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Joint Research Centre

SCIENCE FOR POLICY BRIEF – Industrial Research & Innovation

Scoreboard firms' capabilities in advanced manufacturing

An ecosystem approach based on the Digital Techno-Economic ecoSystem (DGTES)

2025

HIGHLIGHTS

- We analyse the advanced manufacturing (AM) industrial landscape via the Digital Techno-Economic ecoSystem (DGTES) and position the EU Industrial R&D Investment Scoreboard firms.
- Over 70% of global AM firms are concentrated in China (45%), the US (17%), and Europe (10%), pointing to a clear regional dominance in the DGTES AM ecosystem. The EU is still well positioned relative to its number of activities in critical technologies for the AM industry, like ´3D Printing´.
- The EU and Japan have higher R&D investment and patent filings of Scoreboard firms compared to the broader DGTES AM ecosystem (e.g., 16% vs. 10% in the EU) making them candidates for driving the uptake of AM technologies. However, China leads in overall AM ecosystem patent activity.
- ´3D printing´ dominates the AM ecosystem (27%), but Scoreboard firms excel in ´Power Electronics´ (35% vs. 20%). The manufacturing sector leads in both (47% overall, 68% for Scoreboard firms), with significant presence in ´ICT´ and ´professional services´.

Quick Guide

This document describes the industrial landscape and patent-driven innovation in the advanced manufacturing (AM) ecosystem using the Digital Techno-Economic ecoSystem (DGTES) approach. It compares the DGTES ecosystem performance of the EU, US and China and positions the global top innovators from the EU Industrial R&D Investment Scoreboard.

Introduction

The EU Competitiveness Compass[1] and the Draghi report[2] highlight the importance of innovation, technological advancement and R&D-intensive sectors, in shaping Europe´s economic landscape. They emphasise that the EU should be at the forefront of cutting-edge technologies, including artificial intelligence, semiconductor and quantum technologies, and advanced materials. Given the critical role that

[1] Competitiveness compass - European Commission

[2] The Draghi report on EU competitiveness

advanced manufacturing (AM) is likely to play in the development and integration of these technologies, it is reasonable to assume that this sector is a key enabler of the EU's competitiveness strategy. Stemming from the 2020 industrial strategy[3], a recent DGTES ecosystem mapping shows first insights into the global AM landscape (Fabiani et al, 2024).

The connection between AM and emerging technologies is meaningful, as it can facilitate the production of complex systems, such as autonomous vehicles, smart robotics and IoT devices, which need converging technologies. Exploring the intersection of AM with these technologies provides valuable insights into the potential for EU's industrial policy and competitiveness.

First, this document reviews the main insights obtained when mapping the global DGTES AM ecosystem over the period 2009-2023 and presents the players identified as well as their geographical, technological and sectoral characteristics. Second, it zooms in on the Scoreboard companies active in our AM ecosystem. Third, it summarises the key findings and conclusions.

Advanced manufacturing – an ecosystem perspective from DGTES

Advanced manufacturing (AM) is a production mode enhanced by the convergence and integration with and application of most cutting-edge technologies to manufacturing. Being the latest stage of industrial production, AM further extends the frontier of manufacturing by fostering technology-driven innovations in the form of new or improved products, processes, business models and methods – thus influencing *what* is produced and *how* it is produced. In its most advanced forms, AM enables the real-time integration of production systems and leads to the emergence of smart production methods defined as 'smart factory' and 'smart automation', often associated with 'Industry 4.0' (Fabiani et al., 2024).

The Digital Techno-Economic ecoSystem (DGTES) methodological approach describes ecosystems (see Box 1). DGTES allows analysts to compile a unique database from heterogeneous data sources to generate new indicators to define, measure and analyse the AM industry, covering its technological, geographical and industrial dimensions and identifying the players engaging in AM-related activities. We use DGTES to identify the Scoreboard companies engaging in AM activities and compare them against the general landscape of the AM industry.

