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DIGITAL EUROPE: PUSHING THE FRONTIER, CAPTURING THE BENEFITS

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TECHNICAL APPENDIX

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25

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TECHNICAL APPENDIX

This appendix provides details about the methodologies used in this report in the following sections.

1. Europe Digitisation Index and heat map
2. Measuring the digital economy as a share of GDP
3. Estimate of trade in digital services
4. Estimate of €2.5 trillion GDP impact of digitisation by 2025

1. EUROPE DIGITISATION INDEX AND HEAT MAP

MGI's Industry Digitisation Index measures the extent of digitisation in 22 sectors of the European economy. It combines 21 input metrics split into three categories:

- Digital assets (five metrics)
- Digital usage (ten metrics)
- Digital labour (six metrics).

Within each of these categories, we highlight related metrics that offer different views of a particular activity or trend (Exhibit A1).

Using a principal component analysis, the input metrics are combined into an overall digitisation score. The data for these metrics are primarily obtained from public sources such as Eurostat and the OECD. Furthermore, we use both public and proprietary McKinsey data from previous MGI reports, proprietary databases, and client and consumer surveys.

Exhibit A1

Metrics included in the MGI Industry Digitisation Index

		Metric	Description
Assets	**Digital spending**	Hardware spending	Share of total expenditures spent on ICT hardware (e.g., computers, servers)
		Software and IT services spending	Share of total expenditures spent on software and IT services (e.g., enterprise resource planning software)
		Telecommunications spending	Share of total expenditures spent on telecommunications (e.g., broadband access, mobile data services)
	Digital assets stock	Hardware assets	Share of total assets made up of ICT hardware (e.g., computers, servers)
		Software assets	Share of total assets made up of software (e.g., purchased software licenses)
Usage	**Transactions**	Enterprises selling online	Annual sales realised via any computer networks; computer networks include websites, EDI-type systems, and other means of electronic data transfer (excluding e-mails)
		Enterprises purchasing online	Percentage of companies doing at least 1% of their purchases via any computer networks; computer networks include websites, EDI-type systems, and other means of electronic data transfer (excluding e-mails)
	Interactions between firms, customers, and suppliers	Digital supply chain	Enterprises sending/receiving all type of information on the supply chain (e.g., inventory levels, production plans, forecasts, progress of delivery) via computer networks or via websites
		Social media use	Enterprises using two or more of the following social media: social networks, enterprise's blog or microblog, multimedia content sharing websites, wiki-based knowledge-sharing tools
		Companies with ICT very integrated into daily activities	Composite score based on McKinsey's 2015 survey on the digital capabilities of firms in Europe and the United States
		Companies with benefits from external customer-related tools	
		Companies with benefits from using social tools to work with partners	
		Companies where at least half of business is digital in nature	
	Processes	Enterprise Resource Planning use	Enterprises that have an ERP-enterprise resource planning software package, which they use to share information between different functional areas (e.g., accounting, planning, production, marketing)
		Customer Relationship Management use	Enterprises that use a CRM, i.e., any software application used for the analysis of information about clients for marketing purposes
Labour	**Digital spending**	Hardware spending on workers	ICT hardware (e.g., computers, servers) expenditures per full-time-equivalent employee (FTE)
		Software and IT services spending per worker	Software (e.g., enterprise software licenses) and IT services expenditures per FTE
		Telecommunications spending per worker	Telecommunications (e.g., broadband access, mobile data services) expenditures per FTE
	Digital capital deepening	Hardware assets per worker	ICT hardware assets (e.g., servers, computers) per FTE
		Software assets per worker	Software assets (e.g., workers software licenses) per FTE
	Digitisation of work	Share of jobs that are digital	Digital jobs (e.g., computer and information systems managers, web designers, social media community managers, database administrators, big data scientists) as a share of total jobs

SOURCE: McKinsey Global Institute analysis

Sectors included in the digitisation index

The 22 sectors that appear in the digitisation index are arrived at using the methodology deployed in MGI's 2015 report on digital America.[1] This largely followed the North American Industry Classification System (NAICS), but made several adjustments.

