Fraunhofer ISI

Project EASME/COSME/2014/014

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

Deliverable 1 (based on Work Package1):

Quantitative analysis of how EU manufacturing companies currently use advanced manufacturing and potential impact

submitted by Fraunhofer ISI, Karlsruhe, Germany

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Abbreviations

AMT	Advanced Manufacturing Technologies
COSME	Competitiveness of Enterprises & Small and Medium-sized Enterprises (Programme)
EASME	Executive Agency for Small and Medium-sized Enterprises
EMS	*European Manufacturing Survey*
NACE	Statistical Classification of Economic Activities in the European Community

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1 Introduction

1.1 Work Package 1 – Setting the Scene for Further Analysis

This Deliverable summarises and interprets the findings of Work Package 1 as outlined in Chapter 3.2 of the Technical Proposal. The quantitative analysis performed in the following section constitutes the required desk research at EU level to collect and analyse data about the use of a preselected number of advanced manufacturing products and technologies in as many COSME participating countries as possible.

In the context of this project, the key objective of Work Package 1 thus is to set the scene for later analysis. It is aimed at generating first insights and at revealing first patterns to provide a basis for later more comprehensive analyses in Work Package 2. It does expressly not aim to develop generalisable policy conclusions but to inform the development of questionnaires and the selection of case studies in preparation of work under Work Package 2.

After several introductory paragraphs outlining and delineating the object of study, this report will outline our analysis' findings regarding the use/uptake of advanced manufacturing technologies in COSME participating countries as well as the impact of this use/uptake along several innovation- and performance-oriented dimensions in two main descriptive sections. Finally, the report concludes with an interpretive summary and conclusions for further work under later Work Packages will be drawn. Annexes will document all quantitative result for those readers who want to further investigate specific details.

1.2 Which AMT to Study? – Defining AMT vs. KETs

Before embarking on a study of the use and impact of Advanced Manufacturing Technologies, is necessary to delineate the AMT concept from related ones – most prominently the concept of Key Enabling Technologies.

While all KETs can be relevant for manufacturing as they can improve production processes and technologies, the degree to which they practically already do differs strongly. As it is thus not possible to say that some KETs are, in principle, relevant to manufacturing while others are not it would be mistaken to limit technologies relevant to advanced manufacturing to one single KET, that labelled "advanced manufacturing technologies". Other KETs, like nanotechnology or new materials, can be just as relevant to modern manufacturing.

While advanced manufacturing studies thus need to take into account different KETs, yet not always all KETs completely. Other than "pure" KETs studies, advanced manufacturing studies should only consider those KETs that already have an impact on manufacturing processes at the current point in time, i.e. a relevant potential to transform current processes of production (KETs as a driver and enabler of **process innovation**) or allow for the manufacturing of new, KET-based final products (KETs as a driver and enabler of **product innovation**).

KET-based solutions that are still far from technological realisation or implementation beyond early stages will therefore not be considered in this study as they remain irrelevant for any short to mid-term increase in manufacturing performance. “Industrial Biotechnology”, for example, has never been explicitly included in the EMS as it is known that its use among the sample population is generally quite limited and concentrated on a few, larger firms in selected countries. Furthermore, the 2012 EMS explicitly decided against the inclusion of “Photonics” as an area of study. While this technology is of course generally relevant, broad anecdotal evidence suggested that, at the time, its practical uptake in production processes remained minimal across most industries. While this situation may now be gradually changing, it will be up to later Work Packages of this project to study the role of such early-stage, emerging KETs for production in more detail.

In conclusion and agreement with the European Commission, this first exploratory section of the project has chosen to analyse the uptake and potential effects of the following advanced manufacturing technologies:

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 micromechanical components

ICT-Enabled Technologies

- VR / simulation in production reconfiguration
- VR / simulation in product design
- Supply chain management with suppliers/customers
- Product Lifecycle Management Systems

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)

With the exceptions of industrial biotechnology and photonics, as already mentioned, the uptake and impact of KET-based solutions in industrial manufacturing activities can be illustrated for all other major KETs, that is production technology, nanotechnology, micro- and nanoelectronics, as well as advanced materials.

1.3 How to Determine Use and Impact? – Conceptual Approach

To illustrate the **uptake of advanced manufacturing technologies** in European firms, different approaches can be chosen. Not uncommonly, studies simply distinguish between the use and non-use of a certain technology. With a view to this study's ambition to analyse the diffusion of advanced manufacturing technologies, however, a detailed analysis appeared adequate, that allows an at least general statement with regard to the intensity of use of a technology in specific enterprises. Overall, four situations could be distinguished based on EMS data:

- rather intensive use of technology,
- pilot use of technology,
- first use of technology planned,
- technology not used.

As outlined above, the three main groups of advanced manufacturing technologies analysed (high performance manufacturing, ICT-enabled, and sustainable manufacturing technologies) are made up of several specific technologies. For the purpose of analysis, the question thus was if e.g. "any high performance manufacturing technology is intensively used in the firm", entailing a definition pilot use as the situation where "no high performance manufacturing technology is used intensively, yet one or more are piloted" and one of planned use as the situation where "no high performance manufacturing technology is used intensively or piloted, but the future use of one or more such technologies is planned."

The **impact of the use of advanced manufacturing technologies**, moreover, is not easy to determine completely and unequivocally without detailed controls for various factors that must in part remain unknown at this stage. Later Work Packages, in particular the case studies, will aim at establishing cause-effect relationships in more detail and with greater robustness. Nonetheless, EMS 2012 data allow to determine which factors might be relevant for further analyses in an unmatched degree of detail by outlining correlations between firms' use of technologies and their performance with regard to a number of different aspects.

Overall, our approach to determine performance takes recourse to three main dimensions:

- Productive Performance
    - Production lead time
    - Order delivery on time (main product)
    - Rework/Scrap (main product)
- Economic Performance
    - Added Value
    - Return on sales
    - Employment growth
    - Revenue growth
    - Total Factor Productivity

- Innovative Performance
    - Firms with New Products,
    - Turnover with New Products,
    - Firms with Products New to the Market,
    - Turnover with Products New to the Market
    - Firms with Old Products,
    - Turnover with Old Products

For all those, detailed cross-tabulation can identify differences, in average for both specific technologies and the three main groups outlined above. Moreover, it will be validated by means of t-tests whether such differences are statistically significant or not. On this basis EMS 2012 data analysis cannot only provide first indications but robust empirical guidance for all later steps of analysis planned in this project, including the selection of case studies.

1.4 Methodology and Data Used

In this workpackage the analysis on the usage and possible impact of AMTs will be executed based on data of the *European Manufacturing Survey* (EMS). The main advantage and unique selling proposition of EMS data is that it allows an integrated analytical approach at firm level, providing all necessary variables to reach the research objectives described above in one database. Therefore, it is not necessary to match different publically available databases, which may cover different variables at different levels, lack harmonisation and thus not allow a persistent firm-level view on all important topics of this study.

EMS is organized by a consortium of research institutes and universities from and across Europe. EMS surveys the utilisation of techno-organizational innovations in manufacturing at the level of individual manufacturing sites and the thereby achievable performance increases in the manufacturing sector. The roots of the EMS can be found in the *German Manufacturing Survey*, developed in 1993 by Fraunhofer ISI. From 2001 onwards, this survey developed into the *European Manufacturing Survey* (EMS) by means of its extension to a continuously growing number of European and even global partners. Fraunhofer ISI coordinates the consortium.

EMS is carried out as a written or online survey by each partner in his/her country. In each country, the survey comprises a large random sample of manufacturing firms with at least 20 employees covering the whole manufacturing sector. Manufacturing or plant managers are asked to fill in the questionnaire. The majority of questions in the questionnaire are common questions addressed by all partners and often asked repeatedly across several rounds. To ensure comparability, the questionnaire is translated into the respective national language and pretested in each participating country. Currently, a complete data basis is available from five survey rounds 2001, 2003, 2006 and 2009 and 2012.

As required by the Tender Specifications, EMS data allow for a differentiation by country, sector and size class – as well as for companies producing different batch sizes and product with a different degree of complexity. The possible number of countries covered, however, necessarily depends on the number of countries participating in EMS 2012. For this project, data was analysed from a sample of 2,700 manufacturing companies from Germany, Austria, France, Spain, Croatia, Slovenia, Portugal, Denmark and the Netherlands covered by the EMS.

1.5 Novelty/Added Value of Approach

In comparison to earlier studies based on the EMS dataset, this study represents a completely new approach, tailored to the tender specifications of the study: „An analysis of the drivers, barriers and readiness factors of EU companies for adopting advanced manufacturing products and technologies“. This novel approach provides new insights from a number of perspectives:

Firstly, it groups information on specific technologies under the conceptual framework of the Task Force report “Advancing Manufacturing - Advancing Europe” – i.e. “high performance manufacturing technologies”, “ICT-enabled technologies” and “sustainable manufacturing technologies”. So far, no analysis has structured EMS data according to this conceptual framework and no related analysis has been conducted yet. Based on the study’s new approach, therefore, questions like “is there a generalisable impact of high performance manufacturing technologies (rather than ICT-enabled technologies)” can be answered for the first time.

Secondly, it simultaneously explores all relevant technologies covered by the EMS survey as well as the situation in all countries for which data is available. In earlier studies, a focus had either been put on the uptake of one specific technology in various countries[1] or on the uptake of various technologies in one or few particular countries[2]. Based on these studies, therefore, it would not have been possible to establish a sufficiently comprehensive picture of the uptake and general impact of AMT use to guide and focus further work under Work Package 2. Earlier studies with a comparative approach, finally, could not yet draw on EMS data based findings (only available from 2006 onwards) but e.g. had to focus on foresight[3].

[1] e.g. Jäger, A.; Moll, C.; Som, O.; Zanker, C.; Kinkel, S.; Lichtner, R. (2015): Analysis of the impact of robotic systems on employment in the European Union. Final report. European Commission, Directorate-General of Communications Networks, Content & Technology. Publications Office of the European Union. Luxembourg

Kinkel, S., Weißfloch, U. (2009), Estimation of the Future User Potential of Innovative Robot Technologies in SMEs - Promising Prospects, World Robotics 2009, Frankfurt/M

[2] e.g. Som, O., Kirner, E., Jäger, A. (2013): Absorptive Capacity of non-R&D intensive firms in the German manufacturing industry. Paper presented at the 35th DRUID Celebration Conference, 17-19 June, Barcelona, Spain

Kleine, O., Kinkel, S., Jäger, A. (2008), “Flexibilität durch Technologieeinsatz? Nutzung und Erfolgswirkung flexibilitätsfördernder Technologien”, in Nyhuis, P., Reinhart, G. and Abele, E. (Eds.), Wandlungsfähige Produktionssysteme: heute die Industrie von morgen gestalten, PZH, Garbsen, pp. 78–92.

Som, O. (2012): Innovation without R&D – Heterogeneous Innovation Patterns of Non-R&D-Performing Firms in the German Manufacturing Industry. Wiesbaden, Springer, Gabler

[3] Fraunhofer ISI (2006): Final Report of the FP6 Specific Support Action Project: Manufacturing Visions. Integrating diverse Perspectives into Pan-European Foresight. http://cordis.europa.eu/publication/rcn/12399_en.html

Thirdly, it explores not only the question of whether certain AMT technologies are used or not, but differentiates between regular/established use, pilot use as well as planned use of these technologies in manufacturing firms. This perspective has not regularly been taken in analyses of EMS data so far. Thus, it was methodologically further developed in this study to be applicable to the integration of more detailed information under the three main technology groups provided as headings by the AMT taskforce. This dynamic perspective is of key importance as it will allow the study to differentiate between dynamic and less dynamic areas of uptake.

Fourthly, the empirical investigation includes a number of different dimensions of analysis, including differences between countries, sectors, firms of different sizes, firms producing in different batch sizes as well as between firms manufacturing products of different levels of complexity. Such a very broad based analysis, that, once more, will enable a clearer focus of the analysis in Work Package 2, had so far not been conducted on data structured according to the conceptual approach developed by the European Commission Task Force on AMT.

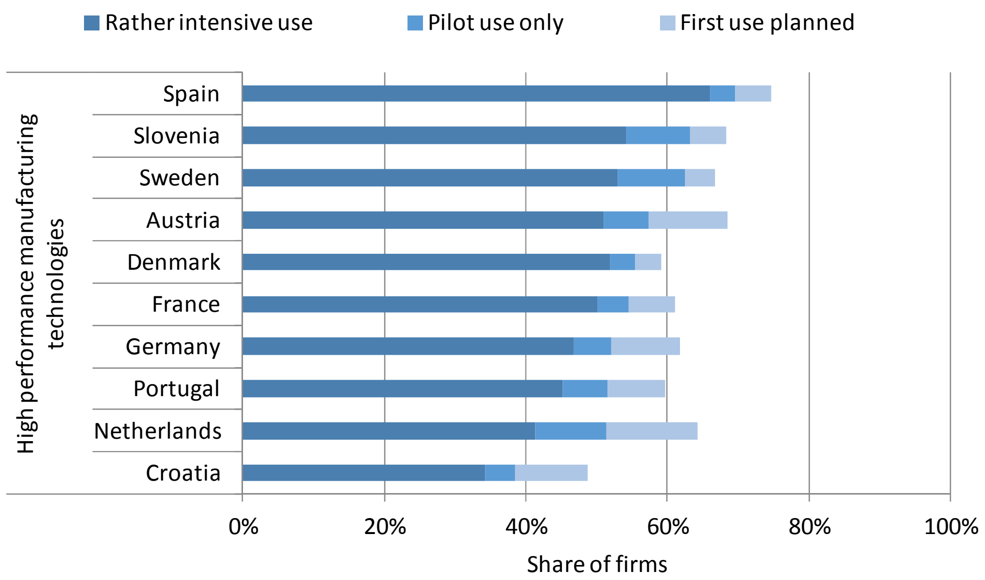
Finally, Work Package 1 combines an analysis of uptake with an analysis of impacts thus providing first insights not only on whether and where uptake occurs but also on positive (or negative) impacts of technology use on firm performance which may well be motivating (or restraining) factors for the uptake of different types of AMT and thus useful for guiding later analysis. While such analyses may have occasionally been performed before, they have never been applied to consciously structured information on such a broad range of technologies.

2 Current Use of AMT

This chapter includes a profound descriptive analysis of the use of advanced manufacturing technologies in industrial companies in ten selected countries based on the EMS data. As a fundamental first step, an extensive descriptive analysis of usage of advanced manufacturing technologies by country, industry and firm size will be delivered. Furthermore, the results of the analysis of the use of AMT by batch size and product complexity will be reported.

2.1 Use of AMT by European Countries and Country Groups

The analysis of AMT utilization in the ten selected countries (Figure 1) shows that the high-performing manufacturing technologies are adopted by between somewhat below 40 percent and nearly 70 percent of manufacturing firms. In the leading group, involving Slovenia, Sweden and interestingly Spain, the adoption rates reach between 60 and 70 percent, although in part based on pilot activities. Germany and Austria, are not part of this group but of a large middle group in which about 50-60 percent of all surveyed firms adopt one or more high-performing manufacturing technologies. Notably, the Netherlands fall into this group only due to a comparatively high share of firms piloting technologies while their share of intensive users hardly exceeded 40 percent, though lower than in the rest of the group. Finally, Croatia, lags behind all other countries with an overall usage rate of less than 40 percent, including pilot use.



Source: European Manufacturing Survey 2012. Extract of 10 countries. Compiled by Fraunhofer ISI – 2015.

Figure 1: Shares of firms using high performance manufacturing technologies, by countries

While pilot use occurred prevalently in about 4-6 percent of all firms, the national shares of firms using high performance manufacturing technologies partly or to full possible extent is much higher than that of those piloting only. Even in the Netherlands, Sweden and Slovenia, where the piloting rates are highest, they hardly exceeded 10 percent. Plans for starting the use of high performance manufacturing technologies in the next three years were on average developed by between 4 and 8 percent of all surveyed firms. Only in Germany, Austria, the Netherlands and Croatia the share is notably higher, amounting to about 10 percent or more.

Figure 2 depicts the use of ICT-enabled technologies in the ten selected countries. The analysis shows that industrial companies in Sweden and Slovenia most frequently use one or more ICT-enabled technologies in their production processes (over 60 percent). However, there is a significant difference between these countries regarding the share of intensive and pilot users. In particular, Slovenia displays a very high share of intensive adopters of one or more of these technologies (60 percent) while the share of pilot users is much lower (less than 5 percent). Sweden, in contrast, displays a quite notable share of pilot users (almost 15 percent). A similar distribution can be found for Portugal and the Netherlands with almost equal levels of utilization (about 60 percent) followed in third and fourth place and displayed an equally significant difference with respect to pilot users. These first four countries form a leading group. Ranks five to eight are occupied by France, Denmark, Spain and Germany, each with between 40 and 50 percent of adopters respectively. The last two places of the ranking, finally, are held by Croatia and Austria, which reported usage rates of close to 40 percent and only a small difference of intensive and pilot users.

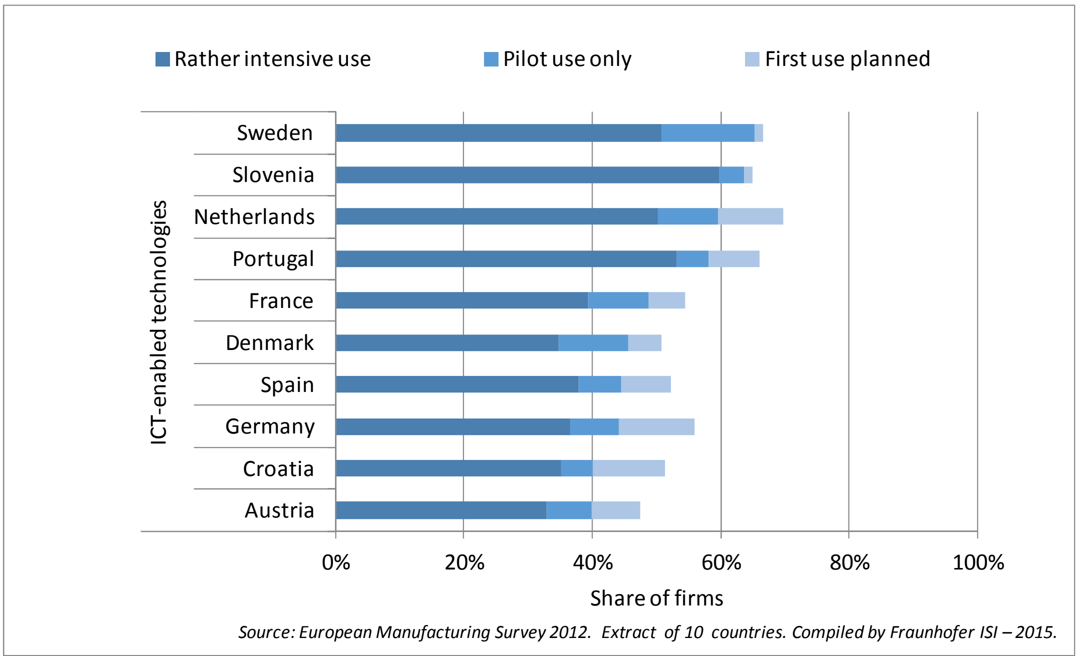
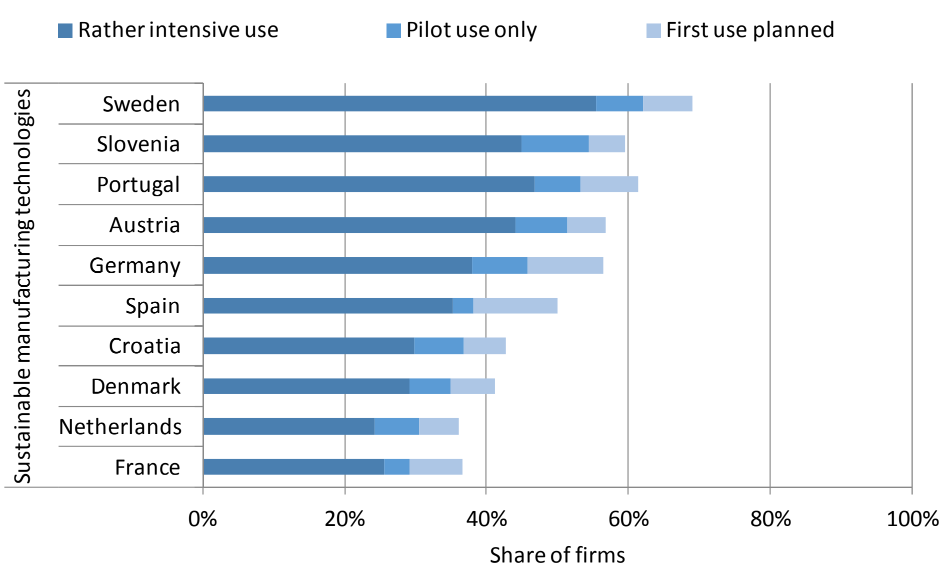


Figure 2: Shares of firms using ICT-enabled technologies, by countries

These final six countries form a second group with overall lower adoption rates than in the first. Taking planned use into account, the data shows a different situation in many countries. Although the current share of users of ICT-enabled technologies in Germany and Croatia is lower than elsewhere, the share of companies with plans for adoption is greater, (12/11 percent). Likewise, about 10 percent of the companies in the Netherlands still plan to adopt ICT-enabled technologies, similarly to the situation with high performance technologies. Only in the two leading nations is it rather low.