Box 1: DGTES for studying the global advanced manufacturing (AM) industry

The Digital Techno-Economic ecoSystem (DGTES) is the application of the Techno-Economic Segment (TES) analytical framework to the analysis of the digital ecosystem. The TES methodological approach is developed by the JRC Digital Economy Unit to analyse dynamic complex segments of rapidly evolving and emerging technologies. Using a series of heterogeneous data sources, DGTES generates a graph database that makes it possible to map the digital ecosystem by identifying players engaging in different types of activities related to the production and exchange of knowledge, goods or services (Calza et al., 2022; 2023).

Thanks to its granularity and flexibility, the DGTES methodology can map several techno-economic specific fields with a clear technological connotation, such as AM (Fabiani et al., 2024). This yields insights into the AM industry: the geographical location of AM firms, the technological and industrial composition of their activities, and the structure of foreign ownership or venture capital flows. We consider 15 technology areas associated with enabling or enhancing AM processes as technological perimeter of the AM ecosystem.

The DGTES approach associates each technology area with a unique list of keywords that are used to build queries and identify relevant documents for AM (see Calza et al., 2024) from various sources (i.e. patents, firm databases). These documents can refer to different activities: business activities (containing information on companies' core business or investments); innovation activities (filing of priority patents or participation in EU-funded projects)[4]; research activities (publications in selected journals, reflecting academic contributions to frontier research)[5]. Here we consider documents issued between 2009 and 2023.

The DGTES advanced manufacturing (AM) ecosystem

The digital technologies and technological solutions that enhance advanced manufacturing (AM) have a markedly applied nature. This implies that, in defining the technological scope of AM, the focus is not on advanced technologies 'per se' as potential enablers of AM, but on their specific applications in products, processes, methods and organisations. Thus, the 'techno-economic space' defining AM corresponds to

[3] Industrial policy dialogue and expert advice - Internal Market, Industry, Entrepreneurship and SMEs

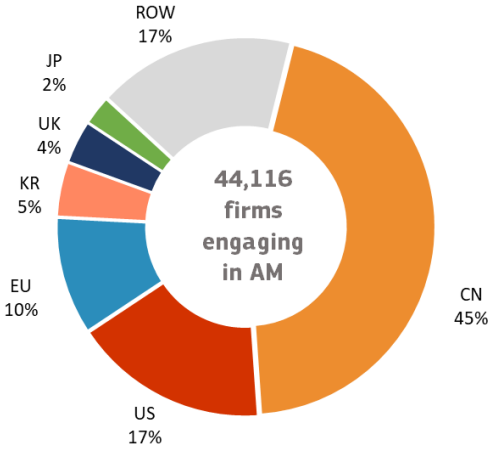
[4] To ensure comparability with the Scoreboard, EU-funded projects are excluded from the analysis.

[5] Research activities are currently excluded from the analysis, which focuses on advanced manufacturing activities.

the industrial application of advanced IT-based production technologies that enhance manufacturing production, including technological solutions related to other families of advanced technologies, such as advanced materials and biotech. A firm belongs to the AM ecosystem if it engages in one or more AM activities – that is, if it has a core business, a priority patent[6] or a publication related to the industrial application of advanced technologies and technological solutions linked to one or more of the 15 AM technology areas we identify (see Box 1)[7].

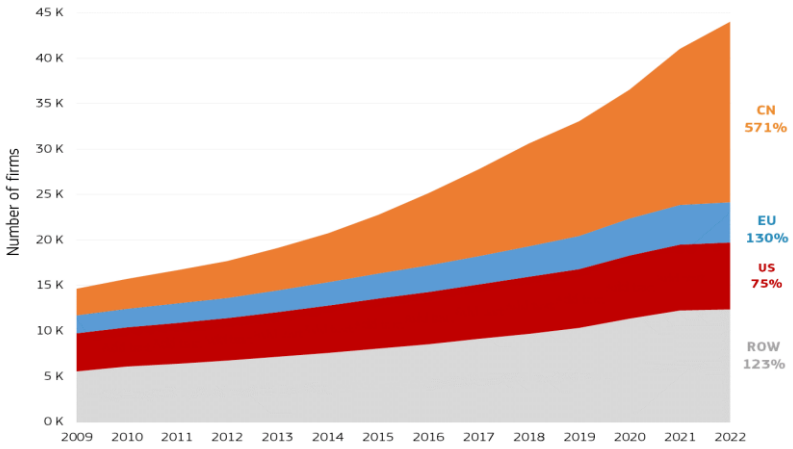
As shown in figure 1, in total 44,116 firms worldwide are engaged in AM between 2009 and 2023, of which 72% are located in China (45%), in the US (17%), or in the EU (10). The number of Chinese firms in AM-related activities has increased by a factor of 6.7 since 2009, surpassing the US in 2014. The number of EU firms engaged in AM also increased significantly during the same period, going from 1,900 to 4,500 and outpacing the US's growth rate (130% versus 75%), thus reducing the gap with the US in recent years (Figure 2).

