increase the cultural acceptance of employees in order to overcome organizational barriers					
Other, please specify					

Page 16

Toon pagina als

7. Please indicate if your company is a user of Advanced Manufacturing Technologies in its production processes, or a producer of Advanced Manufacturing Technologies:...

is gelijk aan *User of advanced manufacturing equipment/technologies*

of

7. Please indicate if your company is a user of Advanced Manufacturing Technologies in its production processes, or a producer of Advanced Manufacturing Technologies:...

is gelijk aan *Both user and producer of advanced manufacturing equipment/technologies*

19. Which policy measures from public authorities do you think would motivate/enable you to introduce Advanced Manufacturing Technologies in your firm?

	No influence				Strong influence
Diffuse the knowledge and awareness on Advanced Manufacturing Technologies among manufacturing companies	○	○	○	○	○
Build pilot/demonstration facilities for Advanced Manufacturing Technologies and make them accessible to SMEs	○	○	○	○	○
Provide financial incentives to implement and use Advanced Manufacturing Technologies	○	○	○	○	○
Subsidise training offers to employees to get acquainted with Advanced Manufacturing Technologies	○	○	○	○	○
Develop new curricula and education programs/methods for the creation of new skills and competences on Advanced Manufacturing Technologies	○	○	○	○	○
Increase access to technology services from competence centres such as research and technology organisations , consulting companies, etc.	○	○	○	○	○
Increase the cultural acceptance of employees in order to overcome organizational barriers	○	○	○	○	○
Other, please specify	○	○	○	○	○

Page 17 - Advanced Manufacturing Technology

20. **Can you indicate which specific Advanced Manufacturing Technologies are relevant to the production processes of your company?**

High performance manufacturing technologies

	Relevant	Not relevant
Industrial robots/handling systems	○	○
Automated Warehouse Management Systems	○	○
Technologies for safe human-machine cooperation, improved usability	○	○
Manufacturing micromechanical components	○	○
Additive manufacturing	○	○
Photonics (other than additive)	○	○
Processes specific to Advanced Materials	○	○
Nano-manufacturing	○	○
Processes for Bio-manufacturing	○	○
High-performance machinery	○	○
Modular and adaptable (interoperable) machines	○	○
Cutting and machining techniques for rapid prototyping equipment	○	○
Self-adaptive production lines	○	○
Printed electronics/roll-to-roll processes	○	○
Silicon-on-chip, heterogeneous circuits, and embedded systems	○	○
Microelectromechanical systems (MEMS) and sensor devices	○	○
Nanoelectronics materials and patterning, Nanoimprint (process and equipment)	○	○
Precision manufacturing and metrology	○	○

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21. **Can you indicate which specific Advanced Manufacturing Technologies are relevant to the production processes for your company? (continued)**

ICT-enabled manufacturing technologies

	Relevant	Not relevant
VR/AR/simulation in production reconfiguration	○	○
VR/AR/simulation in product design, Digital design technologies, Design platforms for modular, adaptable manufacturing	○	○
Supply chain management with suppliers/customers, Network-centric production, Optimization of production networks	○	○
Product Lifecycle Management Systems, Product Data Management Systems	○	○
Enterprise Resource Planning	○	○
Mass customization (three-dimensional printing, direct digital manufacturing)	○	○
Cyber-physical (production) systems, intelligent components	○	○
Cloud manufacturing	○	○

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22. **Can you indicate which specific Advanced Manufacturing Technologies are relevant to the production processes for your company? (continued)**

Sustainable manufacturing technologies

	Relevant	Not relevant
Dry processing/minimum lubrication	○	○
Recuperation of kinetic and process energy	○	○
Control system for shut down of machines	○	○
Combined cold, heat and power (Bi-/Trigeneration)	○	○
Recycling and waste/disposal management technologies	○	○
Use of renewable technologies and processes (e.g. low power electronics, photovoltaics)	○	○
(Advanced) materials for green manufacturing	○	○
Alternately fuelled vehicles, Fuel cell technology	○	○
"Low carbon" technologies, Green design/ Eco-design	○	○
Product Life Cycle optimization, Service Life optimization	○	○
Other, please specify	○	○

Page 20

Toon pagina als

7. Please indicate if your company is a user of Advanced Manufacturing Technologies in its production processes, or a producer of Advanced Manufacturing Technologies:...

is gelijk aan *Producer of advanced manufacturing equipment/technologies*

23. **Your company is (predominantly) a producer of Advanced Manufacturing Technologies to other firms: What percentage of your sales do products based on Advanced Manufacturing Technologies represent?**

- ○ 0 - 20%
- ○ 21 - 40%
- ○ 41 - 60%
- ○ 61 - 80%
- ○ 81 - 100%

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Toon pagina als

7. Please indicate if your company is a user of Advanced Manufacturing Technologies in its production processes, or a producer of Advanced Manufacturing Technologies:...

is gelijk aan *User of advanced manufacturing equipment/technologies*

of

7. Please indicate if your company is a user of Advanced Manufacturing Technologies in its production processes, or a producer of Advanced Manufacturing Technologies:...

is gelijk aan *Both user and producer of advanced manufacturing equipment/technologies*

24. **Your company is (predominantly) a user of Advanced Manufacturing Technologies provided by other firms: What percentage of your sales is produced using Advanced Manufacturing Technologies?**

- ○ 0 - 20%
- ○ 21 - 40%
- ○ 41 - 60%
- ○ 61 - 80%
- ○ 81 - 100%

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25. In case you are interested to receive the results of our study, please provide your email address below.

It will be registered separately from the dataset as such and not used for identification.

Bijkomende opties (vraag 25)

› Validatie: e-mailadres

Your responses have been registered!

Thank you for taking the time to complete the survey, your input is valuable to us.