We separated oil and gas from all other kinds of mining and resource extraction such as coal and metal mining. We split manufacturing into advanced durable goods, chemicals and pharmaceuticals, and basic durable and non-durable goods. These categories allowed us to combine manufacturing subsectors that exhibit similar features with regard to their levels of digitisation. Finally, we isolated the ICT sector from the information and manufacturing sectors. Our definition of the media sector therefore includes only publishing, electronic media, and broadcasting. Our definition of the ICT sector, on the other hand, includes software publishing, telecommunications, data processing, and web-search portals. We also considered computer and electrical manufacturing, and computer systems design and related services in the ICT sector. In addition, we combined the professional, scientific, and technical services and management category with professional and business services. We also combined administrative and support and waste management and remediation services with other services (except public administration) to create a category called personal and local services.

Further, we used simplified naming conventions that do not precisely match NAICS industry names. For instance, we "health care and social assistance" to "health care". Where different from the NAICS terminology, the sector names we used reflect the predominant nature of occupations in that sector.

Construction of the index

For each sector, we combined each of the metrics in a multi-stage process, with the aggregations at each stage displayed in Exhibit A1. For example, software assets and hardware assets were combined into digital assets stock, and this was, in turn, combined with hardware, software and IT services, and telecoms spending into the assets grouping. For some metrics in particular countries, adjustments were needed to reflect methodology differences among the national statistical offices of countries. For example, less investment flows to hardware assets in Germany than in other countries. For this reason, German data for hardware assets were scaled up to match Italian assets per employee, the second lowest in the group.

To aggregate these variables into higher-level metrics at each stage, we assigned a weight to each variable. We use a principal component analysis (PCA) to determine the weights. The PCA is a mathematical transformation that converts a set of potentially correlated input variables into principal components, or new sets of values that explain the variance in the input variables. In this case, the resulting principal components aim to explain the variance in 21 input variables. A PCA yields multiple components, and we therefore used the component that explained the most variance of the original 21 variables. Each component has corresponding variable loadings or weights, which we applied as the weights for each value in the index calculation. Since the 21 input variables are not in the same units, we divided each value by its standard deviation to standardise that value. The multiplication product of weight and standardised value over the sum of all 21 variable weights yields the standardised score for each industry. We then converted the standardised scores to an index with a theoretical maximum of 100. For each index and category, we repeated the same methodology with a subset of the 21 input metrics.

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[1] See *Digital America: A tale of the haves and have-mores*, McKinsey Global Institute, December 2015. The technical appendix can be found on page 83 of that report, which can be downloaded at **http://www.mckinsey.com/industries/high-tech/our-insights/digital-america-a-tale-of-the-haves-and-have-mores**.

Digital frontier

In MGI's 2015 report on digital America, we calculated a "digital frontier" for the United States (please see the appendix of that report for more details on how we calculated that frontier). In this report, we used the US digital frontier as the benchmark to compare Europe's digitisation, since the United States ranks higher on digitisation than Europe overall—its frontier is further ahead—and US firms are major suppliers of digital designs and platforms to Europe. Because the same data were not available in both regions, we could not compare digital frontiers directly. Instead, we calculated an index, using the same approach as for the digitisation index, using only the metrics that were available for both the United States and Europe for each sector in each European country. For each country, we then created a composite industry index using a GDP-weighted average of the sectors. The US index was then set to 18 percent as calculated in the digital America report, and then scaled to other countries appropriately to create an overall comparison between countries.

To calculate a digitisation index for industries within a country, we calculated a digital frontier for each nation. This is done by creating a country-based digitisation frontier. To do this, we assigned a value of 100 percent for the majority of metrics in the index that has a raw percentage value. One example is the percentage of firms using enterprise resource planning products, or the percentage of assets that are digital in nature. Metrics that do not have a maximum value, such as the value of software assets per employee, were excluded from the analysis. Using the same weights and aggregation methodology as used in the methodology for constructing the digitisation index, we created an overall index for this digital frontier. This final index is set to 100 percent, and the index for each industry is scaled by the same ratio.