Figure 1. Proportion of firms in the AM ecosystem by main geographical area (2009-2023)



Note: Cumulative number of firms over 2009-2023. *RoW*: Rest of the world. *Source:* Fabiani et al. (2024) based on the JRC DGTES database

Figure 2. Evolution in the number of firms engaging in AM by geographical area (2009-2022)



Note: Cumulative number of firms in each year of the period under consideration. *RoW*: Rest of the world. The figures on the right show the growth rate over the period. *Source:* Fabiani et al. (2024) based on the JRC DGTES database.

Figure 3 shows the technological characterisation of the AM ecosystem: '3D Printing' is leading with 27% of activities, followed by 'Power Electronics' (20%), and 'Dynamic Data' (14%). Although '3D Printing' is the first technology area (per number of AM activities) in China, the EU and the US (Figure 4), there are differences in its weight across the three world regions. Around 40% of AM activities in the EU and US are related to additive manufacturing technologies, this proportion declines to 30% in China, where technologies such as 'Power Electronics' and 'Dynamic Data' are more relevant than in the US and the EU.

The AM applications of 'Robotics' and 'AI' display similar proportions (between 8% and 10%) in the three main world regions. Interestingly, the technology areas of 'IoT' and 'Extended reality' account for a rather small proportion of the global AM ecosystem (4% and 3% respectively, see Figure 3), but play a relatively more significant role in the European AM ecosystem.

The DGTES approach overcomes the constraints of industrial classifications. Table 1 shows the proportions of industry sectors in the AM ecosystem. Its industrial landscape is driven by 'Manufacturing' (47% of all AM firms, but AM firms do not operate exclusively in 'Manufacturing'. There are significant shares in 'Information and communication' (14%), 'Professional, scientific and technical activities' (13.5%) and 'Wholesale and retail trade; repair of motor vehicles and motorcycles' (12.5%). The remaining industries account for less than 15% of AM firms globally, with each sector accounting for 5% or less.

[6] Priority patent applications are used to proxy innovation activities, without filtering for the office where the patent is registered. This follows the DGTES methodology, which aims to track knowledge flows and identify all digital players via their global 'digital footprint'.

[7] For a detailed description of these technology areas see Annex IV in Fabiani et al. (2024).

Figure 3. Share of DGTES AM ecosystem activities by technology area (2009-2023)[8].