Compared to those for other technologies, data on sustainable manufacturing technologies demonstrate remarkable deviations with regard to technological uptake in specific countries (Figure 3). The quota of users in Sweden (62 percent), for example, is more than double than that found in France or the Netherlands (around 30 percent). Compared to these countries' high share of usage in the other two fields, the share of adopters of sustainable manufacturing technologies is rather low. Similarly, Denmark, Croatia and Spain display relatively low shares of firms using sustainable manufacturing technologies. Together these four countries form a 'lagging group' with adoption rates below 40 percent. According to our findings, moreover, Slovenia, Portugal, Austria and Germany form a second group in which the share of adopters of technology adopters ranges between 40 and 55 percent. Notably, Germany belongs to this group only due to a relatively high share of firms piloting technologies while their share of intensive users alone does not achieve the level of the group (40 percent). In this group, only Spain indicates a similarly high rate of companies planning to adopt further sustainable manufacturing technologies (> 10 percent). Sweden, finally, occupies an exceptional rank with an adoption rate of greater than 60% and an additional planned use of nearly 10 percent.



Source: European Manufacturing Survey 2012. Extract of 10 countries. Compiled by Fraunhofer ISI – 2015.

Figure 3: Shares of firms using sustainable manufacturing technologies, by countries

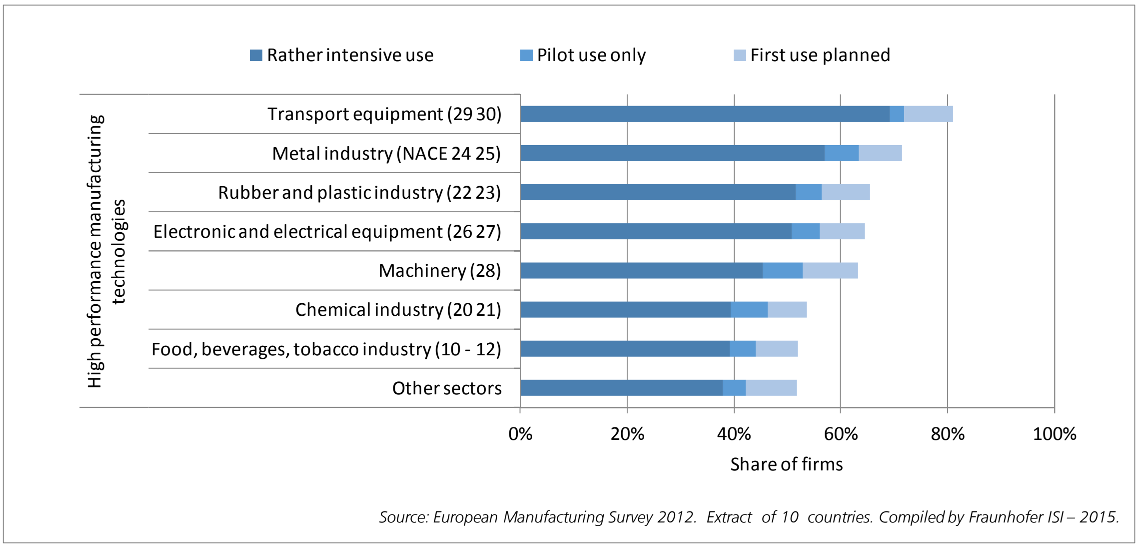
2.2 Use of AMT by Industries

Discussed by Technologies

Looking at sectoral differences regarding the usage of AMTs (Figure 4), it becomes obvious that, with the exception of only a few industries, high-performing manufacturing technologies are adopted by between somewhat below 40 percent and close to 60 percent of manufacturing firms, documenting similar differences between industries as had been found between countries – which should be borne in mind during later analyses.

The manufacturers of transport equipment represent one exception as around 70 percent of them are intensively using high performance technology. Moreover, the share of companies in this industry which plan to use some of these technologies is notably above average. A second industry with above-average adoption rates is the manufacture of metals and metal products even if only due to a comparatively high share of firms piloting technologies, while the share of intensive users in this sector does not reach 60 percent.

In a second group of industries with typical usage rates between 40 and 60 percent, the rubber and plastic industry as well as the electrical industry have dominant positions. In those, around half of the surveyed companies use one or more high performance manufacturing technologies intensively. The machine industry features still in this group, yet with fairly few users (45 percent), in which the level of pilot use only is highest (almost 8 percent). Finally, the chemical industry as well as the food, beverages and tobacco industry display below-average intensities of usage, between 40 and 50 percent.

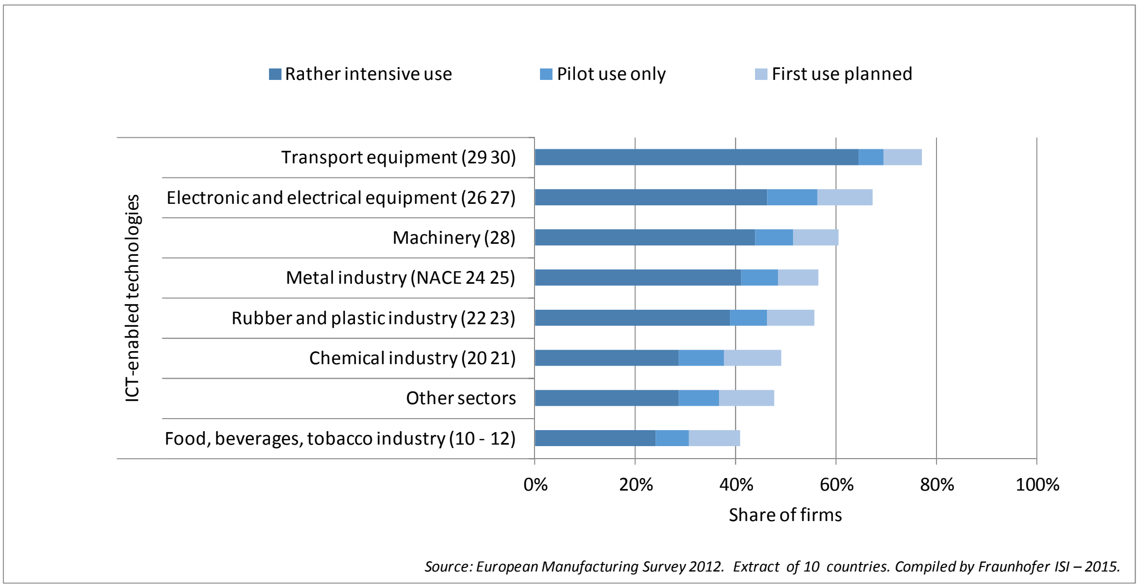


(note: figures in brackets refer to NACE, rev. 2)

Figure 4: Shares of firms using high performance manufacturing technologies, by industries.

Figure 5 depicts the findings regarding the adoption of ICT-enabled technologies by industries. In contrast to the high-performance technologies presented above, the analysis indicates three main groups of industries regarding the usage of ICT-enabled technologies: higher than 60 percent, between 40 and 60 percent, and between 20 and 40 percent. Again, the advanced manufacturing technology in question, here ICT-enabled technologies, was most commonly adopted among manufacturers of transport equipment. In that sector, more than 60 percent of all companies surveyed use ICT-enabled technologies intensively and, unlike in other analyzed industries, only about 5 percent pilot them.

In addition to current usages, almost 8 percent of the companies in this sector plan to use one or more ICT-enabled technology in the future – thus setting the transport industry even stronger apart from others than was the case with respect to high performance manufacturing technologies. Furthermore, a second group represents industries with between 40 and 60 percent of users, including the electrical, the machine building, the metal as well as the rubber and plastic industry. A third group, finally, includes all other considered industries with use rates between 20 and 40 percent. In this group, the food, beverage and tobacco industry displays the lowest rate of technology adopters with only 24 percent of intensive and just over 6 percent of pilot users of ICT-enabled advanced manufacturing technologies.



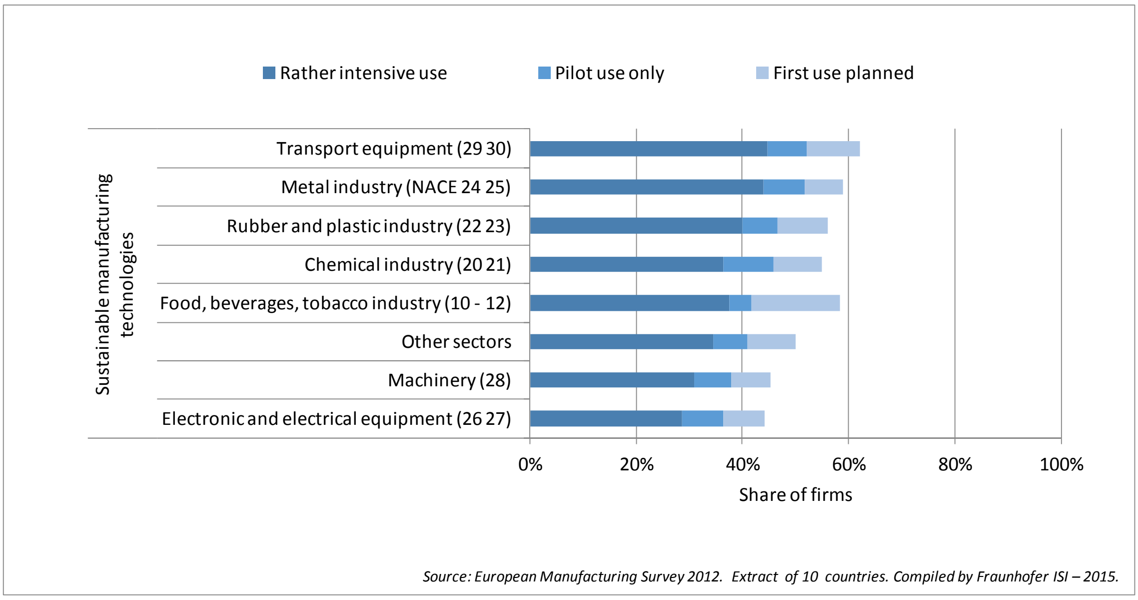
(note: figures in brackets refer to NACE, rev. 2)

Figure 5: Shares of firms using ICT-enabled technologies, by industries

Similar to the findings with respect to high performance technologies, two groups of industries can be distinguished with respect to the adoption of sustainable manufacturing technologies (Figure 6). The leading group, including transport and equipment as well as the metal industry, shows around 45 percent of intensive, and around 8 percent of piloting users, i.e. an over all adoption rate of above 50 percent. Furthermore, between 7 and 10 percent of the companies in these sectors report that they plan a first use of these technologies in the future. In addition to the transport equipment and the metal industry, the rubber and plastic as well as the chemical industry belong to an extended leading group with use rates notably above 40 percent.

However, although almost one half of the companies in these industries use sustainable manufacturing technologies, less than 40 percent of these use them intensively, a situation more similar to that in the food, beverages and tobacco industry. Only the relatively high share of pilot users makes the former two an extended leading group, while, in the food, beverages and tobacco industry, it is lowest among all analyzed industries.

Hence, it falls into a third group with between 20 and 40 percent of users to which all other industries pertain. Interestingly, the share of food, beverages and tobacco manufacturers who plan the first use of sustainable technologies exceeds that of all other examined industries - while in general far less notable differences can be identified with respect to either pilot or planned use than with respect to the two other technology areas analyzed above.



(note: figures in brackets refer to NACE, rev. 2)

Figure 6: Shares of firms using sustainable manufacturing technologies, by industries

Discussed by Industries

Figure 7 depicts the shares of firms using advanced manufacturing technologies in the transport equipment industry. About 70 percent of the surveyed firms use high performance manufacturing technologies slightly more than ICT-enabled technologies, whereas only 52 percent of them have adopted sustainable manufacturing technologies. Regarding the planned first use of AMTs, there are no high discrepancies between the different technologies. The shares of companies in the transport equipment sector which are planning a first use of one of these technologies in the future are between 8 percent and 10 percent (for sustainable manu-facturing technologies).

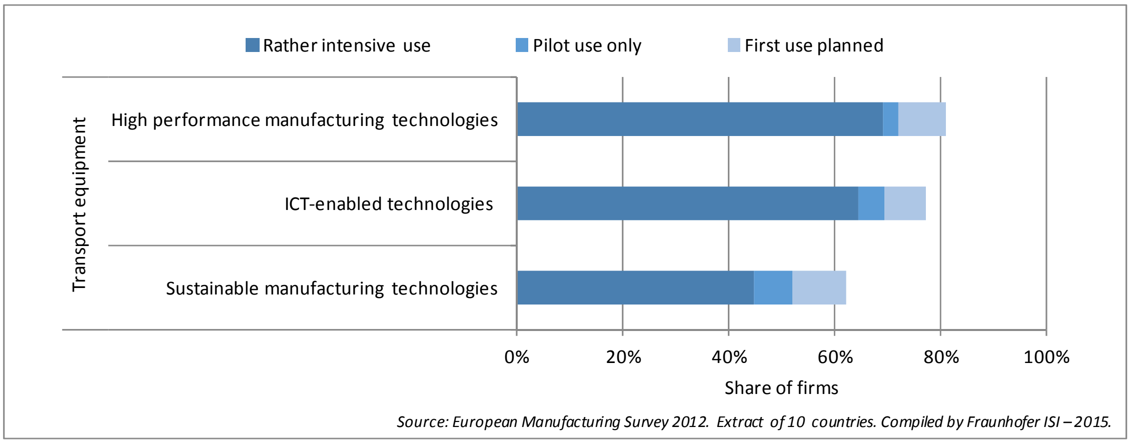


Figure 7: Shares of firms using AMTs in the transport equipment industry

In metal industry (Figure 8), the shares of firms using AMTs are generally lower. The data shows that about 60 percent of the manufacturing companies in this sector have adopted high performance manufacturing technologies, in part based on pilot activities. Moreover, hardly 50% of all firms in the metal industry have adopted ICT-enabled technologies or sustainable manufacturing technologies. The shares of metal manufacturer planning a first use of AMTs, finally, are about 8 percent for every of the three different technologies, not too different from those in the transport equipment industry.

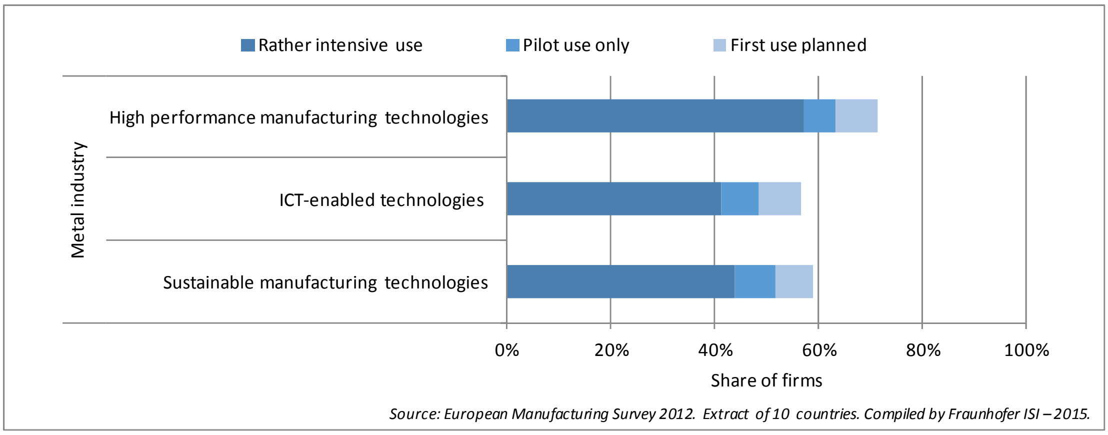


Figure 8: Shares of firms using AMTs in metal industry

The usage of AMTs in the rubber and plastic industry sector is similar to the metal industry sector. Just below 60 percent of the companies have adopted high performance technologies and hardly half of the companies use ICT-enabled technologies or sustainable manufacturing technologies (Figure 9). The shares of firms planning a first use of AMT in the near future are slightly higher than in the metal industry sector. About 9 percent of the companies declare to plan the usage of one or more of these technologies in the future.

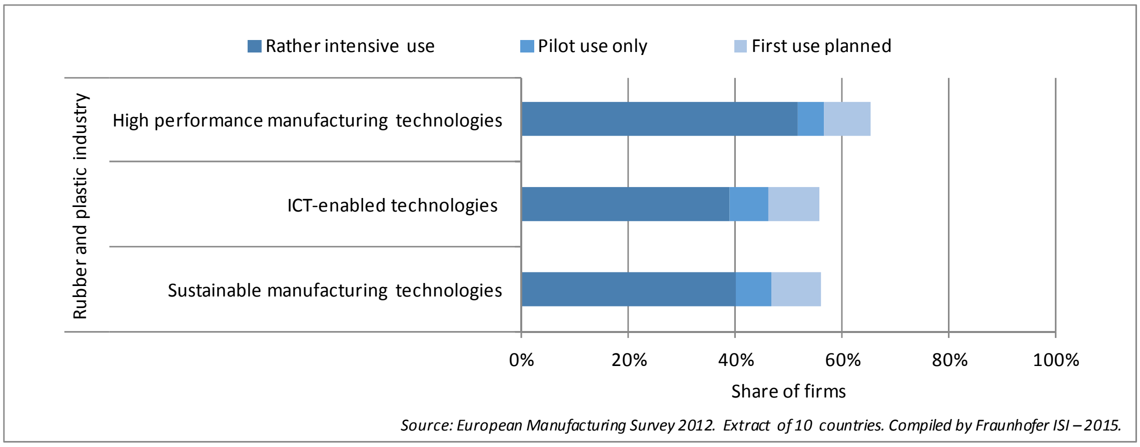


Figure 9: Shares of firms using AMTs in rubber and plastic industry

Figure 10 depicts the shares of firms using AMTs in the electronic and electrical equipment industry sector. In this industry, the discrepancies between use rates of high performance technologies and ICT-enabled technologies (nearly 60 percent) and those of sustainable manufacturing technologies are highest. Overall, hardly more than a third of firms use sustainable manufacturing technologies. Furthermore, less than 8 percent report a planned first use of sustainable manufacturing technologies, whereas almost 11 percent of the companies indicate this with respect to the ICT enabled technologies. Moreover, the share of pilot users is notably higher for ICT-enabled and for high performance manufacturing technologies.