Differences in the methodology between MGI's US and European research on digital intensity by sector

There are some differences in the methodology and in the choice of variables between MGI's 2015 analysis of digitisation in the United States and this report on Europe. This was due mainly to the need to adjust for the fact that common metrics were not always available, as noted.

- In the US analysis, we calculated a composite score for the most digitised sector by taking the maximum value of each metric for any sector. For example, the composite score could use the value from the finance and insurance sectors as the maximum value for one variable, and the value from media as the maximum value of another variable. In Europe, because ICT is so often ranked first among all variables, we decided to use the "pure" ICT sector as the frontier in all cases.

- The choice of variables also differs slightly between the US and European analyses. Data for usage variables used in the US report were largely not available for Europe. We therefore decided to rely on Eurostat ICT Survey data and on an internal McKinsey survey on the usage of digital within European companies.

2. MEASURING THE DIGITAL ECONOMY AS A SHARE OF GDP

The calculation of the digital share of GDP relies on a 2014 McKinsey report on the digital transformation of French companies, which has been updated for the purposes of this research.[2] The analysis estimates the digital share of GDP in a granular manner that includes private consumption and investment, government spending, and net exports. Within consumption, for example, not only does the analysis factor in spending on ICT but it also

[2] See *Accélérer la mutation numérique des entreprises : un gisement de croissance et de compétitivité pour la France*, McKinsey France, 2014. The technical appendix is found on page 130 of the report, which is available to download at **http://www.mckinsey.com/global-locations/europe-and-middleeast/france/en/latest-thinking/accelerer-la-mutation-des-entreprises-en-france**.

includes e-commerce, online gambling, online travel, and internet-related consumption as a whole.

3. ESTIMATE OF TRADE IN DIGITAL SERVICES

The estimate of the trade balance in digital services between EU countries and the United States is based on our analysis of the digital share of the domestic consumption, exports, and imports of services in each of the six EU countries and the EU-28 as a whole.

We started with GDP by expenditure for a selected EU-28 country, isolating the components of household consumption (C), business investment (I), government expenditure (G), and net exports (X minus M) that together add up to country GDP in 2015. We then made a series of adjustments to isolate the digital share of these activities, as follows:

1. While exports and imports are gross outputs (i.e., final and intermediate sales), consumption only comprises final sales. To adjust for this, we used the average gross profit margin by industry to estimate the cost of goods sold, and then used this as a proxy for intermediate sales. This figure was added to C to get a C* that could be compared directly with exports and imports.

2. The second adjustment was to calculate the services share of this economic activity in the country, specifically for adjusted consumption (C*), exports (X) and imports (M). We calculated this share is calculated using data by country from national accounts, Eurostat, and OECD tables that specify services shares of exports and services shares of consumption. For services exports, we adjusted downwards by multiplying total services exports from the country by its share of services exports going to the EU-28 or the United States.

3. The third adjustment was calculating the digital share of consumption of services, and the digital share of service exports from the country to the EU-28 and United States. This was based on the digital share of GDP estimated in our analysis measuring the digital share of consumption in services such as e-commerce, hospitality, media, and travel and tourism.

These steps gave us the country's digital share of consumption and exports to the United States and the EU-28. We then adjusted these shares using data of web-page views from the European Commission Joint Research Centre (JRC) report on international trade in online services.[3] The JRC data provide estimates of traffic to web pages hosted within a country, and the split of this traffic between domestic views and foreign views. The JRC data also provide estimates of traffic from the country to web pages hosted in the United States and the EU-28 countries. Using these data, we estimated the ratio of online exports to imports, and of domestic sales to imports. Using these ratios, and our estimate of digital consumption and exports for the country, we calculated that country's total imports and the split of imports from the United States vs. other EU-28 countries. These numbers for exports and imports (by region) were then revised downwards using an estimated click-through rate that adjusts for online page views to offline sales, and an estimated gravity equation that adjusts for distance and language effects.