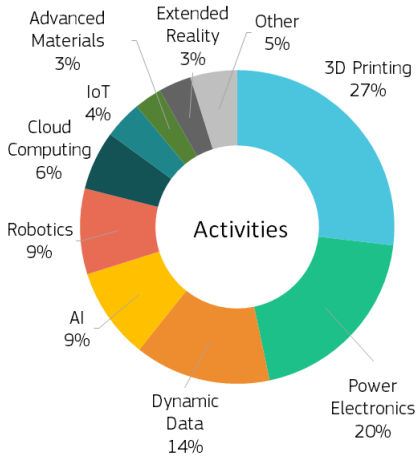
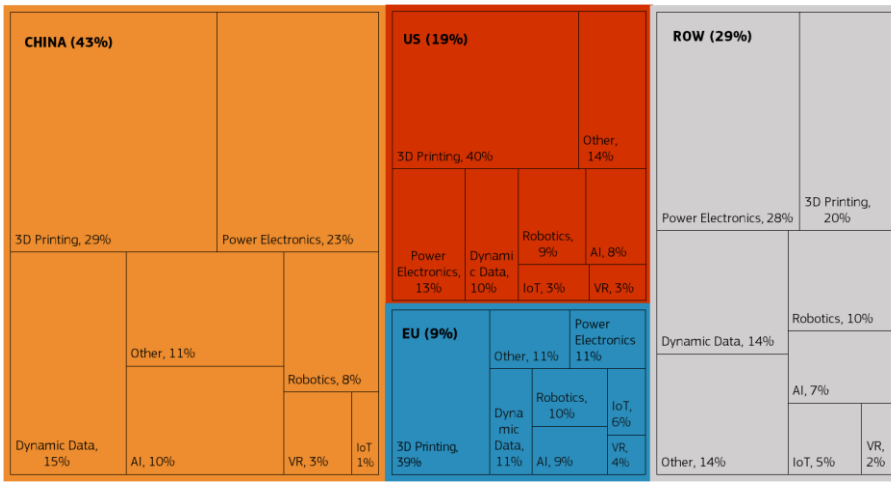


Figure 4. Technological composition of the DGTES AM ecosystem in China, the US and the EU (2009-2023)[9].



Note: Proportions calculated across a cumulative number of activities for 2009-2023. In Figure 4, VR refers to 'Virtual/Extended Reality' technology area. RoW refers to 'rest of the world'. *Source*: Fabiani et al. (2024) based on JRC DGTES database.

Table 1. Proportion of firms by sector in the DGTES AM ecosystem and across AM Scoreboard firms (2009–2023).

	Sector	DGTES AM Ecosystem	Scoreboard AM firms
C	**Manufacturing**	**46.8%**	**67.7%**
D	Electricity, gas, steam and air conditioning supply	0.3%	0.8%
E	Water supply; sewerage, waste management and remediation activities	0.1%	0.0%
F	Construction	1.6%	0.7%
G	**Wholesale and retail trade; repair of motor vehicles and motorcycles**	**12.4%**	**6.9%**
H	Transportation and storage	0.7%	0.2%
I	Accommodation and food service activities	0.4%	0.0%
J	**Information and communication**	**14.0%**	**12.0%**
K	Financial and insurance activities	5.1%	2.5%
L	Real estate activities	0.5%	0.2%
M	**Professional, scientific and technical activities**	**13.4%**	**6.9%**
N	Administrative and support service activities	2.4%	1.2%
O	Public administration and defence	0.1%	0.2%
P	Education	0.3%	0.0%
Q	Human health and social work activities	0.7%	0.2%
R	Arts, entertainment and recreation	0.2%	0.1%
S	Other service activities	0.8%	0.3%
T	Activities of household as employers	0.0%	0.0%

Notes: Proportion of firms in the AM ecosystem and AM Scoreboard companies by NACE Rev. 2 industry, *Source*: JRC DGTES database.

Scoreboard firms in the DGTES advanced manufacturing ecosystem

In this section we compare the EU Industrial R&D Investment Scoreboard[10] firms with the overall AM industry in our DGTES ecosystem, looking at their differences in terms of type of activities, geographical location, sectors of operation and technological composition. Out of 44,116 firms identified in the DGTES AM ecosystem, 2,066 (Figure 5) are subsidiaries owned by 925 Scoreboard companies. As Figure 6

[8] An activity associated with more than one technology area counts as a full activity for each of the areas involved. Thus, the sum of the number of activities across all technology areas can exceed the total number of individual activities in the AM ecosystem. E.g., a patent in two digital areas 'Cybersecurity' and 'Dynamic Data' counts as one activity in 'Cybersecurity' and one in 'Dynamic Data'. This approach considers that almost all activities are associated with one (70%) or two (19%) technology areas and is similar to fractional counting where a fraction of the activity is assigned to each area.

[9] Relating firms' geographical location with their technological activity accounts for the nature of collaboration (i.e. if the activity is performed by more than one firm, such as in co-patenting). If we find all collaborating firms in the same geographical area, we assign one technological activity to that geographical area. If we find collaborating across different geographical areas, we assign a fraction of the collaborative activity the geographical area of each firm. For instance, if two firms - one located in the US and one in the EU - share a patent, then we assign half to the EU and half to the US.