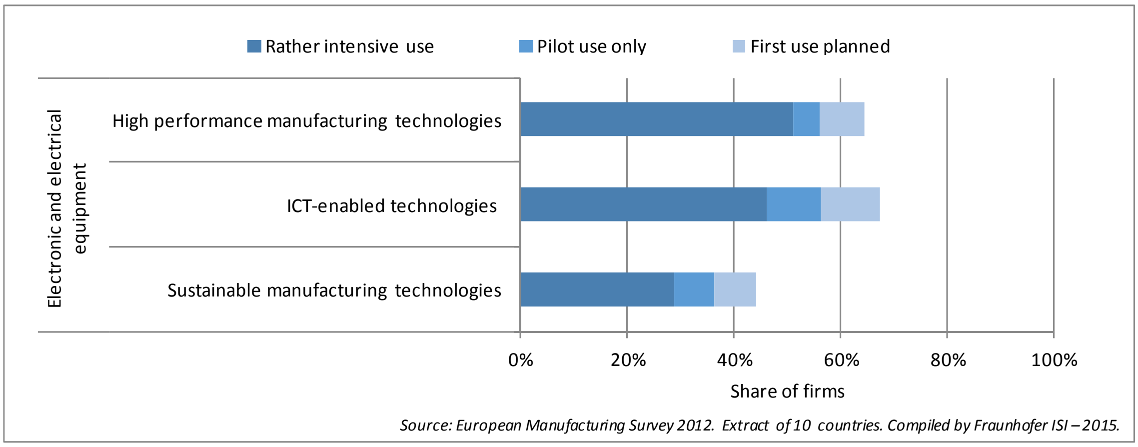


Figure 10: Shares of firms using AMTs in electronic and electrical equipment industry

The pattern of usage of AMTs in the machinery sector is generally similar to the electronic sector. However, the variance of use rates between the technology groups is less pronounced. In the machinery sector, over 51 percent of the companies use high performance manufacturing technologies or ICT-enabled technologies, while only about 38 percent of the use sustainable manufacturing technologies (Figure 11). Different from the electronics sector, however, the share of pilot users is equally high for high performance manufacturing technologies and for ICT-enabled technologies. Additionally, close to 10 percent plan a first use of technologies in one or more of the three fields.

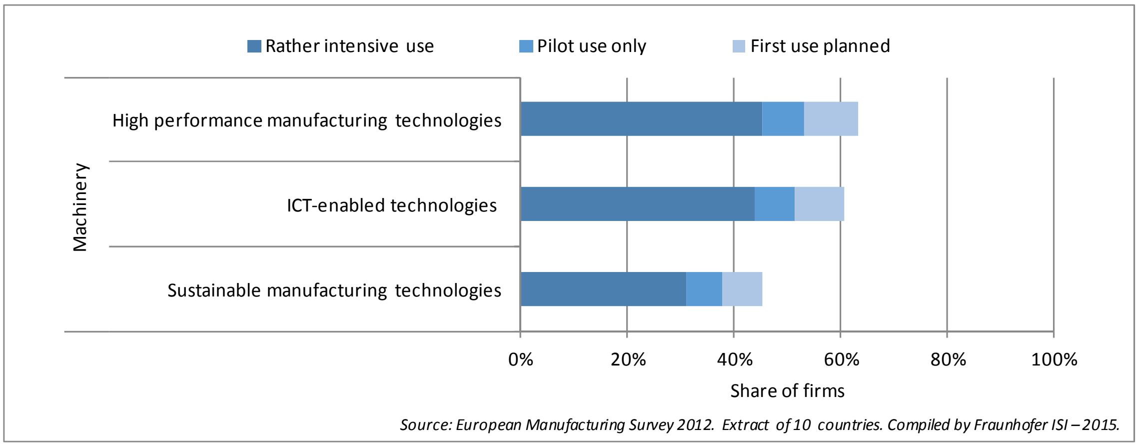


Figure 11: Shares of firms using AMTs in machinery industry

The chemical industry is characterized by a different usage of AMTs (Figure 11). Here the use of sustainable manufacturing technologies is as common as that of high performance manufacturing technologies and higher than in the previous industry sectors. Over 45 percent of the companies use high performance manufacturing technologies or sustainable manufacturing technologies, whereas not even 40 percent of the firms use ICT-enabled technologies. The future development may change the current situation, as over 11 percent of the firms in the chemical industry are planning to use ICT-enabled technologies.

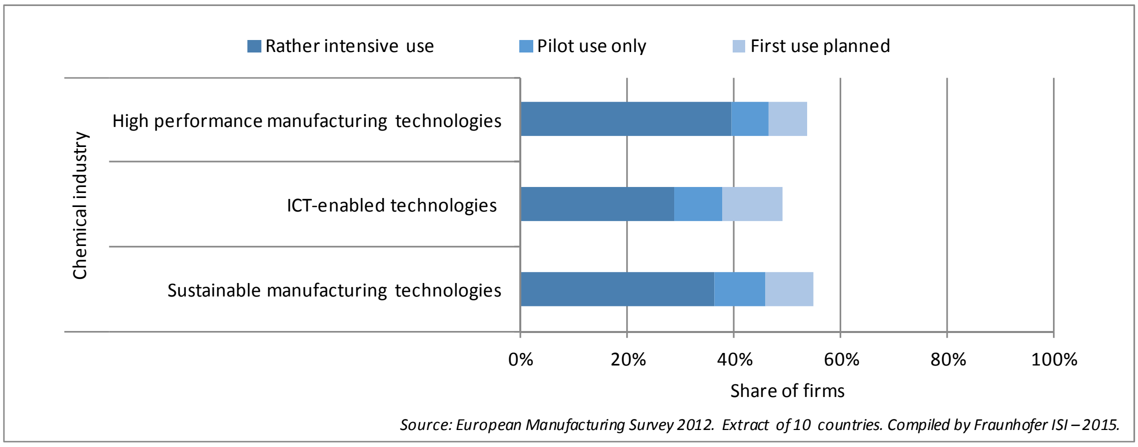


Figure 12: Shares of firms using AMTs in chemical industry

Figure 13, finally, presents the shares of firms using AMTs in the food, beverages and tobacco industry. In this sector the usage pattern of AMTs is similar to that in the chemical industry. Nearly 45 percent of all firms have adopted high performance manufacturing technologies, followed by nearly 42 percent of companies that use sustainable manufacturing technologies. ICT-enabled technologies, in contrast, are used by about only 30 percent of the companies. Furthermore, the share of companies using sustainable manufacturing technologies in this sector may be increasing substantially, as – different from the chemical industry – nearly 17 percent of the companies plan to use the technology in the near future.

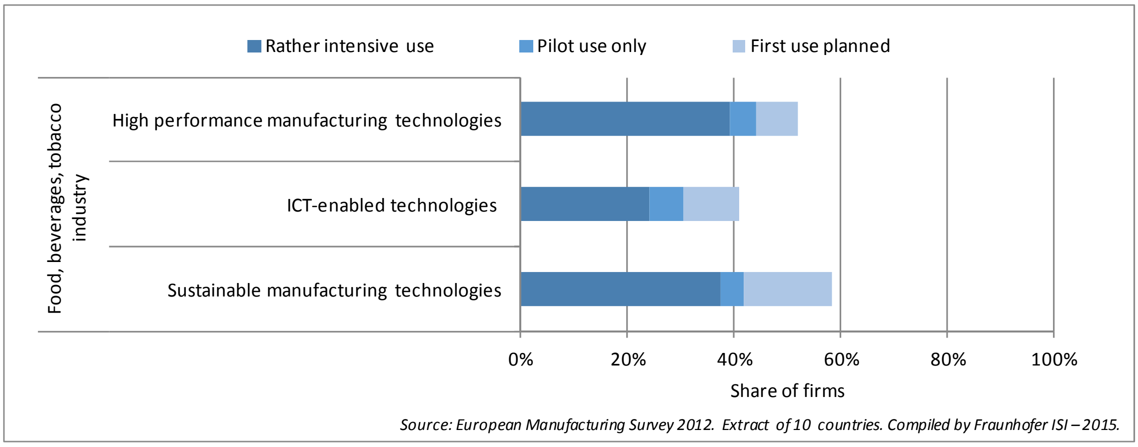


Figure 13: Shares of firms using AMTs in food, beverages and tobacco industry

2.3 Use of AMT by Firm Size

With respect to the relation between the firms' size and the usage of AMT (Figure 14), the data clearly show that larger firms are making much more frequent use of all examined AMTs in their manufacturing processes (more than 60 percent) than medium size firms with 50 to 249 employees (between 40 and somewhat below 60 percent) and, in particular, than small firms with less than 50 employees (between 20 and 40 percent).

An analysis of three technology groups depicts this disparity more precisely. According to the EMS 2012 data, about 40 percent of all surveyed firms with 20 to 49 employees make use of high performance manufacturing technologies in their factories, about one third use sustainable manufacturing technologies, while only about a quarter of them use ICT-enabled technologies. By comparison, nearly 60 percent of all firms with 50 to 249 employees make use of high performance manufacturing technologies while only slightly above 50 percent of all companies in this size group use ICT-enabled technologies and less than half make use of sustainable manufacturing technologies.

This rank order of "high performance"-"ICT-enabled" and "sustainable" is also found for larger firms, rendering smaller firms' lack of uptake of ICT-enabled technologies a notable exception. In conclusion, the adoption rate increases in an almost linear manner with the size of the surveyed companies. Thus, the size of the company, measured by the number of employees, is a clear related to the probability of the use of advanced manufacturing technologies in European industrial companies. With respect to the share of pilot users or those planning first use, however, the findings do not show significant differences between the three size groups.

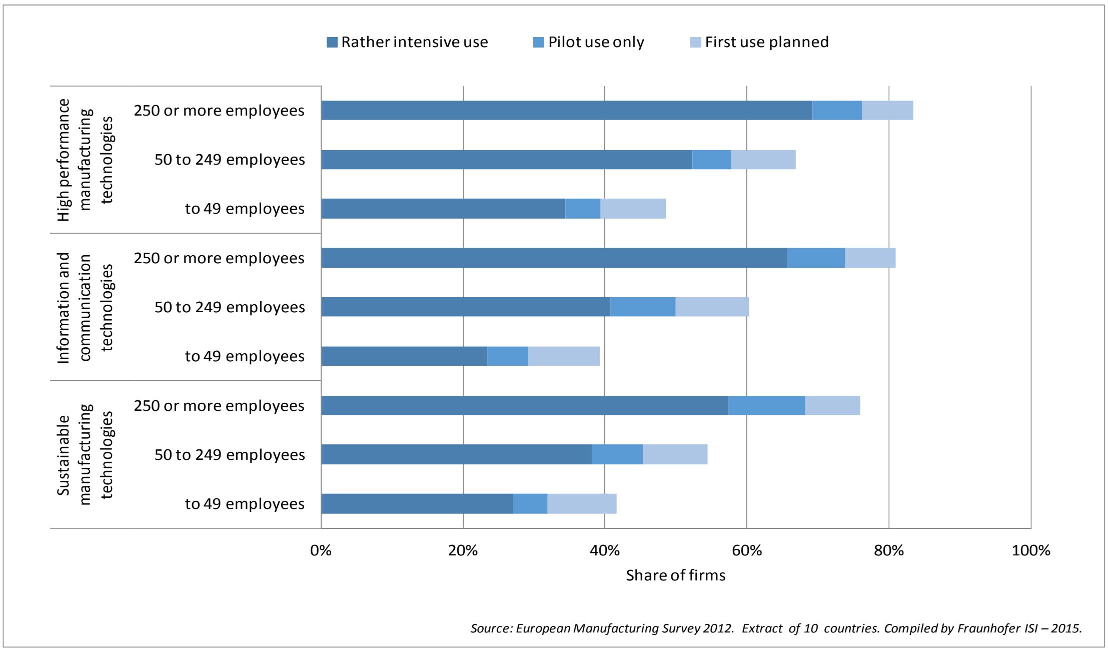


Figure 14: Shares of firms using AMT, by company size

2.4 Use of AMT by Type of Product & Production Process

Figure 15 shows the shares of firms using AMT, differentiated by the batch size typical for their production activities. Overall, the analysis indicates that firms using processes to produce large batch sizes show a higher propensity to use advanced manufacturing technologies than companies producing smaller batches or single units in succession.

A separate analysis of the three technology groups under study further differentiates this finding. In particular, more than 60 percent of the companies running processes to produce large batch sizes make use of high performance manufacturing technologies. Furthermore, about 8 percent of these firms plan a first use of one or more such technologies. In contrast, only about one half of all firms producing in small or medium batch sizes, and less than 45 percent of all firms with single unit production report this.

In general terms, this overall relation is found similar with respect to ICT-enabled technologies as well as sustainable manufacturing technologies, even though the absolute values differ. Even for firms producing large batch sizes, usage rates remain under 60 percent, while for those with single unit production they are in part notably under the rate of 40 percent. Other than with respect to high performance manufacturing technologies, where planned use is above average among producers of small batches, the data indicates no significant differences in the propensity of planned use for either ICT-enabled technologies or sustainable manufacturing technologies.

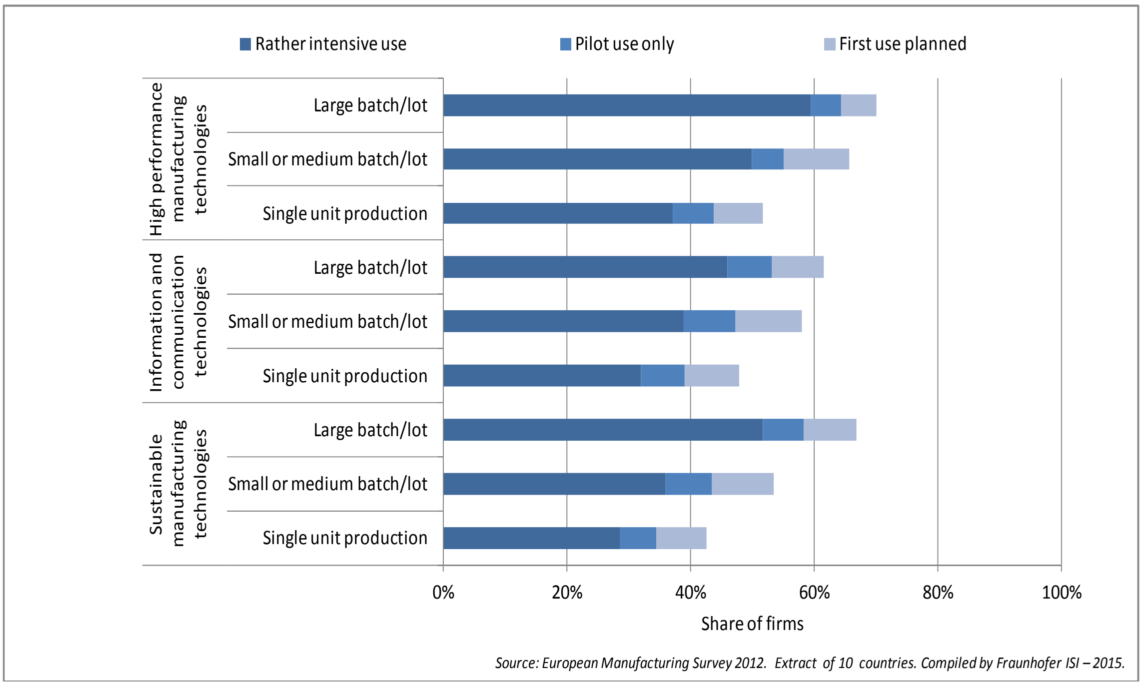


Figure 15: Shares of firms using AMT, by batch size

When analyzing the relation between the use of advanced manufacturing technologies and product complexity (Figure 16), the data show that it depends on the specific type of advanced manufacturing technology in question. Firms producing complex products display a higher propensity to adopt ICT-enabled technologies in their production processes than companies producing product with medium complexity or simple products. This relation, however, is far less clear than with respect to batch sizes and – in extent and ambiguity – depends on the type of advanced manufacturing technology in question. In contrast, a significant difference in user rates regarding High performance technologies can be detected for firms producing simple products compare to firms producing complex products or products with medium complexity. Regarding sustainable manufacturing technologies no differences can be detected.

According to EMS 2012 data, around 55 percent of the firms that produce complex or medium complex products make intensive use of high performance technologies. Moreover, somewhat similar shares of such companies report pilot activities (around 5 percent) or plans to start using of one or more such technologies (7 resp. 9 percent). Remarkably, differences between both groups are limited. In clear contrast, notably less than one half of those assembling simple products make use high performance technologies. With a view to ICT-enabled technologies, finally, much obvious differences in uptake can be documented, equally among all three groups. About 55 percent of companies, which produce complex products, use one or more of these technologies while the usage rate among producers of medium complex products amounts to 47 percent and among producers of simple products to 35 percent. Regarding sustainable manufacturing technologies, in contrast, nearly no significant differences are detected even if total user rates are stepwise slightly higher with higher product complexity. Again, producers of complex and medium complex products display very similar adoption rate differentiated mostly by a higher share of pilot users among those producing truly complex products.

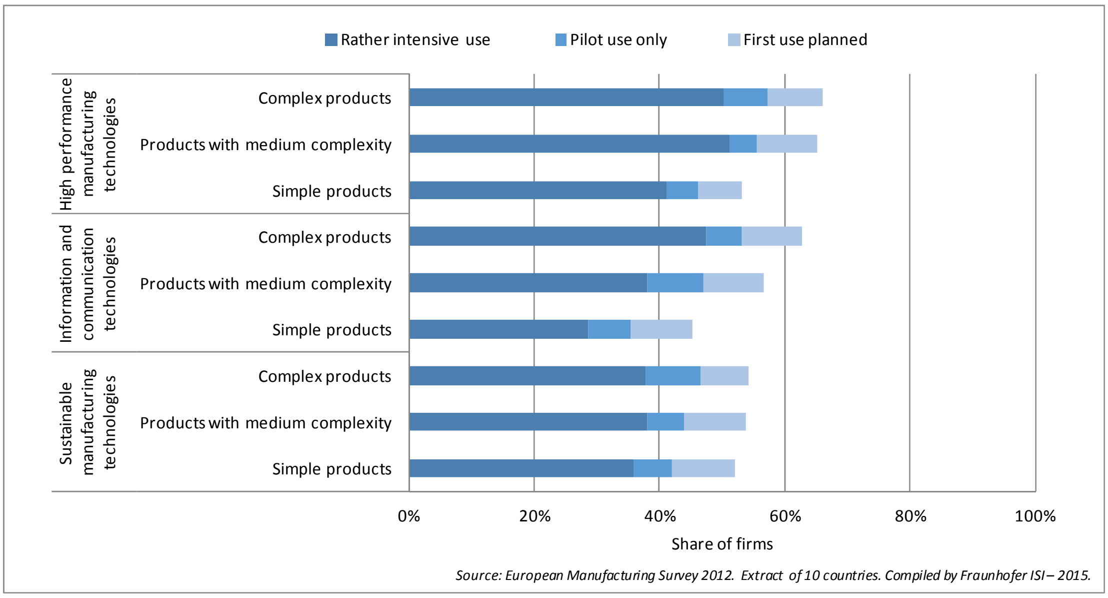


Figure 16: Shares of firms using AMT, by product complexity

2.5 Use of Specific Key Enabling Technologies

In the following, the use of particular key enabling technologies which can be analysed based on EMS data will be illustrated in detail and separate from other, less advanced technologies of their respective main technology group.