The resulting digital services exports and imports for each country, split by the two trading partners of the United States and the EU-28, were then compared with the total services exports and imports for each country with the same trading partners to estimate the final digital services trade balance for that country with the two trading partners. This exercise

[3] Alaveras, Georgios, and Bertin Martens, *International trade in online services*, Institute for Prospective Technological Studies Digital Economy working paper number 08, Joint Research Centre technical reports, European Commission, 2015.

was repeated for six individual countries (France, Germany, Italy, the Netherlands, Sweden, and the United States), and for the EU-28 as a whole.

4. ESTIMATE OF €2.5 TRILLION GDP IMPACT OF DIGITISATION BY 2025

Impact of online platforms

All estimates of the impact of digitisation on GDP on the EU28 economies are expressed in nominal terms. The estimates include several types of digital usage including the Internet of Things, big data, and online talent platforms, and are therefore not comprehensive. The potential for technology-fuelled growth would be much larger if a comprehensive range of uses were to be used. We estimate the GDP impact in three parts: impact on labor via online talent platforms, on capital through asset efficiency and utilitisation, and on multifactor productivity.

The estimated impact of online talent platforms on GDP used an analysis contained in a 2015 MGI report on this topic.[4] For countries not included in that report, we applied the same ratios as countries with similar characteristics.

Impact on capital through improved asset efficiency

We estimated the capital savings that could be realized by 2025 using the methodology detailed in MGI's 2015 report on the Internet of Things.[5] This is because the Internet of Things enables predictive maintenance of equipment (both of which increase utilisation and avoid expenditure on new assets). Assuming that several European countries are already leaders in the adoption of these technologies, we used the average of the lower and upper estimates in the 2015 Internet of Things report as the lower bound of our own estimate and kept the upper bound as the optimistic estimate. We assumed that the cost savings were equal to an increase in GDP, translating into a proportional increase in productivity. This equation also assumed full employment and no slack in demand.

Impact on multifactor productivity

We estimated the cost savings that could be realised in expenditure on R&D, operations, and resource consumption through the use of big data analytics and the Internet of Things to their full potential in these areas. To estimate the size of the impact of big data in Europe, we replicated the methodology used in MGI's 2013 report on game changers in the US economy.[6] We extended the timeline from that 2013 report to 2025. We determined the savings that fall into the R&D, operations, and resource consumption categories; and took lower and upper estimates.

For the Internet of Things, we used the analysis in MGI's 2015 report on this topic to determine the savings that are related to R&D, operations, and resource consumption (excluding the labour and capital impact as well as consumer surplus).[7] We then took the average of that report's pessimistic and optimistic case be the lower bound of our estimate in this report, and the optimistic case as the upper bound of our estimate. Similarly to the methodology adopted for the impact of digitisation on capital, we assumed that cost savings equated to an increase in GDP.

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4 See *A labor market that works: Connecting talent with opportunity in the digital age*, McKinsey Global Institute, June 2105. The technical appendix of that report is available online at **?**_____

5 See *The Internet of Things: Mapping the value beyond the hype*, McKinsey Global Institute, June 2015. The report is available to download at **http://www.mckinsey.com/business-functions/business-technology/our-insights/the-internet-of-things-the-value-of-digitizing-the-physical-world**.

6 See *Game changers: Five opportunities for US growth and renewal*, McKinsey Global Institute, July 2013. The technical appendix appears on page 133 of that report, which is downloadable at **http://www.mckinsey.com/global-themes/americas/us-game-changers**.

7 See *The Internet of Things: Mapping the value beyond the hype*, McKinsey Global Institute, June 2015. The report is available to download at **http://www.mckinsey.com/business-functions/business-technology/our-insights/the-internet-of-things-the-value-of-digitizing-the-physical-world**.

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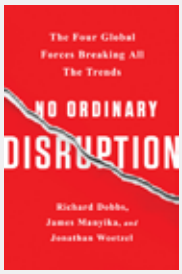

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