[10] Nindl et al., 2023.

shows, a first relevant difference between Scoreboard firms and the wider DGTES AM ecosystem is the proportion of AM firms. This is higher for Scoreboard firms in the EU, US and Japan than for the global AM ecosystem (6, 1 and 7 percentage points more, respectively). Although the weight of Chinese Scoreboard firms that engage in the AM ecosystem is lower than their share in the whole DGTES ecosystem, the share of Chinese Scoreboard firms is still very significant. The left-hand chart of Figure 7 shows how the mother companies connected to the AM firms are distributed across the ranking.

Figure 5. Proportion of Scoreboard (SB) subsidiaries in the DGTES AM ecosystem by main geographical area (2009-2023).

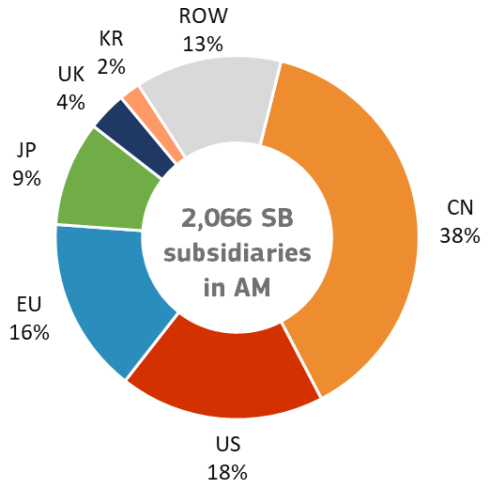


Figure 6. Comparison of proportions of DGTES AM firms by geographical area (2009-2023).

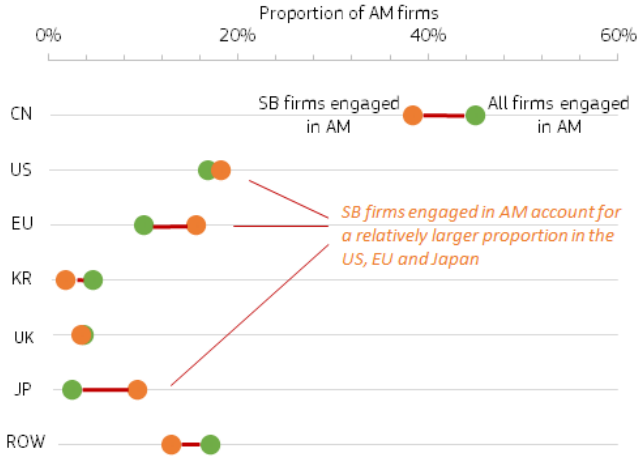
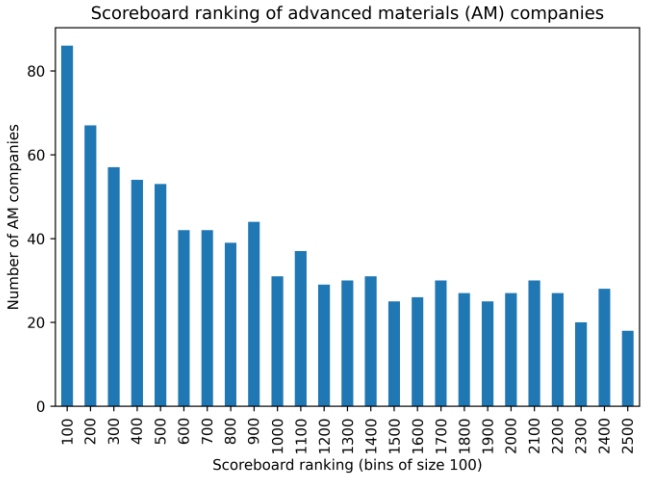
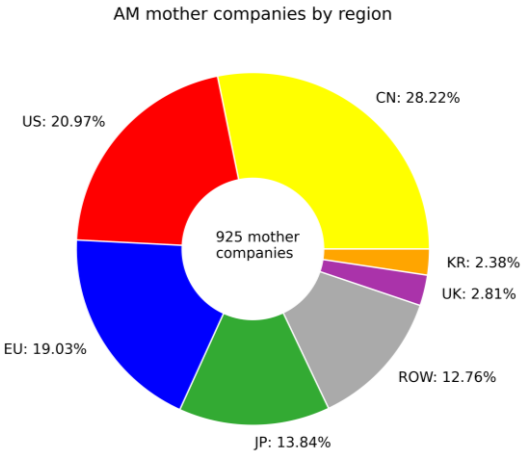