2.5.1 Advanced Materials: Processing of alloy construction materials

With regard to the use of techniques to process alloy construction materials, a major area within the field of advanced materials, an analysis of EMS 2012 data identifies a leading group of four countries: Germany, Austria, Slovenia, and Denmark (Figure 17). In France and Spain, on the contrary, intensive use rates are very low (below 10 percent). With a view to industries (Figure 18), the use of such technologies is most prevalent in the metal and in the transport equipment industry (use rates above 30 percent) and also quite commonly used in the machine building and the electronics industries (around 30 percent). In other industries surveyed, this particular type of process in advanced materials was not very commonly deployed.

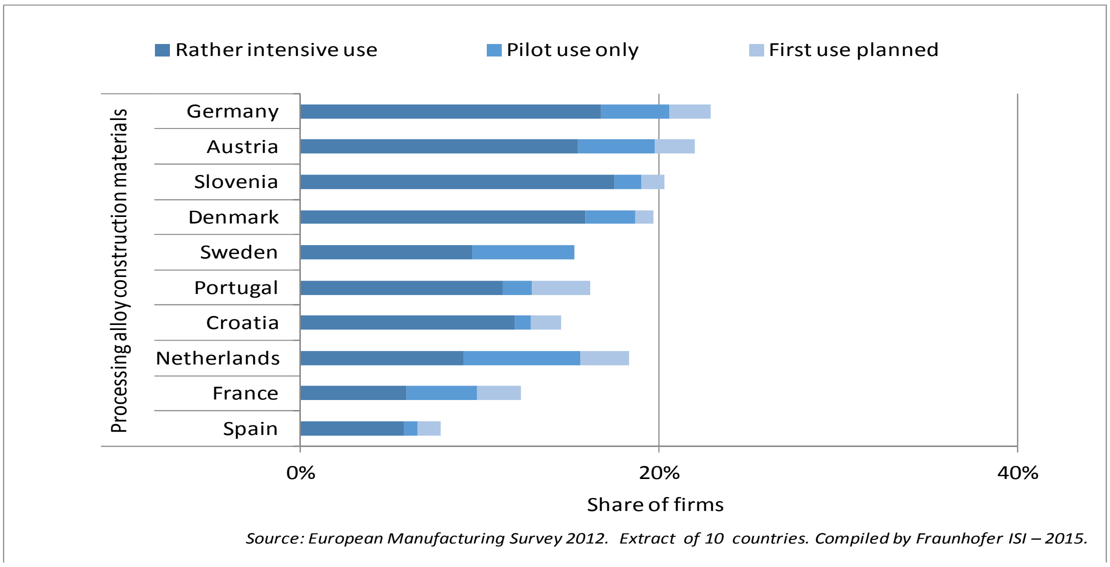


Figure 17: Shares of firms processing alloy construction materials by country

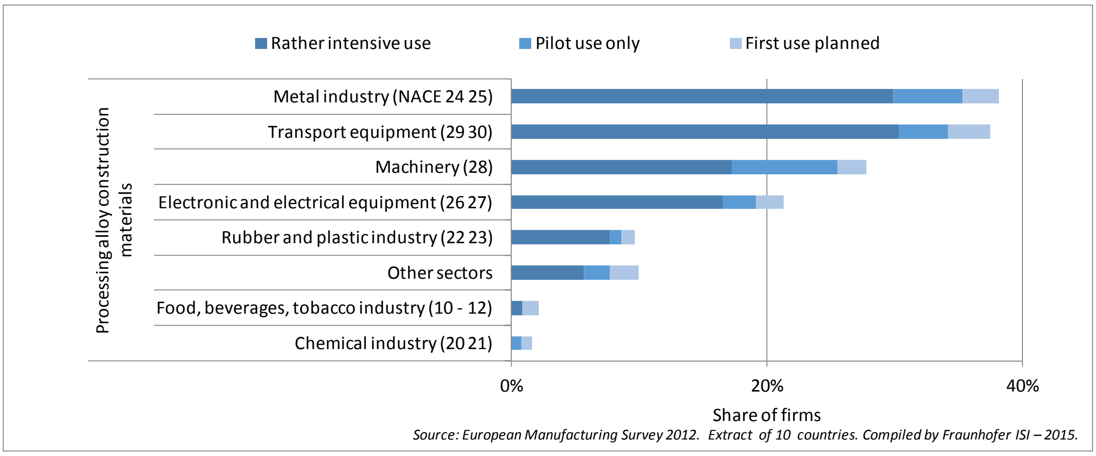
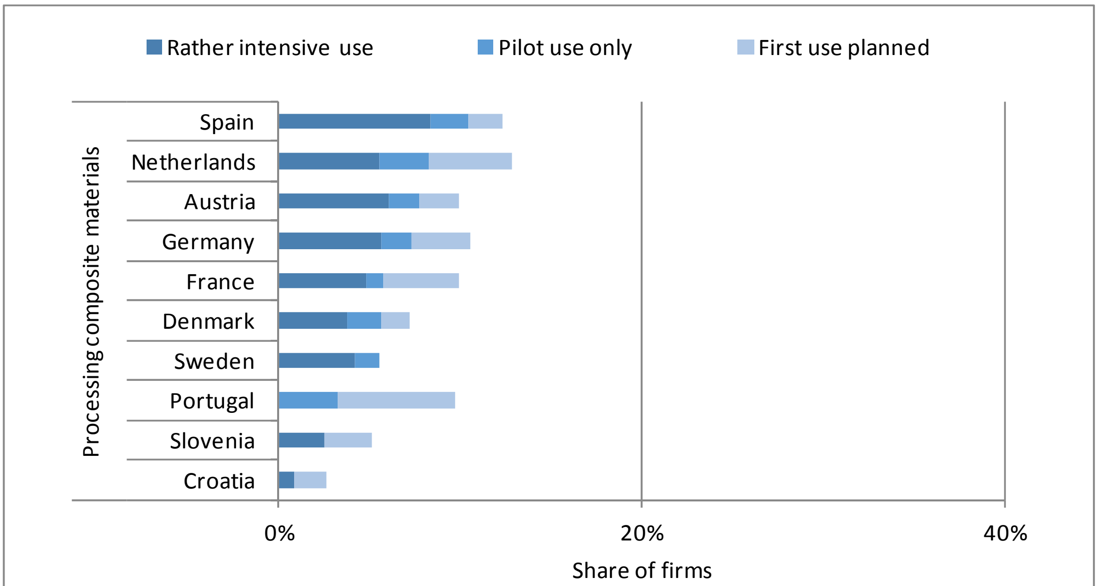


Figure 18: Shares of firms processing alloy construction materials by sector

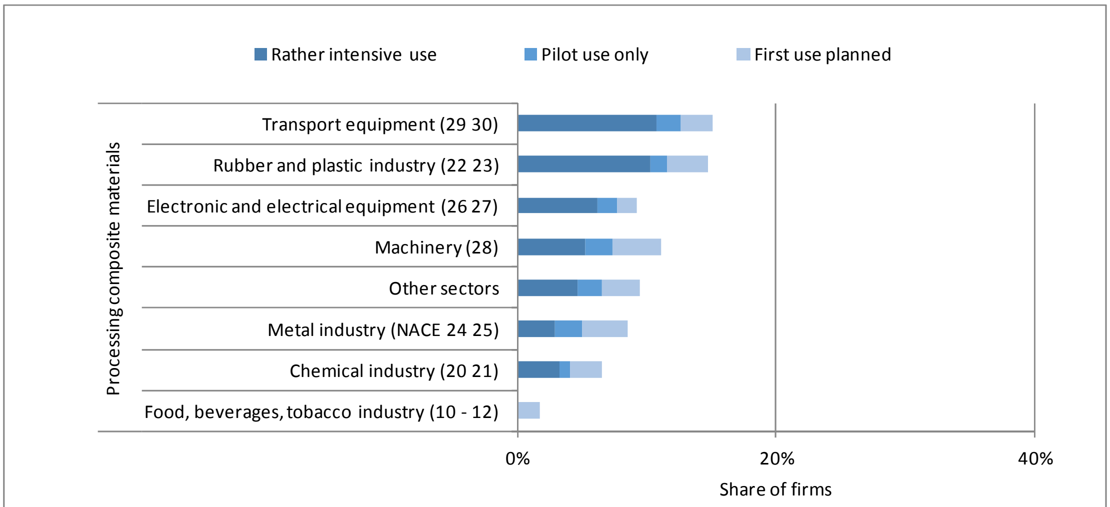
2.5.2 Advanced Materials: Processing of composite materials

With regard to the use of techniques to process composite materials, a further and arguably more challenging area within advanced materials, use rates remain lower than that for those to process alloy construction materials. The country in which the former are most commonly used is Spain, in some distance followed by the Netherlands, Austria, and Germany (Figure 19). In Portugal, intensive use remains unknown, despite a notable share of piloting firms and those planning activities. With a view to sectors (Figure 20), composite materials are most commonly processed in the transport equipment and in the rubber and plastics industries (use rates above 10 percent), while other use rates, even in the machine building and the electronics industry, remain low.



Source: European Manufacturing Survey 2012. Extract of 10 countries. Compiled by Fraunhofer ISI – 2015.

Figure 19: Shares of firms processing composite materials by country



Source: European Manufacturing Survey 2012. Extract of 10 countries. Compiled by Fraunhofer ISI – 2015.

Figure 20: Shares of firms processing composite materials by sector

2.5.3 Nanotechnology: Nanotechnological production processes

In an analysis of EMS 2012 data, the highest use rates for nanotechnological production processes are found for Sweden, France and Spain although even there, they often remain below 10 percent (Figure 21). The position of Sweden is exceptional in that it displays the by far highest share of piloting firms. While the overall use rate of nanotechnological production processes is rather low, the share of firms planning first use is notably and systematically higher than it was in the case of technologies related to advanced materials. Different from those, moreover, nanotechnological production processes are almost equally prevalent across different sectors (Figure 22), with the exception of machine building and the food, beverages, and tobacco industry. Again, the share of firms planning future use is relatively high, with the exception of the chemical industry.

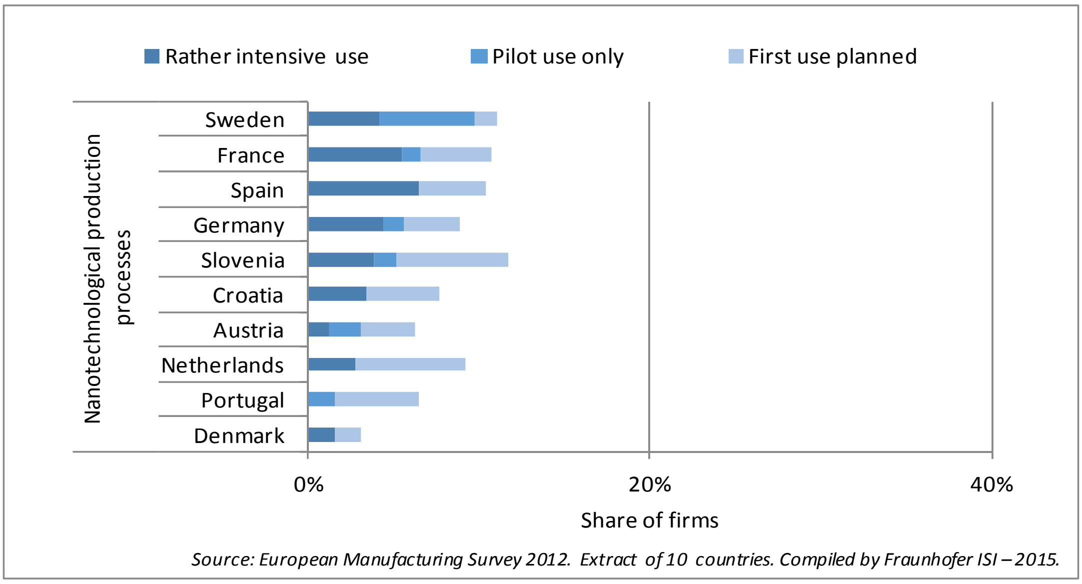


Figure 21: Shares of firms using nanotechnological production processes by country

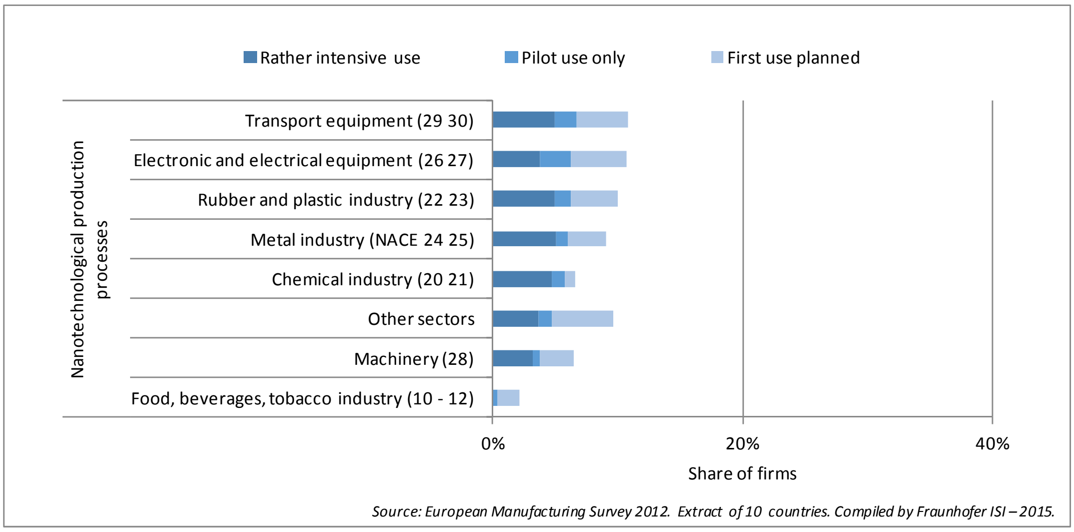


Figure 22: Shares of firms using nanotechnological production processes by sector

2.5.4 Use of Specific Key Enabling Technologies by Firm Size

In general terms, the relation of firm size and the prevalence of the use of specific key enabling technologies follows that identified in Section 2.3 for the main technological areas (Figure 23).

With a view to advanced materials, the relation is stepwise with the lowest share of users among small firms, an intermediate share of users among mid-sized firms and the highest share of users among large firms. For nanotechnological production processes, the findings differ insofar as above average use rates are limited to large firms, whereas the use rates among small and mid-sized firms are comparatively similar.

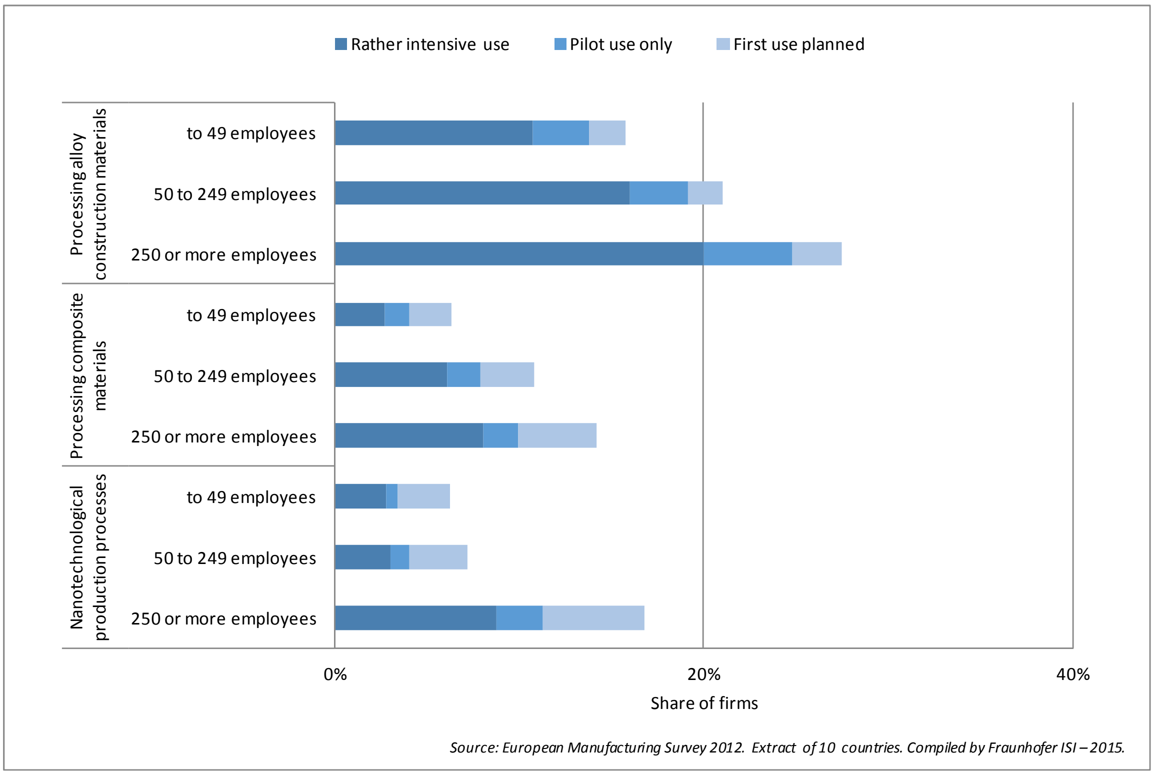


Figure 23: Use of specific key enabling technologies by firm size

2.6 Interim Summary of Findings 1

Chapter 2 presents the results of a comprehensive analysis of the usage of various advanced manufacturing technologies differentiated by countries, size classes, sectors as well as types of main products and of production processes. The findings can be summarized as follows:

In the ten countries covered by the EMS, Advanced Manufacturing Technologies are adopted by between 30 percent and nearly 70 percent of manufacturing firms. Typically, different groups of countries can be identified with respect to their AMT usage rate: a leading group with more than 60 percent users, an average or middle group with between 40 and 60 percent of users and finally a group with low usage rates around or even below 40 percent. How these groups are composed, however, differs according to the type of technologies in question. In particular with regard to sustainable manufacturing technologies, the 'country ranking' differs notably from that found for high performance manufacturing or ICT-enabled technologies. Nonetheless, there are typical leaders, such as Sweden or Slovenia, and typical laggards, such as Croatia. Other countries, such as Spain, the Netherlands or Portugal display very different usage rates depending on the exact technology in question.

In general, the differences between the shares of manufacturing companies using examined advanced manufacturing technologies are quite remarkable. Most prominently, the usage rates of high performance manufacturing technologies are notably higher than those with respect to ICT-enabled or sustainable manufacturing technologies. Remarkably, some of the surveyed countries' display much higher usage rates for high performance manufacturing technologies than for ICT-enabled technologies (Spain, Austria). With respect to sustainable manufacturing technologies, surprisingly low use rates are found among companies in Spain, Denmark, the Netherlands and France.

In general, and naturally, the share of firms, that only pilot one or more AMT technologies as they have so far not implemented any, is lower than the share of those already implementing at least one on a larger scale (and potentially piloting more in parallel). That notwithstanding some Member States display above average shares of piloting rather than large-scale implementation, among them the Netherlands and Sweden and, for specific fields, Denmark, France (ICT-enabled technologies) and Slovenia (sustainable manufacturing technologies). However, differences with this regard are rather low.

Future plans for the adaptation of further high performance manufacturing technologies are on average developed by between four and eight percent of all firms. In Germany, Austria, the Netherlands and Croatia, however, these rates are notably higher, amounting to ten percent or more. With respect to ICT-enabled technologies, such plans are generally not much more common. Only in Germany, Croatia and to a lesser degree the Netherlands can above-average rates be identified. Regarding sustainable manufacturing technologies, plans for the uptake of such technologies are highest in Spain and Germany with respectively over 10 percent.

With a view to sectoral groups, manufacturers of transport equipment or metals and metal products use high performance and sustainable manufacturing technologies more often intensively than companies in other sectors. In comparison, ICT-enabled technologies are most commonly used not only by manufacturers of transport equipment but also by those of electronic and electrical equipment. In general, the food, beverages and tobacco industry show rather low rates of uptake for high performance manufacturing and ICT-enabled technologies. The use of sustainable manufacturing technologies, finally, is least common among firms in the machine building and the electronics and electronic components industry.

With a view to piloting activities and planned use, no substantial differences can be identified between the analysed sector groups, except for the fact that a notably above-average 15 percent of all firms from the food, beverages and tobacco industry plans to implement their first sustainable manufacturing technologies in the coming years.

In contrast to national and sectoral attribution, the size of the company as well as the type of products and production processes represent clear predictors for the frequency of use of AMTs in industrial companies. In principle, this applies irrespective of the type of technology considered, even if not always with respect to the extent. With a view to company size, the usage rate increases in an almost linear manner from about 35 percent of the companies with 20 to 49 employees to 70 percent of the companies with 250 and more employees. Similarly, firms running large batch sizes display a significantly higher propensity to use high performance manufacturing technologies, ICT-enabled technologies, or sustainable manufacturing technologies than companies producing single units. With a view to product complexity, the relation is less linear but – for high performance manufacturing and ICT-enabled technologies – still shows a clear distinction in AMT usage propensity between firms manufacturing products with an at least medium degree of complexity and those focusing on simple products. For sustainable manufacturing technologies, in contrast, this relation is less pronounced.

With a view to individual key enabling technologies the study – somewhat consequentially – finds lower use rates and, in the case of alloy construction materials, relatively pronounced attribution to specific sectors. With respect to composite materials and nanotechnology, planned use plays a much larger role than on average and with respect to alloy construction materials, it appears noteworthy that firms from the machine building industry were displaying a notable amount of piloting activities, making this the third sector group in which the use of such technologies is becoming common.

3 Impacts of AMT Uptake as documented in the Data

This chapter outlines the impacts of the use of advanced manufacturing technologies on several performance indicators of manufacturing firms in the selected sample of ten analyzed European countries (or, more precisely, the differences in performance between users and non-users). Statistical analyses are used to examine the relationships between the extent of the usage of specific technologies on the one hand and various indicators of production, economic and innovative performance on the other hand. In line with common scientific practice, the overview only highlights those differences that are statistically significant. To facilitate reading, desirable outcomes are highlighted in green (irrespective of the fact if indicated by negative or positive figures), whereas non-desirable outcomes are highlighted in red.

3.1 Regarding High Performance Manufacturing Technologies

Table 1 indicates the advantages that users of high performance manufacturing technologies enjoy with respect to several performance dimensions over European manufacturing firms which are not using such technologies.

In general terms, manufacturing firms using at least one high performance manufacturing technology display on average a higher firm performance with respect to added value per employee (+ 4,400 €) than non-using firms. Equally, a greater share of these firms generated a return on sales greater than 2% in 2011 (+ 3.9 percentage points, p.p.) and their growth of revenue in the 2009-11 period was 0.6 percentage points than that of non-users. Moreover, they are more likely to sell product innovations: Among firms using at least one high performance manufacturing technology the share of firms introducing new products is 14.3 percentage points higher than among non-users. Accordingly, these firms generate a higher share of turnover by new products (+ 2.8 p.p.) and a lower share of turnover by products over ten years old (- 4.5 p.p.) respectively. Likewise, the share of innovating firms that sell products new to the market is notably higher (+ 6.8 p.p.). Overall, our findings thus document a clear correlation between the use of high performance manufacturing technologies and the innovative performance of firms – accompanied by some positive effects on the commercial side. Effects on employment growth, however, remained absent or mixed.

With a view to specific technologies (cf. Table Annex 1), further detailed analyses illustrate that usage of all high performance manufacturing technologies goes along with at least a higher share of firms introducing new products and a higher share of turnover of such products. In many cases, the use of specific technologies also correlates with a higher share of innovators introducing products new to the market and a lower share of turnover with products older than 10 years. With respect to economic and production performance indicators, the identifiable effects of specific technology usage appear mixed.

The use of ‘processing of composite materials’, for example, is not connected to any difference in performance. Likewise, the use of manufacturing of micromechanical components correlates with few positive differences in performance, mostly related to growth.

The use of industrial robots and handling systems, automated warehouse management systems, technologies for safe human-machine cooperation, the processing of alloy construction materials and nano-technological production processes, in contrast, have mixed, in part detrimental implications for the economic and production performance of firms that can be outlined as follows:

Use of any of the four technologies is accompanied by a higher added value per employee and/or share of firms with a return on sales. Correlations between the use of specific technologies and firms’ performance with respect to employment and revenue growth, in contrast, differ in terms of both direction and amplitude. Robotics and automation, for example, go along with lower rather than higher revenue growth and users of nanotechnology display lower employment growth than non-users, even if the share of firms with high return on sales is greater. While the production performance among users of industrial robots and handling systems and/or technologies for safe human-machine cooperation is generally higher, that of users of processing of alloy construction materials remains lower. The use of automated warehouse management systems, finally, is accompanied by a higher production lead time.

Table 1: Differences in various dimensions of firm performance between users and non-users of high performance manufacturing technologies (documented when significant)

Performance Indicator	**Use of any, at least one high-performance manufacturing technology**
Production performance	
Production lead time[work days]	n.s.
Order delivery on time [%]	n.s.
Rework/Scrap [%]	n.s.
Economic performance	
Added Value [Revenue - Input p. Employee, 1000 €]	4.4**
Return on sales (bef. tax 2011) > 2% [% surveyed firms]	3.9%*
Employment growth (2009-2011) [% annually]	n.s.
Revenue growth (2009-2011) [% annually]	0.6%**
Total Factor Productivity [turnover - input / depreciation + staff cost]	n.s.
Innovative performance	
New products [% *among all firms*]	14.3%**
Turnover generated by new products [% among innovative firms]	n.s.
Turnover generated by new products [% among all firms]	2.8%**
Products new to the market [% innovative firms]	6.8%*
Products new to the market [%among all firms]	n.s.
Turnover gen. by prod. new to market [% among innovative firms]	-0.0%**
Turnover gen. by prod. new to market [% among all firms]	1.0%**
Old products (over 10 years old) [*among all firms*]	n.s.
Turnover generated by old products [among all firms]	-4.5%**

Source: *European Manufacturing Survey 2012. Extract of 10 countries. Compiled by Fraunhofer ISI – 2015.* Notes: significance level: *p < 0,05, **p < 0,0. **Green**: desirable outcomes. **Red**: non-desirable outcomes

3.2 Regarding ICT-Enabled Technologies

Table 2 indicates the advantages that users of ICT-enabled technologies enjoy with respect to several performance dimensions over European manufacturing firms which are not using such technologies.

In general terms, a positive correlation between the use of at least one such technology and higher performance can be identified with respect to added value per employee (+ 27,400 €), the share of firms with a return on sales greater than 2% in 2011 (+ 6.0 p.p.), the share of firms introducing new products (+ 17.5 p.p.), the share of turnover generated by new products (+ 3.7 p.p.), the share of innovating firms that introduce products new to the market (+ 1.1 p.p.), the share of turnover generated by such products among both all and innovating firms (+ 1.8 p.p., + 1.3 p.p.) as well as the share of turnover generated by products over ten years old (- 8.7 p.p.). Overall, our findings thus document a clear correlation between the use of ICT-enabled technologies and almost all key economic or innovation-oriented performance indicators.

With respect to production performance, in contrast, the use of at least one ICT-enabled technology systematically goes along with a higher production lead time (+ 4.7 days). Finally, there is a notable, negative effect on 2009-11 revenue growth (- 0.3 p.p.).

With a view to specific technologies, Table Annex 2 illustrates that all ICT-enabled technologies go along with a higher share of firms introducing new products and a higher share of turnover generated by those products (among all firms). With the partial exception of ‘VR – simulation in production reconfiguration’, the use of ICT-enabled technologies goes along with an about one percentage point higher share of innovating firms that introduce products new to the market as well as a higher share of turnover generated by products new to the market among innovating firms - with the exception of ‘supply chain management’. Finally, the uptake of any ICT-enabled technology is found correlated with an up to 11 percentage points lower share of turnover generated by old products, although none per se correlates with a lower share of firms manufacturing such products.

With a view to economic performance, the use of ‘VR – simulation in product design’, ‘supply chain management’ and ‘product lifecycle management systems’ goes along with better performance – with the exception of lower revenue growth among firms using ‘VR – simulation in product design’. For all these technologies, the share of firms with a return on sales greater than 2% is significantly higher among users than among non-users as is the amount of added value per employee for the latter two. The use of ‘VR – simulation in production reconfiguration’, in contrast, increases revenue growth, yet without any marked differences for other indicators.

With a view to production performance, finally, 'VR – simulation in production reconfiguration' and 'VR – simulation in product design' go along with a higher production lead time and, in the case of the latter, a lower share of order delivery on time. Usage of 'supply chain management', in contrast, goes along with a higher share of order delivery on time. The use of 'product lifecycle management systems', finally, does not correlate with any type of production performance.

Table 2: Differences in various dimensions of firm performance between users and non-users of ICT-enabled technologies (documented when statistically significant)

Performance Indicator	**Use of any, at least one ICT-enabled technology**
Production performance	
Production lead time[work days]	4.7**
Order delivery on time [%]	n.s.
Rework/Scrap [%]	n.s.
Economic performance	
Added Value [Revenue - Input p. Employee, 1000 €]	27.4**
Return on sales (bef. tax 2011) > 2% [% surveyed firms]	6.0%**
Employment growth (2009-2011) [% annually]	n.s.
Revenue growth (2009-2011) [% annually]	-0.3%*
Total Factor Productivity [turnover - input / depreciation + staff cost]	n.s.
Innovative performance	
New products [% *among all firms*]	17.5%**
Turnover generated by new products [% among innovative firms]	n.s.
Turnover generated by new products [% among all firms]	3.7%**
Products new to the market [% innovative firms]	1.1%*
Products new to the market [%among all firms]	n.s.
Turnover gen. by prod. new to market [% among innovative firms]	1.3%**
Turnover gen. by prod. new to market [% among all firms]	1.8%**
Old products (over 10 years old) [*among all firms*]	n.s.
Turnover generated by old products [among all firms]	-8.7%**

Source: *European Manufacturing Survey 2012. Extract of 10 countries. Compiled by Fraunhofer ISI – 2015.*
Notes: significance level: *p < 0,05, **p < 0,0. **Green**: desirable outcomes. **Red**: non-desirable outcomes

3.3 Regarding Sustainable Manufacturing Technologies

Table 3 indicates the advantages that users of sustainable manufacturing technologies enjoy with respect to several performance dimensions over European manufacturing firms which are not using such technologies. Other than in the cases of high performance manufacturing or ICT-enabled technologies, the correlation between the use of sustainable manufacturing technologies and the innovative performance of user firms is much less systematic. While the use of any such technology goes along with a higher share of firms introducing new products (+ 8.5 p.p.) and a slightly higher share of turnover generated by new products (+ 0.4 p.p.), the share of such turnover generated in innovating firms is lower for users than for non-users (- 1.5 p.p.).

With a view to economic performance indicators, the use of at least one sustainable manufacturing technology goes along with a higher added value per employee (+ 17,300 €) while, at the same time, it correlates with lower revenue growth (- 1.5 p.p.) in the period between 2009 and 2011. With a view to production performance, there is an unambiguously positive effect of main product order delivery on time (+ 1.4%).

With respect to specific technologies, Table Annex 3 illustrates that all sustainable manufacturing technologies, with the exception of ‘combined heat and power generation’ go along with a higher share of firms introducing new products. For other innovation-oriented performance indicators, however, the effects are less clear. For ‘dry processing / minimum lubrication’ and ‘combined heat and power generation’ there are no significant correlations. The implementation of a ‘recuperation of kinetic and process energy’ goes along with lower shares of turnover for both new products in general (all firms and innovators) and products new to the market among innovators. The use of ‘control systems to shut down machines’, finally, is accompanied by higher shares of turnover for both new products in general and products new to the market for all firms respectively. In this case only the share of turnover generated by products new to the market is lower among technology users than among non-users.

With a view to economic performance, the implementation of a ‘recuperation of kinetic and process energy’ as well as of ‘control systems to shut down machines’ correlates with a higher added value per employee as well as in the former case with a higher share of firms with a 2011 return on sales greater than 2%. Furthermore, those using ‘dry processing / minimum lubrication’ realised somewhat higher revenue growth than non-users. For ‘combined heat and power generation’, no positive correlations can be identified.

Finally, the use of any sustainable manufacturing technologies except ‘dry processing / minimum lubrication’ correlates with a higher main product order delivery on time and the use of ‘combined cold, heat and power generation’ goes along with a lower production lead time. In contrast, the use of ‘dry processing / minimum lubrication’ correlates with two non-desirable outcomes: a lower share of order delivery on time and a higher production lead time. As with ICT-enabled technologies, no technology correlates with the share of products that need to be scrapped or reworked.

Table 3: Differences in various dimensions of firm performance between users and non-users of sustainable manufacturing technologies (documented when statistically significant)

Performance Indicator	**Use of any, at least one sustainable manufacturing technology**
Production performance	
Production lead time[work days]	n.s.
Order delivery on time [%]	1.4%**
Rework/Scrap [%]	n.s.
Economic performance	
Added Value [Revenue - Input p. Employee, 1000 €]	17.3**
Return on sales (bef. tax 2011) > 2% [% surveyed firms]	n.s.
Employment growth (2009-2011) [% annually]	n.s.
Revenue growth (2009-2011) [% annually]	-1.5%*
Total Factor Productivity [turnover - input / depreciation + staff cost]	0.20*
Innovative performance	
New products [% *among all firms*]	8.5%**
Turnover generated by new products [% among innovative firms]	-1.5%*
Turnover generated by new products [% among all firms]	0.4%*
Products new to the market [% innovative firms]	n.s.
Products new to the market [%among all firms]	n.s.
Turnover gen. by prod. new to market [% among innovative firms]	-0.0%*
Turnover gen. by prod. new to market [% among all firms]	0.5%*
Old products (over 10 years old) [*among all firms*]	n.s.
Turnover generated by old products [among all firms]	n.s.

Source: *European Manufacturing Survey 2012. Extract of 10 countries. Compiled by Fraunhofer ISI – 2015.* Notes: significance level: *p < 0,05, **p < 0,0. **Green**: desirable outcomes. **Red**: non-desirable outcomes

3.4 Interim Summary of Findings 2

Overall, the use of advanced manufacturing technologies correlates most prevalently with a comparatively good **innovative performance** and limited reliance on older products. Most notably, this is the case for the different high performance manufacturing and ICT-enabled technologies while, among sustainable manufacturing technologies, such findings are less pronounced as no higher share of turnover with product innovations nor less reliance on older products is detectable.

With respect to **economic performance**, the use of advanced manufacturing technologies also commonly goes along with the realisation of higher added value per employee or a higher share of firms with a return on sales greater than 2%. For company growth, however, results are mixed and – on several occasions – the relation with employment growth has been found even negative. Other than with respect to innovative performance, there is a stronger variation within the main technology fields. While the use of several high performance technologies is positively correlated with key economic indicators, this is not (yet) – or much less – the case for ‘processing composite materials’, ‘manufacturing micro-mechanical components’, and ‘nanotechnological production processes’.

Thus, it can be stated that the use of complex, advanced KETs technologies like nanotechnology and or some areas of advanced materials is (still) less directly correlated with a higher economic performance than the use of more straightforward, broader established process-oriented solutions like ‘industrial robots and handling systems’, ‘automated warehouse management systems’, and ‘technologies for safe human-machine cooperation’. Along similar lines, the use of ICT-enabled technologies is correlated directly with economic performance as seen in return on sales – with the exception of ‘virtual reality – simulation in production reconfiguration’. Among sustainable manufacturing technologies, some positive correlations are only found for ‘technologies for the recuperation of kinetic and process energy’ and ‘control systems to shut down machines’.

With a view to **production performance**, finally, correlations are even more mixed. Overall, a common correlation of the use of sustainable manufacturing technologies (other than dry processing) and delivery on time seems to be the most systematic finding. Among high performance manufacturing technologies the use of ‘industrial robots and handling systems’ as well as ‘technologies for safe human-machine cooperation’ goes along with higher values in all three indicators while the ‘processing of alloy construction materials’ unanimously correlates with lower values. Among ICT-enabled technologies, the use of ‘virtual reality – simulation in production reconfiguration’ and ‘virtual reality – simulation in product design’ correlates with higher production lead times even though the latter also goes along with a slightly better order delivery on time. Other technologies remain without notable or systematic effect.

In sum, it can thus be stated that the use of advanced manufacturing technologies is most strongly correlated with an improved innovative performance, not uncommonly accompanied by better economic performance. In contrast, most effects on production performance depend on the specific type of technology in question. Finally, sustainable manufacturing technologies remain the exception of all general rules, not least as all performance levels going along with the use of any of them strongly depend on the precise technology concerned.

4 Conclusions for Further Work

4.1 A Quick Interpretive Summary of the Findings

Overall, our analysis yields the following five main findings with respect to the current use of Advanced Manufacturing Technologies across European Member States and sectors:

Firstly, the analysis' findings clearly underline that it is crucial to distinguish between Advanced Manufacturing's different sub-fields as both the patterns of use of the related technologies and their impact on firms' performance differ remarkably. Already, this applies to relevant differences between – often more established – high performance manufacturing technologies and the – still less prevalent – ICT-enabled, Industry 4.0 type technologies. Even more clearly, it applies to differences between both of them on the one hand and sustainable manufacturing technologies on the other hand which are distinct not only in technological means but also in commercial and/or political ends. In all analyses of patterns and trends in the "AMT field", this differentiation into quite distinct sub-fields needs to be prominently considered.

Secondly, a 'ranking' of European countries or, more precisely, groups of countries should be interpreted with caution. On the one hand, rankings differ notably with respect to specific technologies while, on the other hand, these ranking are relative in nature and conceal important background information. For example, a middle rank of Austria or Germany does not imply that these Member States were "underperforming" in Advanced Manufacturing but simply gives evidence of a broad industrial base that also includes less modern firms. As long as there is critical mass in the Advanced Manufacturing capabilities there are and as long as these countries' non-AMT oriented firms are competitive, an increase in AMT adoption rates need thus not necessarily constitute a policy target per se.