Figure 7. Distribution of AM mother companies in the Scoreboard ranking (left) and their geographical distribution (right).





Source: JRC DGTES and Scoreboard databases.

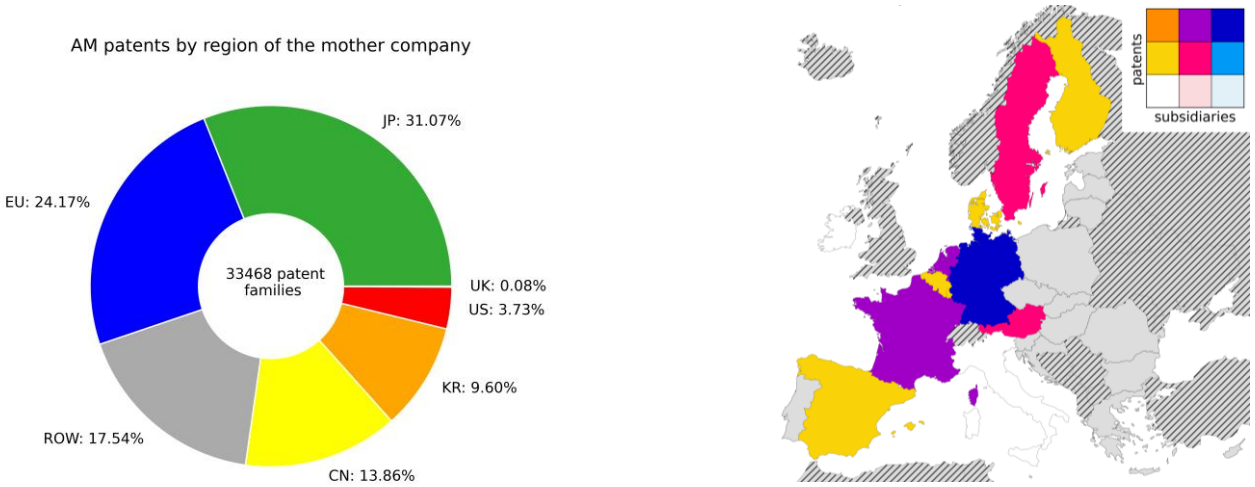
The bars show the number of AM mother companies within bins, each bar comprising 100 positions in the Scoreboard ranking, which is established based on R&D investment. AM mother companies are more often found in the top positions: over 80% of the top 100 Scoreboard firms are active in AM, over 60% of those ranked 101 to 200, and so on.

The right-hand chart in Figure 7 shows that the geographical distribution of the Scoreboard AM companies is qualitatively similar to that of the AM subsidiaries reported in Figure 5. Most Scoreboard AM companies are in fact based in China (28%), followed by the US (21%) and the EU (19%). This is even though the proportion of China-based mother companies is lower than the proportion of China-based subsidiaries (38%) and the proportion of Scoreboard AM companies in almost all other regions is higher. For instance, Japanese Scoreboard AM companies are represented more substantially (14%) than Japan-based subsidiaries (9%).

Tech capabilities in advanced manufacturing of the Scoreboard firms

The AM Scoreboard companies produced over 33,000 AM patent families between 2000 and 2022. The regional breakdown in Figure 8 (left-hand graphic) shows that Japan-based mother companies and their subsidiaries are the most active (31% of filed AM patents), followed by EU-based companies (24%), those from the RoW (18%), China (14%), South Korea (10%) and the US (4%). In combination with Figure 7, this indicates more intense patenting activity in AM by EU-based, Japanese, South Korean and RoW Scoreboard companies.