Thirdly, selected industries and firm types are more prone to constitute a fertile environment for the adoption or use of Advanced Manufacturing Technologies than others. Overall, most findings with a view to firm size, production type and product complexity prove much less technology specific than the patterns of uptake across Member States. Consequently, there seems to be a strong indication that a large share of all national disparities with respect to the uptake of AMT may in fact be due to these differences mediated through known, pronounced differences in countries' industrial or sectoral structure. While this is not naturally the case and needs deeper analyses, it casts a clear light on the fact that different countries' policy makers and manufacturing firms operate under very different framework conditions.

Fourthly, next to all our analyses, equally from which perspective, give evidence of notable dynamics of uptake and diffusion. Although the share of companies implementing at least one technology is – by empirical definition – higher than that of those piloting or planning first uses, the combined share of the latter plays a notable role in many countries, sectors and types of manufacturing firms. Not irregularly, the 'ranking' of Member States with respect to the uptake of Advanced Manufacturing Technologies differs markedly, depending on whether piloting activities and planned use are taken into account or not. Thus, an ongoing process of diffusion can be identified for a large majority of manufacturing technologies analysed in this study, irrespective of whether they are already widespread or not.

Fifthly, there are perceivable differences between the three broad AMT technology groups as defined for this study on the one hand and individual key enabling technologies on the other. On the one hand, the current relevance of certain KET-based solutions can be rather sector specific (as is the case for advanced materials). On the other hand, the technological readiness of other remains notably lower than in the case of already more prevalent high-performance manufacturing technologies (as is the case for nanotechnology). Hence, suitable adaptation environments for those can either be more specific (limited to specific industrial sectors) or generally less developed (focused on piloting activities and planned use).

With a view to this uptake's impact on firm performance, moreover, two main areas of firm performance should be distinguished, before the overall study's findings are summarised.

The first batch of indicators on *productive performance* do not refer to an end in itself and can be highly sector and firm-type specific. Hence, any impact on them should be considered with care, but not necessarily considered an attainment per se. For example, the introduction of new technologies may temporarily decrease performance, yet increase it on the long-run. Moreover, policy does not directly aim at production performance.

The second batch of indicators on *economic and innovative performance*, in contrast, can be considered a better joint point of reference as it correlates more directly with European policy targets like the creation of growth and jobs. Universally, manufacturing firms want to achieve good economic results and, quite universally, the regular development of new products and solutions is considered an important step to that end.

In summary, the results of this study are of paramount importance for European technology and innovation policy. It provides novel empirical evidence that the positive stimulation provided by the further development and diffusion of advanced manufacturing technologies is a key means to improve the competitiveness of and exploit growth potentials in the European manufacturing industry, most notably small- and medium-sized enterprises.

4.2 Identified Gaps in Knowledge

As illustrated above, the EMS-based study has thus created a robust, reliable and broad basis for future analysis that exceeds any so far available basis of information on the use and uptake of Advanced Manufacturing Technologies in European manufacturing firms.

Nonetheless, four major gaps in knowledge can be identified with regard to this study's overall final objective of not only documenting but also explaining the use and impact of the use of Advanced Manufacturing Technologies:

Firstly, the EMS-based analysis documents many differences in AMT usage between countries, sectors and firm types precisely and reliably, yet, by itself, cannot fully explain whether these, besides mere differences in national industrial structures, result from different business models in the same industry, the presence or absence of public support efforts, or other internal and external drivers and barriers.

Secondly, the list of both Member States and relevant AMT technologies covered by the EMS is comprehensive yet not all-encompassing. In particular some key enabling technologies at an early stage of diffusion have, intentionally, not been covered by the survey since, at the time, other studies suggested very limited adoption rates. Still, they may begin to play a relevant role. Also, complementary data should be compiled for further countries.

Thirdly, while it is possible to demonstrate clear impacts of the use of various Advanced Manufacturing Technologies, it remains less than clear how these impacts occur in practice. As the adaptation of Advanced Manufacturing Technologies is only one of many factors that influence firms' performance, moreover, clear causal relations remain to be established.

Fourthly, the role of specific diffusion dynamics that could be documented in several countries and sectors in terms of piloting, planning and non-use needs to be further explored. It needs to be established which barriers hinder take up, to what extent efforts remain underway and to what extent those found in the 2012 data have come to fruition in the meantime. Especially regarding key enabling technologies dynamic developments can be assumed.

In sum, the EMS-based analyses provides a robust framework outlining trends and patterns of the use and impact of Advanced Manufacturing Technologies in Europe's manufacturing firms in a so far unknown degree of detail. However, these quantitative analyses remain limited to documentation and will in the further steps of this study have to be complemented by in-depth qualitative analysis and a complementary, tailor-made quantitative survey.

In the course of the work to be conducted under Work Package 2 these findings will thus not only be complemented with that from further countries and regarding further technologies but, more importantly, with a case-study-based identification of reasons for and modes of uptake as well as causal relationships between any such uptake and firms' performance.

4.3 Conclusions for the Selection of Case Studies

Based on the key findings of the study and the identified gaps the following suggestions can be made for the selection of case studies to be conducted in Work Package 2 of this project:

Because the drivers and barriers for adopting advanced manufacturing technologies may vary according to the different technologies the case studies should cover examples from all three main technology groups – high performance manufacturing technologies, ICT-enabled technologies and sustainable manufacturing technologies – separately and in a balanced manner. All three main groups should be equally addressed in their particular context of technological means and commercial or political ends which, in particular for sustainable manufacturing technologies may be a specific one. The goal thereby is to identify specific support needs for adoption with respect to three AMT technology groups. Thereby, for in-depth understanding different specific technologies have to be addressed as well.

The case studies should cover examples from all three groups of countries that can typically be identified within any one of the three main technology groups as presented in the chapter 2.1: leaders, followers and laggards. Studies should be conducted in as many COSME countries as possible complementing those so far covered by the EMS data analysis. e.g. with findings from Italy, the UK, Belgium, Hungary or Serbia. Examples should be selected so as to cover all five geographical regions in Europe (Northern, Western, Southern, Eastern- and Central Europe). In doing so, particular attention should be paid to countries with exceptionally low usage rates in one or more AMT technology groups so as to identify main barriers and determine country or region specific needs for support measures to overcome these barriers – most importantly in small and medium-sized firms.

In the identification of case studies differences between industries should be borne in mind – taking into account both the findings regarding different industries' use rates and particular industries role in different countries. Ideally, key sectoral groups should be represented within different country environment. The aim is to detect industry specific obstacles and barriers for adopting these technologies and, based on these results, identify sectoral specific support needs for adoption of AMTs in different industries. In doing so, firm size has to be considered as well. In particular, a main focus should be paid to small and medium sized firms.

The case studies should cover examples with a view to dynamism identified in the EMS based analyses. Companies with notably low rates of piloting activities and planned usage should be specifically considered – to close the knowledge gap with a view to most recent developments. Furthermore, the case studies should cover also companies which have not adopted AMTs yet in order to create an overall picture about the barriers for adopting these technologies.

Findings related to firm size, product complexity and batch size should be borne in mind in the sense that companies should not only be selected from different countries or sectors but also from different stages of international, national, or local value chains. Therefore, tier-1, tier-2 or component suppliers should be covered as much as OEM, with a focus on SME.

In the end, it will inevitably be challenging to take these five dimensions into account fully without exceeding the overall number of interviews planned and budgeted for this study. Nonetheless, any method for case study selection should bear in mind both the main findings of the EMS-based analysis (4.1) and the knowledge gaps identified on its basis (4.2).

Annex

Table Annex 1: Differences in Firm Performance depending on the uptake of high performance manufacturing technologies

Performance Indicator	Unit	industrial robots and handling systems	automated warehouse management systems (internal)	technologies for safe human-machine cooperation	processing alloy construction materials	processing composite materials	manufacturing micro-mechanical components	nano-technological production processes	*use of any. at least one* ***high-perform. manufacturing technology***
TECHNICAL PERFORMANCE									
Production lead time	**work days**	-6.1	3.4	-10.7	13.3				
Order delivery on time (main product)	**%**	1.4%		2.0%	-2.4%				
Rework/Scrap (main product)	**%**	-0.4%		-0.2%	0.4%				
ECONOMIC PERFORMANCE									
Added Value	**(Revenue - Input p. Employee. 1000 €)**	5.8	20.4	60.9					4.4
Return on sales (bef. tax 2011) > 2%	**% surveyed firms**		5.9%		4.2%			8.3%	3.9%
Employment growth (2009-2011)	**% annually**				0.1%		1.3%	-2.3%	
Revenue growth (2009-2011)	**% annually**	-1.2%	-0.2%		3.1%		7.5%		0.6%
Total Factor Productivity	**(turnover - input / depr.+staff cost)**		0.10	0.29	-0.56				
INNOVATIVE PERFORMANCE									
New products	**% surveyed firms**	10.7%	17.8%	14.8%	10.0%	17.8%	18.4%	16.9%	14.3%
Turnover generated by new products	*% (among innov.)*			3.0%					
Turnover generated by new products	*% (among all)*	1.9%	3.4%	4.4%	1.1%	3.2%	4.4%	2.4%	2.8%
Products new to the market	*% innovative firms*	6.2%	9.9%	10.8%			23.3%	20.1%	6.8%
Products new to the market	*% surveyed firms*								
Turnover gen. by prod. new to market	*% (among innov.)*	-0.6%	1.6%	0.4%	-1.1%	0.4%	-0.2%	-0.5%	-0.0%
Turnover gen. by prod. new to market	*% (among all)*	0.7%	2.2%	1.6%		1.7%	2.5%	2.1%	1.0%
Old products (over 10 years old)	**% surveyed firms**								
Turnover generated by old products	*% (among all)*	-4.3%	-6.5%		-7.0%		-8.5%	-7.7%	-4.5%

Source: European Manufacturing Survey 2012. Extract of 10 countries. Compiled by Fraunhofer ISI – 2015. Note: Significance level - dark grey background p <0.05. light grey background: p<0.001

Table Annex 2: Differences in Firm Performance depending on the uptake of ICT-enabled technologies

Performance Indicator	Unit	virtual reality/ simulation in production reconfiguration	virtual reality/ simulation in product design	supply chain management with suppliers/ customers	product lifecycle management-systems	*use of any. at least one ICT-enabled technology*
TECHNICAL PERFORMANCE						
Production lead time	**work days**	**11.9**	**19.3**			**4.7**
Order delivery on time (main product)	**%**		**-0.2%**	**1.3%**		
Rework/Scrap (main product)	**%**					
ECONOMIC PERFORMANCE						
Added Value	**(Revenue - Input per Employee. 1000 €)**			**26.6**	**31.7**	**27.4**
Return on sales (bef. tax 2011) > 2%	**% surveyed firms**		**4.5%**	**7.8%**	**8.8%**	**6.0%**
Employment growth (2009-2011)	**% annually**					
Revenue growth (2009-2011)	**% annually**	**1.4%**	**-1.3%**			**-0.3%**
Total Factor Productivity	**(turnover - input / depr. + staff cost)**					
INNOVATIVE PERFORMANCE						
New products	**% surveyed firms**	**10.3%**	**24.7%**	**10.1%**	**21.9%**	**17.5%**
Turnover generated by new products	*% (among innov.)*				3.0%	
Turnover generated by new products	*% (among all)*	2.5%	5.2%	1.2%	5.7%	3.7%
Products new to the market	*% innovative firms*		1.1%	1.1%	1.2%	1.1%
Products new to the market	*% surveyed firms*					
Turnover generated by prod. new to market	*% (among innov.)*	2.2%	1.8%	-0.7%	0.6%	1.3%
Turnover generated by prod. new to market	*% (among all)*	1.4%	2.7%	0.7%	2.4%	1.8%
Old products (over 10 years old)	**% surveyed firms**					
Turnover generated by old products	*% (among all)*	-4.3%	-11.0%	-8.1%	-9.5%	-8.7%

Source: European Manufacturing Survey 2012. Extract of 10 countries. Compiled by Fraunhofer ISI – 2015. Note: Significance level - dark grey background p <0.05. light grey background: p<0.001

Table Annex 3: Differences in Firm Performance depending on the uptake of Sustainable Manufacturing Technologies

Performance Indicator	unit	dry processing/ minimum lubrication	recuperation of kinetic and process energy	control systems to shut down machines	combined cold. heat and power (bi-/tri) generation	***use of any. at least one sustainable manufacturing technology***
TECHNICAL PERFORMANCE						
Production lead time	**work days**	**6.7**			**-7.3**	
Order delivery on time (main product)	**%**	**-1.6%**	**2.1%**	**2.9%**	**0.6%**	**1.4%**
Rework/Scrap (main product)	**%**					
ECONOMIC PERFORMANCE						
Added Value	**(Revenue - Input per Employee. 1000 €)**		**19.1**	**36.2**		**17.3**
Return on sales (bef. tax 2011) > 2%	**% surveyed firms**		**5.5%**			
Employment growth (2009-2011)	**% annually**					
Revenue growth (2009-2011)	**% annually**	**0.4%**				**-1.5%**
Total Factor Productivity	**(turnover - input / depr. + staff cost)**					**0.20**
INNOVATIVE PERFORMANCE						
New products	**% surveyed firms**	**5.5%**	**8.2%**	**11.7%**		**8.5%**
Turnover generated by new products	*% (among innov.)*		-2.8%			-1.5%
Turnover generated by new products	*% (among all)*		-0.5%	1.6%		0.4%
Products new to the market	*% innovative firms*					
Products new to the market	*% surveyed firms*		4.9%			
Turnover generated by prod. new to market	*% (among innov.)*		-1.5%	-0.4%		-0.0%
Turnover generated by prod. new to market	*% (among all)*			0.6%		0.5%
Old products (over 10 years old)	**% surveyed firms**		3.3%			
Turnover generated by old products	*% (among all)*					

Source: European Manufacturing Survey 2012. Extract of 10 countries. Compiled by Fraunhofer ISI – 2015. Note: Significance level - dark grey background p <0.05. light grey background: p<0.001

Table Annex 4: Production lead time [work days at 8 hours]
(analyses based on EMS 2012. Extract of 10 countries. compiled by Fraunhofer ISI – 2015)

Production Lead Time - High performance manufacturing technologies

		[work days at 8 hours]			
		Mean	Std.Dev.	Median	Valid N
industrial robots and handling systems	no	30.2	58.2	9.7	1544
	yes	24.2	82.7	6.5	880
automated warehouse management systems (internal)	no	27.5	69.3	7.0	1973
	yes	30.9	63.4	10.0	447
technologies for safe human-machine cooperation	no	29.3	70.5	9.0	2165
	yes	18.6	43.0	5.0	242
processing alloy construction materials (KET: advanced materials)	no	25.6	52.9	7.0	1965
	yes	38.9	113.9	11.0	435
processing composite materials (KET: advanced materials)	no	26.6	53.8	7.5	2234
	yes	47.1	168.9	10.0	164
manufacture of micromechanical components	no	26.9	55.0	8.0	2335
	yes	67.1	249.2	11.0	66
nanotechnological production processes (KET: nanotechnology)	no	27.2	55.0	8.0	2280
	yes	45.1	190.5	10.0	119
any high performance manufacturing technology	none	28.5	56.4	7.0	1093
	at least one	27.7	76.7	9.0	1315

Production Lead Time - ICT-enabled technologies

		[work days at 8 hours]			
		Mean	Std.Dev.	Median	Valid N
virtual reality - simulation in production reconfiguration	no	26.5	53.8	7.0	2077
	yes	38.3	126.9	10.0	320
virtual reality - simulation in product design	no	24.0	49.9	7.0	1883
	yes	43.3	112.2	12.0	505
supply chain management with suppliers/customers	no	29.0	74.9	7.0	1562
	yes	25.8	53.5	10.0	844
product lifecycle management systems	no	27.2	68.4	7.5	2140
	yes	35.4	68.2	10.0	238
any ICT-enabled technology	none	25.8	53.3	7.0	1279
	at least one	30.5	82.2	10.0	1112

Production Lead Time - Sustainable manufacturing technologies

		[work days at 8 hours]			
		Mean	Std.Dev.	Median	Valid N
dry processing - minimum lubrication	no	27.1	69.6	7.0	2018
	yes	33.8	61.9	12.0	360
recuperation of kinetic and process energy	no	29.2	73.8	7.3	1696
	yes	25.5	52.7	10.0	716
control systems to shut down machines	no	28.9	71.6	8.8	2004
	yes	25.0	49.8	7.0	379
combined cold. heat and power (bi-/tri) generation	no	28.7	70.5	8.0	2161
	yes	21.4	45.5	5.0	216
any sustainable manufacturing technology	none	29.3	78.1	7.0	1323
	at least one	26.6	54.0	10.0	1061

Table Annex 5: Share of orders delivered on time [%]

(analyses based on EMS 2012. Extract of 10 countries. compiled by Fraunhofer ISI – 2015)

Order Delivery on Time - High performance manuf. technologies

		Share [%]			
		Mean	Std.Dev.	Median	Valid N
industrial robots and handling systems	no	90.2	12.9	95.0	1592
	yes	91.5	12.9	95.0	891
automated warehouse management systems (internal)	no	90.5	13.1	95.0	2030
	yes	91.5	12.2	95.0	450
technologies for safe human-machine cooperation	no	90.5	13.0	95.0	2225
	yes	92.5	12.6	95.0	240
processing alloy construction materials (KET: advanced materials)	no	91.1	12.6	95.0	2014
	yes	88.7	14.3	95.0	445
processing composite materials (KET: advanced materials)	no	90.6	13.2	95.0	2290
	yes	91.8	8.7	95.0	167
manufacture of micromechanical components	no	90.7	12.9	95.0	2391
	yes	88.9	12.9	95.0	67
nanotechnological production processes (KET: nanotechnology)	no	90.7	12.9	95.0	2336
	yes	89.5	13.3	95.0	119
any high performance manufacturing technology	none	90.8	12.5	95.0	1130
	at least one	90.5	13.3	95.0	1338

Order Delivery on Time - ICT-enabled technologies

		Share [%]			
		Mean	Std.Dev.	Median	Valid N
virtual reality - simulation in production reconfiguration	no	90.5	13.1	95.0	2129
	yes	91.8	11.6	95.0	329
virtual reality - simulation in product design	no	90.7	13.3	95.0	1934
	yes	90.5	11.6	95.0	514
supply chain management with suppliers/customers	no	90.2	13.2	95.0	1598
	yes	91.5	12.4	95.0	869
product lifecycle management systems	no	90.5	13.0	95.0	2196
	yes	91.7	12.7	95.0	244
any ICT-enabled technology	none	90.4	13.3	95.0	1310
	at least one	90.9	12.5	95.0	1142

Order Delivery on Time - Sustainable manufacturing technologies

		Share [%]			
		Mean	Std.Dev.	Median	Valid N
dry processing - minimum lubrication	no	90.9	12.6	95.0	2074
	yes	89.3	14.4	95.0	366
recuperation of kinetic and process energy	no	90.1	13.2	95.0	1737
	yes	92.1	12.1	95.0	735
control systems to shut down machines	no	90.2	13.3	95.0	2057
	yes	93.1	10.8	95.0	389
combined cold. heat and power (bi-/tri) generation	no	90.7	12.7	95.0	2221
	yes	91.2	14.6	95.0	216
any sustainable manufacturing technology	none	90.1	13.1	95.0	1360
	at least one	91.5	12.6	95.0	1086

Table Annex 6: Share of products that have to be scrapped or reworked [%]
(analyses based on EMS 2012. Extract of 10 countries. compiled by Fraunhofer ISI – 2015)

Share Rework / Scrap - High performance manufacturing technologies

		Share [%]			
		Mean	Std.Dev.	Median	Valid N
industrial robots and handling systems	no	3.3	5.4	2.0	1537
	yes	2.9	5.4	1.5	859
automated warehouse management systems (internal)	no	3.3	5.6	2.0	1964
	yes	2.8	4.4	1.5	429
technologies for safe human-machine cooperation	no	3.2	5.3	2.0	2148
	yes	3.0	6.8	1.0	233
processing alloy construction materials (KET: advanced materials)	no	3.1	5.3	1.5	1953
	yes	3.6	6.0	2.0	423
processing composite materials (KET: advanced materials)	no	3.2	5.4	2.0	2215
	yes	2.9	4.1	2.0	158
manufacture of micromechanical components	no	3.2	5.4	1.8	2309
	yes	3.5	4.3	2.0	66
nanotechnological production processes (KET: nanotechnology)	no	3.2	5.4	1.8	2256
	yes	3.5	4.7	2.0	116
any high performance manufacturing technology	none	3.2	5.1	2.0	1091
	at least one	3.2	5.7	2.0	1292

Share Rework / Scrap - ICT-enabled technologies

		Share [%]			
		Mean	Std.Dev.	Median	Valid N
virtual reality - simulation in production reconfiguration	no	3.2	5.2	2.0	2061
	yes	3.3	6.7	1.7	311
virtual reality - simulation in product design	no	3.2	5.3	1.8	1873
	yes	3.3	6.0	2.0	490
supply chain management with suppliers/customers	no	3.2	5.4	2.0	1549
	yes	3.1	5.6	1.5	833
product lifecycle management systems	no	3.2	5.5	2.0	2129
	yes	2.7	4.3	1.5	227
any ICT-enabled technology	none	3.2	5.2	2.0	1272
	at least one	3.2	5.7	2.0	1096

Share Rework / Scrap - Sustainable manufacturing technologies

		Share [%]			
		Mean	Std.Dev.	Median	Valid N
dry processing - minimum lubrication	no	3.2	5.3	2.0	2000
	yes	3.1	5.7	1.5	354
recuperation of kinetic and process energy	no	3.2	5.4	2.0	1674
	yes	3.1	5.2	1.8	712
control systems to shut down machines	no	3.3	5.7	2.0	1981
	yes	2.7	4.1	1.5	380
combined cold. heat and power (bi-/tri) generation	no	3.2	5.5	2.0	2142
	yes	2.7	3.5	2.0	214
any sustainable manufacturing technology	none	3.3	5.5	2.0	1311
	at least one	3.1	5.2	1.5	1050

Table Annex 7: Labour productivity - added value per employee [1,000 euro per employee]
(analyses based on EMS 2012. Extract of 10 countries. compiled by Fraunhofer ISI – 2015)

Added Value per Employee - High performance manufacturing technologies

		Added Value [Th. Euro]			
		Mean	Std.Dev.	Median	Valid N
industrial robots and handling systems	no	117.0	208.61	77.50	1183
	yes	122.8	185.75	85.99	650
automated warehouse management systems (internal)	no	115.6	206.46	77.11	1507
	yes	136.0	171.49	95.99	326
technologies for safe human-machine cooperation	no	113.3	187.09	79.37	1638
	yes	174.2	295.78	93.50	183
processing alloy construction materials (KET: advanced materials)	no	121.3	201.41	80.73	1487
	yes	111.6	202.18	76.67	330
processing composite materials (KET: advanced materials)	no	120.8	203.02	80.00	1689
	yes	103.6	181.16	81.43	128
manufacture of micromechanical components	no	119.6	202.25	80.00	1759
	yes	117.3	181.94	83.33	57
nanotechnological production processes (KET: nanotechnology)	no	118.3	200.08	80.00	1722
	yes	145.3	230.84	84.86	91
any high performance manufacturing technology	none	117.0	212.83	75.53	840
	at least one	121.4	190.84	84.83	983

Added Value per Employee - ICT-enabled technologies

		Added Value [Th. Euro]			
		Mean	Std.Dev.	Median	Valid N
virtual reality - simulation in production reconfiguration	no	111.8	180.71	79.61	1596
	yes	177.5	310.99	86.32	217
virtual reality - simulation in product design	no	119.3	199.15	79.32	1432
	yes	118.8	208.56	85.26	378
supply chain management with suppliers/customers	no	110.1	180.69	76.19	1177
	yes	136.6	232.95	86.67	649
product lifecycle management systems	no	116.8	196.38	79.30	1643
	yes	148.5	251.46	91.57	164
any ICT-enabled technology	none	107.1	172.09	76.19	979
	at least one	134.5	231.39	85.36	832

Added Value per Employee - Sustainable manufacturing technologies

		Added Value [Th. Euro]			
		Mean	Std.Dev.	Median	Valid N
dry processing - minimum lubrication	no	114.9	182.64	80.00	1539
	yes	140.7	272.81	81.61	266
recuperation of kinetic and process energy	no	113.7	194.56	76.92	1286
	yes	132.8	215.27	89.75	541
control systems to shut down machines	no	112.7	185.01	78.57	1513
	yes	148.9	255.59	90.91	293
combined cold. heat and power (bi-/tri) generation	no	118.2	200.73	80.00	1637
	yes	136.6	217.95	80.00	165
any sustainable manufacturing technology	none	110.9	186.77	76.28	996
	at least one	128.2	211.80	84.62	811

Table Annex 8: Total factor productivity

(analyses based on EMS 2012. Extract of 10 countries. compiled by Fraunhofer ISI – 2015)

Total Factor Productivity - High performance manufacturing technologies

		Total Factor Productivity			
		Mean	**Std.Dev.**	**Median**	**Valid N**
industrial robots and handling systems	no	1.83	3.59	1.6	989
	yes	2.02	1.88	1.7	566
automated warehouse management systems (internal)	no	1.89	3.37	1.6	1270
	yes	1.98	1.10	1.7	285
technologies for safe human-machine cooperation	no	1.88	3.21	1.6	1398
	yes	2.17	1.53	1.9	147
processing alloy construction materials (KET: advanced materials)	no	2.01	1.69	1.7	1259
	yes	1.45	6.30	1.6	280
processing composite materials (KET: advanced materials)	no	1.93	3.18	1.7	1438
	yes	1.71	1.52	1.6	104
manufacture of micromechanical components	no	1.92	3.14	1.6	1496
	yes	1.71	0.71	1.6	44
nanotechnological production processes (KET: nanotechnology)	no	1.91	3.17	1.6	1463
	yes	1.86	0.89	1.6	75
any high performance manufacturing technology	none	1.98	1.64	1.6	707
	at least one	1.85	3.92	1.7	838

Total Factor Productivity - ICT-enabled technologies

		Total Factor Productivity			
		Mean	**Std.Dev.**	**Median**	**Valid N**
virtual reality - simulation in production reconfiguration	no	1.88	3.23	1.6	1364
	yes	2.13	1.79	1.7	174
virtual reality - simulation in product design	no	1.91	3.42	1.6	1209
	yes	1.92	1.38	1.7	328
supply chain management with suppliers/customers	no	1.85	3.57	1.6	1018
	yes	2.03	1.83	1.7	532
product lifecycle management systems	no	1.90	3.23	1.6	1395
	yes	2.06	1.28	1.8	138
any ICT-enabled technology	none	1.84	3.86	1.6	841
	at least one	1.99	1.79	1.7	697

Total Factor Productivity - Sustainable manufacturing technologies

		Total Factor Productivity			
		Mean	**Std.Dev.**	**Median**	**Valid N**
dry processing - minimum lubrication	no	1.90	3.26	1.7	1311
	yes	1.97	1.94	1.6	220
recuperation of kinetic and process energy	no	1.89	3.58	1.6	1105
	yes	1.94	1.17	1.7	445
control systems to shut down machines	no	1.89	3.35	1.6	1278
	yes	1.98	1.25	1.7	253
combined cold. heat and power (bi-/tri) generation	no	1.89	3.22	1.6	1384
	yes	2.11	1.64	1.7	139
any sustainable manufacturing technology	none	1.82	3.91	1.6	855
	at least one	2.02	1.56	1.7	677

Table Annex 9: Return on sales (before taxes) [categorized]

(analyses based on EMS 2012. Extract of 10 countries. compiled by Fraunhofer ISI – 2015)

Return on Sales - High performance manufacturing technologies

		Return on sales (before tax in 2011)			
		< 2%		>= 2%	
		n	%	n	%
industrial robots and handling systems	no	398	29.2%	966	70.8%
	yes	218	29.2%	528	70.8%
automated warehouse management systems (internal)	no	522	30.1%	1215	69.9%
	yes	89	24.1%	280	75.9%
technologies for safe human-machine cooperation	no	548	28.9%	1345	71.1%
	yes	66	31.9%	141	68.1%
processing alloy construction materials (KET: advanced materials)	no	511	29.9%	1199	70.1%
	yes	97	25.7%	280	74.3%
processing composite materials (KET: advanced materials)	no	575	29.5%	1374	70.5%
	yes	34	24.5%	105	75.5%
manufacture of micromechanical components	no	597	29.5%	1430	70.5%
	yes	13	21.3%	48	78.7%
nanotechnological production processes (KET: nanotechnology)	no	588	29.6%	1396	70.4%
	yes	22	21.4%	81	78.6%
any high performance manufacturing technology	none	306	31.2%	674	68.8%
	at least one	305	27.3%	812	72.7%

Return on Sales - ICT-enabled technologies

		Return on sales (before tax in 2011)			
		< 2%		>= 2%	
		n	%	n	%
virtual reality - simulation in production reconfiguration	no	543	29.6%	1291	70.4%
	yes	65	25.8%	187	74.2%
virtual reality - simulation in product design	no	497	30.1%	1155	69.9%
	yes	110	25.6%	320	74.4%
supply chain management with suppliers/customers	no	434	32.1%	917	67.9%
	yes	182	24.3%	566	75.7%
product lifecycle management systems	no	565	30.1%	1310	69.9%
	yes	42	21.3%	155	78.7%
any ICT-enabled technology	none	358	31.9%	764	68.1%
	at least one	249	25.9%	711	74.1%

Return on Sales - Sustainable manufacturing technologies

		Return on sales (before tax in 2011)			
		< 2%		>= 2%	
		n	%	n	%
dry processing - minimum lubrication	no	526	29.9%	1234	70.1%
	yes	79	25.0%	237	75.0%
recuperation of kinetic and process energy	no	458	30.8%	1029	69.2%
	yes	155	25.3%	458	74.7%
control systems to shut down machines	no	519	29.7%	1228	70.3%
	yes	88	26.4%	245	73.6%
combined cold. heat and power (bi-/tri) generation	no	546	28.9%	1344	71.1%
	yes	57	31.3%	125	68.7%
any sustainable manufacturing technology	none	355	30.6%	805	69.4%
	at least one	250	27.2%	670	72.8%

Table Annex 10: Employment growth - annual trend of numbers of employee [%-change per year]
(analyses based on EMS 2012. Extract of 10 countries. compiled by Fraunhofer ISI – 2015)

Employment Growth - High performance manufacturing technologies

		growth per year [%]			
		Mean	Std.Dev.	Median	Valid N
industrial robots and handling systems	no	7.1	89.1	1.6	1584
	yes	2.9	11.7	1.7	886
automated warehouse management systems (internal)	no	6.2	79.0	1.6	2022
	yes	3.1	13.6	1.7	447
technologies for safe human-machine cooperation	no	5.9	75.6	1.7	2211
	yes	3.5	14.9	1.6	246
processing alloy construction materials (KET: advanced materials)	no	5.7	78.9	1.2	2001
	yes	5.8	23.6	3.2	447
processing composite materials (KET: advanced materials)	no	5.8	74.6	1.6	2280
	yes	3.6	11.2	2.4	166
manufacture of micromechanical components	no	5.6	73.0	1.6	2379
	yes	7.0	13.7	4.3	68
nanotechnological production processes (KET: nanotechnology)	no	5.8	73.9	1.5	2324
	yes	3.5	10.7	3.1	120
any high performance manufacturing technology	none	8.1	104.5	1.2	1129
	at least one	3.6	16.8	1.9	1328

Employment Growth - ICT-enabled technologies

		growth per year [%]			
		Mean	Std.Dev.	Median	Valid N
virtual reality - simulation in production reconfiguration	no	5.6	76.2	1.6	2128
	yes	5.5	33.4	1.9	317
virtual reality - simulation in product design	no	5.0	66.8	1.4	1937
	yes	7.9	90.1	2.2	500
supply chain management with suppliers/customers	no	6.7	88.1	1.5	1607
	yes	3.5	16.2	1.9	849
product lifecycle management systems	no	5.8	75.3	1.6	2197
	yes	4.4	32.0	2.0	230
any ICT-enabled technology	none	5.6	79.9	1.4	1326
	at least one	5.6	61.7	1.9	1114

Employment Growth - Sustainable manufacturing technologies

		growth per year [%]			
		Mean	Std.Dev.	Median	Valid N
dry processing - minimum lubrication	no	5.8	77.8	1.5	2059
	yes	5.0	26.0	2.2	367
recuperation of kinetic and process energy	no	6.5	84.8	1.6	1741
	yes	3.7	15.9	1.7	720
control systems to shut down machines	no	6.2	78.6	1.7	2047
	yes	2.8	12.0	1.6	385
combined cold. heat and power (bi-/tri) generation	no	6.0	75.7	1.7	2211
	yes	2.0	10.7	1.5	216
any sustainable manufacturing technology	none	7.1	94.7	1.6	1367
	at least one	3.8	20.2	1.7	1065

Table Annex 11: Turnover Growth - annual trend of turnover [%-change per year]
(analyses based on EMS 2012. Extract of 10 countries. compiled by Fraunhofer ISI – 2015)

Turnover Growth - High performance manufacturing technologies

		[% growth per year]			
		Mean	**Std.Dev.**	**Median**	**Valid N**
industrial robots and handling systems	no	15.3	50.9	8.0	1486
	yes	14.1	34.6	9.2	827
automated warehouse management systems (internal)	no	14.8	49.0	8.1	1899
	yes	14.7	24.5	10.0	412
technologies for safe human-machine cooperation	no	15.2	47.8	8.3	2069
	yes	11.4	21.0	8.3	230
processing alloy construction materials (KET: advanced materials)	no	14.2	47.5	7.7	1878
	yes	17.3	35.6	11.7	414
processing composite materials (KET: advanced materials)	no	14.8	46.6	8.3	2135
	yes	13.8	30.0	8.9	153
manufacture of micromechanical components	no	14.6	45.5	8.3	2225
	yes	22.0	51.4	11.9	65
nanotechnological production processes (KET: nanotechnology)	no	14.9	46.6	8.2	2179
	yes	13.1	19.3	10.0	108
any high performance manufacturing technology	none	14.4	54.0	7.1	1056
	at least one	15.0	36.9	9.2	1243

Turnover Growth - ICT-enabled technologies

		[% growth per year]			
		Mean	**Std.Dev.**	**Median**	**Valid N**
virtual reality - simulation in production reconfiguration	no	14.7	46.3	8.2	2001
	yes	16.0	42.4	10.0	285
virtual reality - simulation in product design	no	15.1	49.7	7.9	1818
	yes	13.8	25.9	10.0	464
supply chain management with suppliers/customers	no	14.4	48.7	7.5	1501
	yes	15.5	39.5	10.0	796
product lifecycle management systems	no	14.9	47.1	8.3	2062
	yes	13.3	31.4	8.8	212
any ICT-enabled technology	none	15.0	51.7	7.7	1240
	at least one	14.7	37.9	9.2	1042

Turnover Growth - Sustainable manufacturing technologies

		[% growth per year]			
		Mean	**Std.Dev.**	**Median**	**Valid N**
dry processing - minimum lubrication	no	14.8	48.0	8.0	1937
	yes	15.2	31.8	11.1	333
recuperation of kinetic and process energy	no	15.5	50.7	8.2	1637
	yes	13.2	30.5	8.9	669
control systems to shut down machines	no	15.0	47.5	8.1	1923
	yes	13.5	36.2	9.3	354
combined cold. heat and power (bi-/tri) generation	no	15.2	47.9	8.3	2075
	yes	10.4	13.7	8.3	195
any sustainable manufacturing technology	none	15.5	52.0	7.9	1289
	at least one	14.0	36.6	8.8	988

Table Annex 12: Product innovation [share of firms]
(analyses based on EMS 2012. Extract of 10 countries. compiled by Fraunhofer ISI – 2015)

Product Innovation - High performance manufacturing technologies

		firms with new products		firms w. old products (over 10 years old)	
		n	%	n	%
industrial robots and handling systems	no	921	56.4%	1410	87.2%
	yes	604	67.1%	791	88.2%
automated warehouse management systems (internal)	no	1186	57.1%	1802	87.4%
	yes	340	74.9%	396	88.2%
technologies for safe human-machine cooperation	no	1335	58.7%	1973	87.5%
	yes	178	73.6%	213	88.0%
processing alloy construction materials (KET: advanced materials)	no	1197	58.4%	1786	87.7%
	yes	313	68.3%	395	87.2%
processing composite materials (KET: advanced materials)	no	1377	59.0%	2026	87.4%
	yes	132	76.7%	155	90.1%
manufacture of micromechanical components	no	1453	59.7%	2117	87.6%
	yes	57	78.1%	62	84.9%
nanotechnological production processes (KET: nanotechnology)	no	1414	59.4%	2073	87.7%
	yes	93	76.2%	104	86.0%
any high performance manufacturing technology	none	610	52.5%	998	86.6%
	at least one	906	66.8%	1191	88.5%

Product Innovation - ICT-enabled technologies

		firms with new products		firms w. old products (over 10 years old)	
		n	%	n	%
virtual reality - simulation in production reconfiguration	no	1288	58.9%	1907	87.9%
	yes	221	69.3%	271	85.8%
virtual reality - simulation in product design	no	1088	55.1%	1722	87.9%
	yes	413	79.7%	447	86.8%
supply chain management with suppliers/customers	no	936	56.8%	1427	87.1%
	yes	580	66.9%	761	88.6%
product lifecycle management systems	no	1305	58.0%	1960	87.9%
	yes	187	79.9%	198	84.3%
any ICT-enabled technology	none	710	52.2%	1189	88.0%
	at least one	793	69.7%	983	87.1%

Product Innovation - Sustainable manufacturing technologies

		firms with new products		firms w. old products (over 10 years old)	
		n	%	n	%
dry processing - minimum lubrication	no	1256	59.4%	1827	87.2%
	yes	242	64.9%	331	88.7%
recuperation of kinetic and process energy	no	1040	58.0%	1543	86.6%
	yes	482	66.2%	647	89.9%
control systems to shut down machines	no	1233	58.4%	1829	87.3%
	yes	267	70.1%	335	87.7%
combined cold. heat and power (bi-/tri) generation	no	1356	59.7%	1970	87.3%
	yes	138	64.5%	190	90.0%
any sustainable manufacturing technology	none	795	56.5%	1208	86.5%
	at least one	705	64.9%	956	88.7%

Table Annex 13: Product Innovation II [share of firms]

(analyses based on EMS 2012. Extract of 10 countries. compiled by Fraunhofer ISI – 2015)