Figure 8. Distribution of AM patents by region of mother company in the Scoreboard (left-hand graphic) and the EU panoramic map combining numbers of subsidiaries and patents by member state (right-hand map).



Source: JRC Scoreboard database

The map on the right-hand side of Figure 8 is a panoramic depiction of the level of involvement of EU-based mother companies in AM-related activities. EU countries are coloured based on the number of subsidiaries owned and the number of patents filed by the mother companies they host (see legend in the top right-hand corner of the map).

- Italy-based Scoreboard companies (white in the map) own few AM-involved subsidiaries and filed few AM patents relative to the rest of the bloc, while Germany-based mother companies (dark blue) own many subsidiaries related to AM and produce many patents compared with other Member States.
- Companies based in Sweden and Austria (pink) are in the middle, i.e. they are more active in patenting and own more subsidiaries than companies based in Italy, but less than companies based in Germany.
- Companies based in Spain and Finland (yellow) are in the middle in terms of ownership of AM subsidiaries but produce few AM patents.
- Countries coloured in purple (e.g. France and the Netherlands) host companies that own many AM subsidiaries and are responsible for a slightly higher number of AM-based patents than countries coloured in pink.

The technological composition of the activities of the Scoreboard AM firms differs with respect to the overall DGTES AM ecosystem. 'Power Electronics' is the largest technology area, accounting for more than one in three AM activities among the Scoreboard firms. Technologies included in this domain, like semiconductors and control systems, require capital-intensive R&D that is often at the frontier of chip design and system integration.

This finding suggests a positive correlation between R&D investment and engaging in this technology area. '3D Printing' is the second largest technology area per number of activities and is followed, as in the overall AM ecosystem, by 'Dynamic Data', 'AI' and 'Robotics'. These differences showcase that firms with smaller capital strength innovate in technologies where market entry costs are lower.

When looking at the relative weights of the technology areas in the different world regions, for Chinese Scoreboard companies the largest proportion of AM activities now corresponds to 'Power Electronics' (35% for Scoreboard firms vs 20% for the global ecosystem firms), followed by '3D Printing' (27% for both Scoreboard and ecosystem firms) and 'Dynamic Data' (11% vs 14%, respectively). These technological divergence hints to diverse industrial specialization as well as different policy priorities across regions. For the EU and the US, the largest technology area is still '3D Printing', followed by 'Power Electronics' and 'AI'. In US

Scoreboard AM firms, more than half of the activities (56%) comes from a single specialisation on one main technology area ('3D Printing').

Table 1 above shows that, compared to the overall DGTES AM ecosystem, Scoreboard firms are more concentrated in manufacturing (67.7% vs.46.8%), and also operate in 'Information and communication' (12%), 'Professional, scientific and technical activities' (7%) and 'Wholesale and retail trade; and repair of motor vehicles and motorcycles' (7%).

Table 2 shows the top 10 Scoreboard AM companies ranked by their AM-related patenting activities. The top three patenting Scoreboard AM companies are the China-based company BOE Technology Group (3 883 AM patents filed between 2000 and 2023), which operates in the Electronics sector; the South Korea-based SK Hynix (3 176 patents) operating in the Hardware sector; and Japan-based Sony (2 615 AM patents) operating in the Leisure Goods sector. The EU-based AM company with the largest AM patent output is Philips (ranked 5th, with 1 342 AM patents). Among the next 10 firms beyond the top 10 there are another four EU-based players: L'Air Liquide, ASM International, Heraeus, and Thyssenkrupp. These numbers suggest that there is worldwide concentration of AM patents in leading innovators, and that European companies retain a substantial base.

In terms of the number of Scoreboard mother companies, the most represented sectors among the top 20 AM patenting mother companies are Electronics, Hardware and Chemicals. In terms of AM patents filed, the most represented sectors are Electronics (over 8 000 AM patents), Hardware (over 5 500) and Leisure Goods (over 2 500).

Table 2. Top 10 patenting Scoreboard AM companies.