Product Innovation II - High performance manufacturing technologies

		Products new to market [% innovators]		Products new to market [% all firms]	
		n	%	n	%
industrial robots and handling systems	no	465	51.1%	465	28.7%
	yes	345	57.3%	345	38.4%
automated warehouse management systems (internal)	no	602	51.2%	602	29.1%
	yes	206	61.1%	206	45.7%
technologies for safe human-machine cooperation	no	687	51.9%	687	30.4%
	yes	111	62.7%	111	46.1%
processing alloy construction materials (KET: advanced materials)	no	628	52.8%	628	30.8%
	yes	165	53.4%	165	36.3%
processing composite materials (KET: advanced materials)	no	712	52.2%	712	30.7%
	yes	80	60.6%	80	46.5%
manufacture of micromechanical components	no	751	52.2%	751	31.0%
	yes	43	75.4%	43	58.9%
nanotechnological production processes (KET: nanotechnology)	no	728	52.0%	728	30.7%
	yes	67	72.0%	67	54.9%
any high performance manufacturing technology	none	296	49.0%	296	25.6%
	at least one	502	55.8%	502	37.2%

Product Innovation II - ICT-enabled technologies

		Products new to market [% innovators]		Products new to market [% all firms]	
		n	%	n	%
virtual reality - simulation in production reconfiguration	no	678	53.1%	678	31.2%
	yes	118	53.9%	118	37.2%
virtual reality - simulation in product design	no	549	50.9%	549	27.9%
	yes	246	60.1%	246	47.9%
supply chain management with suppliers/customers	no	470	50.5%	470	28.6%
	yes	329	57.4%	329	38.3%
product lifecycle management systems	no	668	51.6%	668	29.8%
	yes	122	65.9%	122	52.6%
any ICT-enabled technology	none	345	48.9%	345	25.5%
	at least one	449	57.2%	449	39.7%

Product Innovation - Sustainable manufacturing technologies

		Products new to market [% innovators]		Products new to market [% all firms]	
		n	%	n	%
dry processing - minimum lubrication	no	672	54.0%	672	31.9%
	yes	120	49.8%	120	32.3%
recuperation of kinetic and process energy	no	548	53.0%	548	30.7%
	yes	257	53.9%	257	35.5%
control systems to shut down machines	no	651	53.3%	651	31.0%
	yes	146	54.9%	146	38.4%
combined cold. heat and power (bi-/tri) generation	no	713	53.0%	713	31.5%
	yes	80	58.4%	80	37.6%
any sustainable manufacturing technology	none	416	52.7%	416	29.7%
	at least one	379	54.2%	379	35.1%

Table Annex 14: Share of turnover with new products (innovators) [%]
(analyses based on EMS 2012. Extract of 10 countries. compiled by Fraunhofer ISI – 2015)

Turnover with New Prod. (innov.) - High performance manuf. technologies

		Share [%]			
		Mean	Std.Dev.	Median	Valid N
industrial robots and handling systems	no	15.7	16	10	877
	yes	16.0	17	10	570
automated warehouse management systems (internal)	no	15.6	17	10	1131
	yes	16.5	17	10	318
technologies for safe human-machine cooperation	no	15.5	16	10	1269
	yes	18.5	18	12	167
processing alloy construction materials (KET: advanced materials)	no	15.9	17	10	1145
	yes	15.3	15	10	291
processing composite materials (KET: advanced materials)	no	15.7	17	10	1311
	yes	16.3	17	10	123
manufacture of micromechanical components	no	15.7	17	10	1384
	yes	17.9	21	10	51
nanotechnological production processes (KET: nanotechnology)	no	15.8	17	10	1345
	yes	15.5	16	10	87
any high performance manufacturing technology	none	15.1	16	10	584
	at least one	16.2	17	10	856

Turnover with New Prod. (innov.) - ICT-enabled technologies

		Share [%]			
		Mean	Std.Dev.	Median	Valid N
virtual reality - simulation in production reconfiguration	no	15.6	16	10	1227
	yes	17.0	18	10	207
virtual reality - simulation in product design	no	15.3	16	10	1036
	yes	17.1	18	10	390
supply chain management with suppliers/customers	no	16.1	17	10	891
	yes	15.4	16	10	548
product lifecycle management systems	no	15.5	17	10	1246
	yes	18.5	18	13	172
any ICT-enabled technology	none	15.1	16	10	674
	at least one	16.5	17	10	754

Turnover with New Prod. (innov.) - Sustainable manufacturing technologies

		Share [%]			
		Mean	Std.Dev.	Median	Valid N
dry processing - minimum lubrication	no	15.9	17	10	1195
	yes	15.6	17	10	229
recuperation of kinetic and process energy	no	16.6	18	10	993
	yes	13.8	14	10	453
control systems to shut down machines	no	15.9	17	10	1171
	yes	15.4	17	10	254
combined cold. heat and power (bi-/tri) generation	no	15.9	17	10	1298
	yes	15.3	19	10	122
any sustainable manufacturing technology	none	16.5	17	10	759
	at least one	15.0	16	10	666

Table Annex 15: Share of turnover with new products (all firms) [%]
(analyses based on EMS 2012. Extract of 10 countries. compiled by Fraunhofer ISI – 2015)

Turnover with New Prod. (all) - High performance manufacturing technologies

		Share [%]			
		Mean	Std.Dev.	Median	Valid N
industrial robots and handling systems	no	8.6	14.5	2.0	1589
	yes	10.5	15.8	5.0	866
automated warehouse management systems (internal)	no	8.7	14.6	2.0	2021
	yes	12.1	16.4	5.0	432
technologies for safe human-machine cooperation	no	8.9	14.6	3.0	2207
	yes	13.3	17.1	10.0	231
processing alloy construction materials (KET: advanced materials)	no	9.1	15.1	3.0	1998
	yes	10.2	14.4	5.0	436
processing composite materials (KET: advanced materials)	no	9.1	14.8	3.0	2269
	yes	12.3	16.4	5.0	163
manufacture of micromechanical components	no	9.2	14.8	4.0	2365
	yes	13.6	19.5	5.0	67
nanotechnological production processes (KET: nanotechnology)	no	9.2	15.0	3.0	2313
	yes	11.6	15.5	8.0	116
any high performance manufacturing technology	none	7.8	13.7	1.0	1135
	at least one	10.6	15.9	5.0	1306

Turnover with New Prod. (all) - ICT-enabled technologies

		Share [%]			
		Mean	Std.Dev.	Median	Valid N
virtual reality - simulation in production reconfiguration	no	9.0	14.7	3.0	2124
	yes	11.5	16.9	5.0	305
virtual reality - simulation in product design	no	8.3	14.2	2.0	1924
	yes	13.5	17.3	8.0	495
supply chain management with suppliers/customers	no	9.0	15.2	2.0	1603
	yes	10.1	14.6	5.0	835
product lifecycle management systems	no	8.8	14.6	3.0	2191
	yes	14.5	17.8	10.0	219
any ICT-enabled technology	none	7.7	13.7	0.0	1324
	at least one	11.3	16.3	5.0	1099

Turnover with New Prod. (all) - Sustainable manufacturing technologies

		Share [%]			
		Mean	Std.Dev.	Median	Valid N
dry processing - minimum lubrication	no	9.2	14.9	3.0	2054
	yes	9.9	15.4	5.0	360
recuperation of kinetic and process energy	no	9.5	15.6	3.0	1747
	yes	9.0	13.3	5.0	699
control systems to shut down machines	no	9.1	14.8	3.0	2051
	yes	10.6	15.6	5.0	368
combined cold. heat and power (bi-/tri) generation	no	9.3	14.9	4.0	2215
	yes	9.4	16.8	3.5	198
any sustainable manufacturing technology	none	9.2	15.1	2.0	1372
	at least one	9.5	14.9	5.0	1047

Table Annex 16: Share of turnover with products new to the market (innovators) [%]
(analyses based on EMS 2012. Extract of 10 countries. compiled by Fraunhofer ISI – 2015)

Turnover with Prod. New to Market (innov.) - High performance manuf. technologies

		Share [%]			
		Mean	Std.Dev.	Median	Valid N
industrial robots and handling systems	no	10.1	13	5	436
	yes	9.5	14	5	314
automated warehouse management systems (internal)	no	9.5	12	5	561
	yes	11.1	16	5	188
technologies for safe human-machine cooperation	no	9.9	13	5	640
	yes	10.4	12	5	99
processing alloy construction materials (KET: advanced materials)	no	10.1	13	5	586
	yes	9.0	12	5	148
processing composite materials (KET: advanced materials)	no	9.8	13	5	661
	yes	10.2	14	5	73
manufacture of micromechanical components	no	9.9	13	5	698
	yes	9.7	16	5	38
nanotechnological production processes (KET: nanotechnology)	no	9.9	13	5	674
	yes	9.4	14	5	63
any high performance manufacturing technology	none	9.9	12	5	281
	at least one	9.9	14	5	458

Turnover with Prod. New to Market (innov.) - ICT-enabled technologies

		Share [%]			
		Mean	Std.Dev.	Median	Valid N
virtual reality - simulation in production reconfiguration	no	9.6	12	5	629
	yes	11.9	16	5	110
virtual reality - simulation in product design	no	9.4	12	5	511
	yes	11.2	15	5	227
supply chain management with suppliers/customers	no	10.2	12	5	438
	yes	9.5	14	5	304
product lifecycle management systems	no	9.9	13	5	622
	yes	10.5	15	5	110
any ICT-enabled technology	none	9.2	11	5	321
	at least one	10.5	15	5	416

Turnover with Prod. New to Market (innov.) - Sustainable manuf. technologies

		Share [%]			
		Mean	Std.Dev.	Median	Valid N
dry processing - minimum lubrication	no	9.9	12	5	622
	yes	10.0	16	5	112
recuperation of kinetic and process energy	no	10.4	13	5	507
	yes	8.8	13	5	239
control systems to shut down machines	no	9.9	13	5	604
	yes	9.5	14	5	135
combined cold. heat and power (bi-/tri) generation	no	10.0	13	5	665
	yes	9.2	14	5	69
any sustainable manufacturing technology	none	9.9	12	5	385
	at least one	9.9	14	5	352

Table Annex 17: Share of turnover with products new to the market (all firms) [%]
(analyses based on EMS 2012. Extract of 10 countries. compiled by Fraunhofer ISI – 2015)

Turnover with Prod. New to Market (all) - High performance manuf. technologies

		Share [%]			
		Mean	Std.Dev.	Median	Valid N
industrial robots and handling systems	no	2.8	8.0	0.0	1593
	yes	3.5	9.4	0.0	867
automated warehouse management systems (internal)	no	2.6	7.6	0.0	2025
	yes	4.8	11.7	0.0	433
technologies for safe human-machine cooperation	no	2.9	8.4	0.0	2214
	yes	4.5	9.4	0.0	229
processing alloy construction materials (KET: advanced materials)	no	3.0	8.5	0.0	2000
	yes	3.1	8.3	0.0	437
processing composite materials (KET: advanced materials)	no	2.8	8.1	0.0	2271
	yes	4.5	10.7	0.0	165
manufacture of micromechanical components	no	2.9	8.3	0.0	2368
	yes	5.4	12.5	1.0	68
nanotechnological production processes (KET: nanotechnology)	no	2.9	8.3	0.0	2315
	yes	5.0	11.3	.5	118
any high performance manufacturing technology	none	2.4	7.3	0.0	1140
	at least one	3.5	9.4	0.0	1305

Turnover with Prod. New to Market (all) - ICT-enabled technologies

		Share [%]			
		Mean	Std.Dev.	Median	Valid N
virtual reality - simulation in production reconfiguration	no	2.8	8.0	0.0	2125
	yes	4.2	11.3	0.0	309
virtual reality - simulation in product design	no	2.5	7.4	0.0	1929
	yes	5.1	11.8	0.0	495
supply chain management with suppliers/customers	no	2.8	7.9	0.0	1610
	yes	3.4	9.5	0.0	835
product lifecycle management systems	no	2.8	8.1	0.0	2194
	yes	5.2	12.0	0.0	220
any ICT-enabled technology	none	2.2	6.5	0.0	1331
	at least one	4.0	10.4	0.0	1097

Turnover with Prod. New to Market (all) - Sustainable manufacturing technologies

		Share [%]			
		Mean	Std.Dev.	Median	Valid N
dry processing - minimum lubrication	no	3.0	8.2	0.0	2054
	yes	3.1	9.8	0.0	364
recuperation of kinetic and process energy	no	3.0	8.5	0.0	1746
	yes	3.0	8.5	0.0	705
control systems to shut down machines	no	2.9	8.2	0.0	2055
	yes	3.5	9.7	0.0	369
combined cold. heat and power (bi-/tri) generation	no	3.0	8.5	0.0	2214
	yes	3.1	9.1	0.0	202
any sustainable manufacturing technology	none	2.8	7.7	0.0	1371
	at least one	3.3	9.5	0.0	1053

Table Annex 18: Share of turnover with Products older than 10 years (all firms) [%]
(analyses based on EMS 2012. Extract of 10 countries. compiled by Fraunhofer ISI – 2015)

Turnover with Old Products - High performance manufacturing technologies

		Turnover Share [%]			
		Mean	Std.Dev.	Median	Valid N
industrial robots and handling systems	no	56.5	30.7	60.0	1310
	yes	52.2	29.2	50.0	737
automated warehouse management systems (internal)	no	56.1	30.4	60.0	1683
	yes	49.6	28.9	50.0	361
technologies for safe human-machine cooperation	no	55.0	30.3	60.0	1842
	yes	54.2	29.2	57.0	191
processing alloy construction materials (KET: advanced materials)	no	56.1	30.2	60.0	1661
	yes	49.1	29.8	50.0	366
processing composite materials (KET: advanced materials)	no	55.2	30.3	60.0	1887
	yes	51.6	29.3	50.0	140
manufacture of micromechanical components	no	55.2	30.1	60.0	1967
	yes	46.6	32.3	40.0	57
nanotechnological production processes (KET: nanotechnology)	no	55.3	30.3	60.0	1927
	yes	47.6	27.0	40.0	95
any high performance manufacturing technology	none	57.4	30.9	60.0	932
	at least one	52.9	29.5	50.0	1102

Turnover with Old Products - ICT-enabled technologies

		Turnover Share [%]			
		Mean	Std.Dev.	Median	Valid N
virtual reality - simulation in production reconfiguration	no	55.4	30.2	60.0	1777
	yes	51.1	30.3	50.0	247
virtual reality - simulation in product design	no	57.2	30.2	60.0	1602
	yes	46.3	29.0	50.0	414
supply chain management with suppliers/customers	no	57.7	30.1	60.0	1332
	yes	49.6	29.8	50.0	702
product lifecycle management systems	no	55.7	30.2	60.0	1833
	yes	46.2	29.7	40.0	172
any ICT-enabled technology	none	58.8	30.2	60.0	1113
	at least one	50.1	29.6	50.0	905

Turnover with Old Products - Sustainable manufacturing technologies

		Turnover Share [%]			
		Mean	Std.Dev.	Median	Valid N
dry processing - minimum lubrication	no	55.4	30.2	60.0	1700
	yes	52.3	30.8	55.0	307
recuperation of kinetic and process energy	no	54.9	30.7	60.0	1432
	yes	55.0	29.4	60.0	604
control systems to shut down machines	no	54.5	30.4	50.0	1705
	yes	57.5	29.4	60.0	308
combined cold. heat and power (bi-/tri) generation	no	54.9	30.3	60.0	1841
	yes	55.3	29.7	60.0	167
any sustainable manufacturing technology	none	55.3	30.5	60.0	1125
	at least one	54.4	30.0	55.0	888

Annex Table 19: Industry Structure of Analyzed Countries, Distribution of Companies by Firm Size Classes and Sector according to European Statistics

		Country																			
		Germany		Austria		Netherlands		France		Denmark		Croatia		Sweden		Spain		Slovenia		Portugal	
		N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Company Size	below 49 employees	16.435	44%	2.190	53%	2.753	54%	9.969	58%	1.359	55%	994	55%	2.078	56%	9.269	66%	588	50%	3.860	63%
	50 – 249 employees	16.415	44%	1.438	35%	1.970	39%	5.810	34%	933	38%	644	36%	1.305	35%	4.095	29%	489	41%	1.988	33%
	above 250 employees	4.196	11%	472	12%	344	7%	1.480	9%	184	7%	159	9%	322	9%	721	5%	107	9%	248	4%
	total	37.046	100%	4.100	100%	5.067	100%	17.259	100%	2.476	100%	1.797	100%	3.705	100%	14.085	100%	1.184	100%	6.096	100%

		Germany		Austria		Netherlands		France		Denmark		Croatia		Sweden		Spain		Slovenia		Portugal	
		N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Sector Groups	Food, Beverages, Tobacco	329	13%	5.209	14%	2.973	21%	2.918	17%	408	23%	759	15%	738	18%	923	15%	100	8%	396	11%
	Chemical Industry	127	5%	1.493	4%	924	7%	968	6%	57	3%	310	6%	132	3%	173	3%	49	4%	153	4%
	Rubber and Plastic Industry	260	11%	4.279	12%	1.697	12%	1.837	11%	186	10%	461	9%	444	11%	594	10%	150	13%	328	9%
	Metal Industry	468	19%	7.801	21%	2.399	17%	3.417	20%	264	15%	1.058	21%	772	19%	837	14%	316	27%	889	24%
	Machinery	448	18%	5.340	14%	1.024	7%	1.301	8%	83	5%	656	13%	459	11%	221	4%	126	11%	492	13%
	Electronic & Electrical Equipment	248	10%	3.600	10%	676	5%	1.129	7%	86	5%	304	6%	284	7%	158	3%	104	9%	278	8%
	Transport Equipment	68	3%	1.286	3%	609	4%	661	4%	59	3%	231	5%	110	3%	170	3%	45	4%	230	6%
	Other Sectors	528	21%	7.999	22%	3.612	26%	4.917	29%	654	36%	1.288	25%	1.161	28%	3.020	50%	294	25%	939	25%
	total	37.007	100%	13.914	100%	17.148	100%	1.797	100%	5.067	100%	4.100	100%	6.096	100%	1.184	100%	3.705	100%	37.007	100%

Source: Annual enterprise statistics by size class for special aggregates of activities (NACE Rev. 2) (sbs_sc_sca_r2) – 24.11.2015.
Note: Differences in total sum occur due to non-disclosure of the number of companies of sector 12, 15, 16, 19, or 29 for some countries for some firm size classes.
Regarding the structural picture these differences are without significance.

Annex Table 20: Overview of Analyzed Sample/Population of EMS 2012 Data, Distribution of Companies by Firm Size Classes and Sector (Representative of the Actual Industrial Structure)

		Total	
		N	**%**
Company Size	20 to 49 employees	1,011	37,5%
	50 to 99 employees	668	24,8%
	100 to 249 employees	592	22,0%
	250 to 499 employees	233	8,6%
	500 to 999 employees	110	4,1%
	1000 and more employees	81	3,0%
	total	2,695	100%

		Total	
		N	**%**
Sector Groups (NACE Rev. 2)	Food, Beverages, Tobacco Industry (10 - 12)	248	9,2%
	Chemical Industry (20 - 21)	126	4,7%
	Rubber and Plastic Industry (22 - 23)	417	15,5%
	Metal Industry (24 - 25)	581	21,6%
	Machinery Industry (28)	411	15,3%
	Electronic and Electrical Equipment (26 - 27)	280	10,4%
	Transport Equipment (29 30)	122	4,5%
	Other Sectors	510	18,9%
	total	2,695	100%

Source: Own analysis