Scoreboard AM company	Industry Classification (ICB) sector*	Global Scoreboard rank	Region	AM patent number
BOE Technology GroupP	Electronic & Electrical Equipment	159	CN	3,883
SK Hynix	Tech Hardware & Equipment	54	KR	3,176
Sony	Leisure Goods	40	JP	2,615
Murata Manufacturing	Electronic & Electrical Equipment	246	JP	1,494
Philips	General Industrials	123	EU	1,342
BASF	Chemicals	95	EU	1,299
Robert Bosch	Automobiles & Parts	23	EU	1,206
Hitachi	Electronic & Electrical Equipment	89	JP	1,126
Mamoura Global Holdings	Financial Services	495	RoW	1,021
United Micro-electronics	Tech Hardware & Equipment	493	RoW	983

Note: * https://www.lseg.com/en/ftse-russell/industry-classification-benchmark-icb
Source: own compilation

Key findings & conclusions

This briefing document has examined the AM capabilities of top R&D investors covered by the EU Industrial R&D Investment Scoreboard from an ecosystem approach based on the Digital Techno-Economic ecosystem (DGTES). The analysis shows in which world regions and technologies the Scoreboard firms excel.

Most companies in the AM ecosystem are based in China (45%), with a significant number located in the US (17%) and Europe (10%). The EU is well positioned relative to its number of activities in critical technologies for the AM industry, like '3D Printing'. The EU's relatively high share of patents compared to its share of firms also points to a strong innovation base. However, a lower number of companies compared to China and the US suggests insufficient diffusion of advanced technologies across traditional manufacturing firms and the need to scale-up AM-related startups. Such technologies require significant investments, which is a greater challenge for smaller firms, suggesting the need for better alignment between EU and national policies together with streamlined access to Horizon Europe initiatives. Harmonized standards and interoperability in digital infrastructure (e.g., AI, IoT) would also help the adoption of these technologies by smaller firms.

The EU and Japan have higher R&D investment and patent filings of Scoreboard firms compared to the broader AM ecosystem (e.g., 16% vs. 10% in the EU) making them candidates for driving the uptake of AM technologies. These firms are much more active than the ecosystem especially in 'Power Electronics' (35% for Scoreboard firms vs 20% for ecosystem firms). Scoreboard firms from the EU also file more patents than the average AM ecosystem actor, underlining their potential role as innovation leaders. These EU-based firms play a role in driving 'Power Electronics' (19% for Scoreboard firms vs 11% for ecosystem firms) and US-based Scoreboard firms in '3D Printing' (56% vs 40%, respectively).

The report highlights divergent levels of AM activity across EU countries, with Scoreboard firms in Germany, France, and the Netherlands leading in patents and subsidiaries active in AM, while Scoreboard companies based in Italy or Ireland are less represented. Cohesion policy and regional smart specialisation strategies should better integrate AM as a priority area, ensuring that innovation and production capacities are distributed more evenly across the Union. This aligns with the EU's commitment to resilience and avoiding excessive regional concentration of critical technologies.

The sectoral analysis reveals high concentration of AM-related Scoreboard firms in the manufacturing sector. While this might be expected, EU policy should encourage stronger linkages across sectors, for instance through initiatives like the EIT Manufacturing Knowledge and Innovation Community. Facilitating collaboration between manufacturing incumbents, digital startups, and service providers can accelerate the diffusion of AM into diverse industrial contexts, from automotive to healthcare and energy. That there are 7 EU-based firms among the global top 20 AM patenting Scoreboard firms shows the wide opportunities that AM offers for industrial transformation.

In conclusion, advanced manufacturing represents both a strength and a challenge for Europe. The EU hosts a strong traditional manufacturing sector and possesses a strong innovation base, which combined can lead to a rapid expansion of the AM ecosystem. However, the state of play of the European AM ecosystem compared to China and the US suggest the EU faces challenges in terms of scale, diffusion, and geographical balance. By leveraging its existing industrial policy instruments, ensuring coordination across Member States, and aligning R&D, skills, and investment strategies, the EU can turn AM into a cornerstone of its competitiveness, resilience, and twin transition agendas.

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